fishes

Activity Guide for Grades K-8

BY SHEDD AQUARIUM

Shedd Aquarium Activity Guide Series

Look for these and other Shedd Aquarium Publications:
Frogs: Activity Guide for Grades K-2
Oceans: Activity Guide for Grades 3-5
Oceans: Activity Guide for Grades 6-8
Penguins: Activity Guide for Grades K-3
Sharks: Activity Guide for Grades 3-5
Whales: Activity Guide for Grades 3-5

Published in the United States by the Shedd Aquarium Society,
1200 S. Lake Shore Drive, Chicago, Illinois 60605.

Shedd Aquarium's *Fishes Activity Guide* was made possible by the Albert Pick, Jr. Fund

ISBN 0-9611074-8-0

Acknowledgments
President/CEO: Ted A. Beattie
Writer: Fran Donovan
Editors: Karen Furnweger

Illustration & Design: Donovan Design, Inc.
Cover Photo: George Parsons
Additional Photography: Ed Lines, Jr.
Poster: James Frost

Advisors: Katherine San Fratello, Cheryl Mell, Nicole Pierson, Linda Schubert, Sean Shaffer, Sally Smith, Bert Vescolani, Information Services and Technology Department

Table of Contents

Table of Contents (cont.)

Fishes Activity Guide
for Grades K-8

Fishes is a special edition of our teacher Activity Guide series. Thanks to the generous support of the Albert Pick, Jr. Fund, we are able to offer this comprehensive guide for Kindergarten through 8th grade with a bonus full color poster included. To facilitate your use of the book, we have included the following icons for each grade grouping:

Grades K-2	Grades 3-5	Grades 6-8
Angelfish icon	*Seahorse icon*	*Manta ray icon*

These grade designations are meant to be broadly interpreted. You may find it helpful to use the activities even if they are not specifically designated for the grade you teach. For example, if your 5th grade class has not previously studied fishes, you may want to begin with the K-2 category as an introduction.

OBJECTIVES

This Activity Guide is designed to provide teachers with a resource for incorporating the study of aquatic science, specifically fishes, into their existing curricula. Each activity will help meet specific learning objectives. If all of the activities in this Guide are completed, the following learning objectives will be met:

- Illinois State Goals in Science: *Goals 1 through 4*
- National Science Education Standards:
  Unifying Concepts and Processes Standard
  K-4 Content Standards A through G
  5-8 Content Standards A through G

GOALS

- To provide teachers with an interactive teaching tool and curriculum on fishes for grades K-8
- To build students' critical thinking skills and scientific literacy
- To approach the study of science in an interdisciplinary way
- To offer students a fun, hands-on learning experience

Do You Say Fish or Fishes?

Even though we are used to using the word "fish" for both singular and plural, when referring to fish from more than one species, they are called fishes. Therefore, we can say, "I caught a *fish*." or "We saw many gold*fish* in the aquarium." However, if more than one species is involved, we would say, "There are many tropical *fishes* in the aquarium."

Using this Book:
Guidelines for Teachers

Children are naturally intrigued by and curious about fishes. Take advantage of this inherent interest as a springboard to scientific inquiry. Get in the habit with your students of wondering and then pursuing your questions by conducting research. For example, why do some fishes swim near the top of the aquarium and others swim along the bottom? Why do some fishes have brightly colored stripes? Doesn't that make them easier for ***predators*** to find? You can make guesses, but without researching fishes, they will be made with very little context.

GETTING STARTED

This Activity Guide is meant to accommodate your needs regardless of your specific goals. Whether you're looking for a week-long investigation of fishes or an in-depth course of study on marine life, this book will be a valuable resource. We recommend you peruse the entire book before you begin the activities, to ascertain which are most relevant to and appropriate for your students. Activities can stand alone but are designed to build on each other. It is most advantageous to complete all or most of the activities in the book. Hang the poster at the beginning of the study (after students complete their initial drawings in the first activity) and leave it for the duration as a reference.

The activities will give you a good base to begin, but they are not meant to be a strict formula to follow. There are many sideroads upon which you can venture. Some will not be evident until you've already begun your journey. For example, you may find your study leads to an interest in other animals in the sea. We encourage you to be open to these interests as they evolve. It is not so important exactly what subject matter is "covered," but what mysteries are uncovered based on the genuine interests of your students. You will find many ways to adapt these ideas, and we encourage you to do so.

DIRECT EXPERIENCE

The more time and experience children have observing and studying live fishes, the better. For example, a trip to an aquarium at the beginning of your study will give children a jump-start. They will be fascinated by the variety of fishes and their many unique ***adaptations***. After studying fishes for a length of time, a repeat visit will be even more meaningful.

FOR CONTINUITY

The less time that passes between activities the better. Begin each activity with a review of previous topics studied and questions that will move the children towards the next topic of inquiry. Throughout the experience, revisit major ideas to reinforce learning, and document the process through photographs, videotapes, and transcriptions of student dialogues. Documentation done by the students in the form of writing, drawing, painting, or 3-D models is valuable.

LESS IS MORE

If feasible, the most effective way to conduct the activities is in small groups that remain consistent throughout the study. In a small group, children can more readily express opinions, hear and discuss varying points of view, and develop relationships within the group. Groups should be carefully chosen at the beginning, assuring the children are able to work together productively. For fun, have the students vote on a fish name for their group.

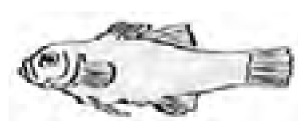
Introduction

To learn about fishes is to embark on a fantastic voyage. To observe fishes is to witness the drama of evolution in action. The name of the game is survival. Each species is superbly adapted to life in the water with unique ***adaptations*** for hunting or avoiding being eaten. Fishes are remarkable creatures represented by a vast range of ***habitat***, size, shape, and color.

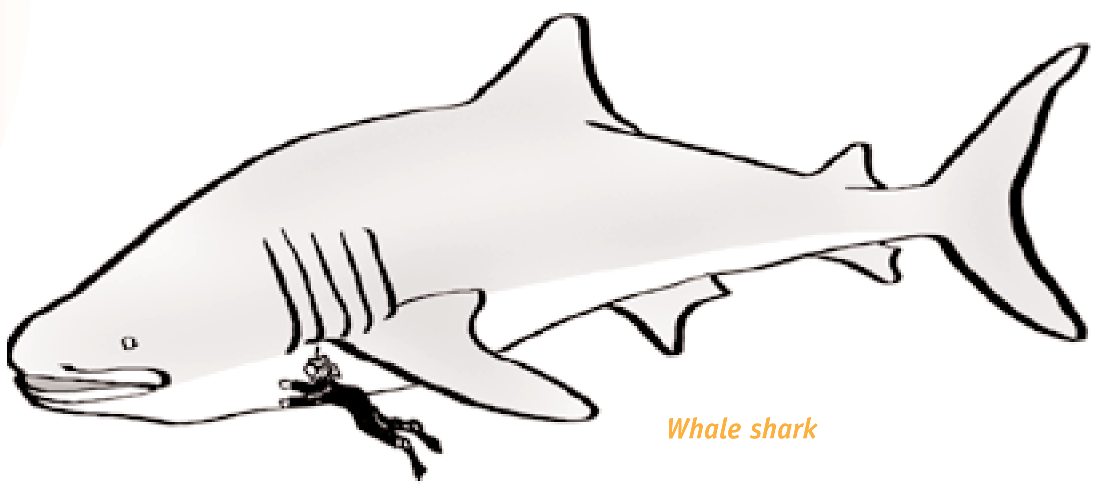
Fishes live in just about every body of water on Earth. They have made their homes everywhere, from seasonal puddles to the perpetually dark ocean ***abyss*** where the water pressure is so immense that humans cannot survive even a short visit. Some fishes even live inside other animals!

Whale sharks, the largest fish, compete in size with the world's most immense animals, while the smallest fish, the pygmy goby, would fit on your thumbnail and is the world's tiniest ***vertebrate***. Fishes vary in shape from something akin to a snake to what might appear to be a weed-infested rock. Still others are shaped like footballs, pancakes, or feather dusters. One of the most striking features of fishes is their vast and often vivid array of coloring. Some are dull, or even transparent, blending in with their surroundings, while others display sparkling silver, iridescent blues and greens, black-and-white polka dots, or brilliant reds.

But as with so many animals on Earth, this wealth of life is in jeopardy, mostly because of human action. And just as we have the power to destroy fish habitats and deplete fish populations, we also have the capacity to protect and save them. As the future generation, children are the most important players in this dilemma and those most affected by it. The first step is awareness and appreciation of fishes as fellow creatures of the Earth, each with a niche in the complex world of underwater life. That's why this book is so important, so dive right in and enjoy the wondrous world of fishes!



Pygmy goby



Whale shark

Theme I
Getting to Know Fishes

BACKGROUND

Studying fishes begins with establishing what makes a fish a fish. Often, the assumption is made that anything that swims or lives in the water is a fish. But many animals in the sea are not fishes. So what does it take to be a fish? To become familiar with fishes, students should know that:

Fishes breathe by using their gills to get oxygen out of the water. As a fish swims, it takes in water through its mouth. The water flows back over the gills, and oxygen is absorbed into the blood flowing close to the gill surface. In most fishes, gills are protected by a bony flap called an ***operculum***, or gill cover. Fishes also have nostril-like organs, called ***nares***, but they are used for smelling, not breathing.

Fishes have scales. Most fishes are covered with a layer of thin, but surprisingly tough, scales running from front to back and overlapping like shingles on a roof. These small, bony plates provide the fish protection without compromising flexibility. Most fishes also have a visible ***lateral line***, which runs along the length of each side of the body. This network of sensory cells enables fishes to detect even minor vibrations in the water.

Fishes have fins used for swimming. Fishes use their fins, especially their strong tails, to propel themselves forward in the water. Their fins also work together to help them steer or stop and to prevent them from rolling over on their sides. Most fishes have the following fins (see illustration on page 15):

- ***caudal:*** tail fin
- ***dorsal:*** the fin (or fins) on a fish's back
- ***anal:*** the single fin on the underside of a fish nearest the tail
- ***pelvic:*** the pair of fins on the underside of a fish in front of the anal fin
- ***pectoral:*** the pair of fins usually found on each side behind the operculum

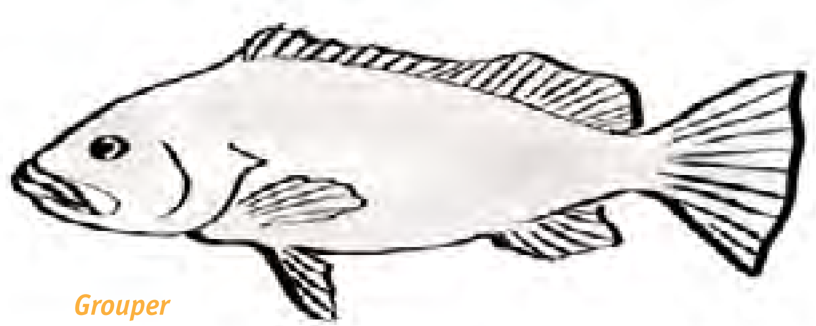
Fishes are cold-blooded. The bodies of cold-blooded animals take on the temperature of the environment in which they live. Fishes, therefore, are the same temperature as the water and don't need protection such as hair or fur to keep them warm.

Fishes are vertebrates. Like us, fishes have a backbone and an internal skeleton. Most fishes have a bony skeleton, while some, such as sharks, have a backbone made of cartilage.

Once children understand these fish basics, they will be ready to explore the many variations and exceptions to these rules. This includes the myriad amazing ***adaptations*** fishes have developed to fit every possible niche provided by the Earth's waters. We will explore these often unimaginable fish adaptations further in Theme III.

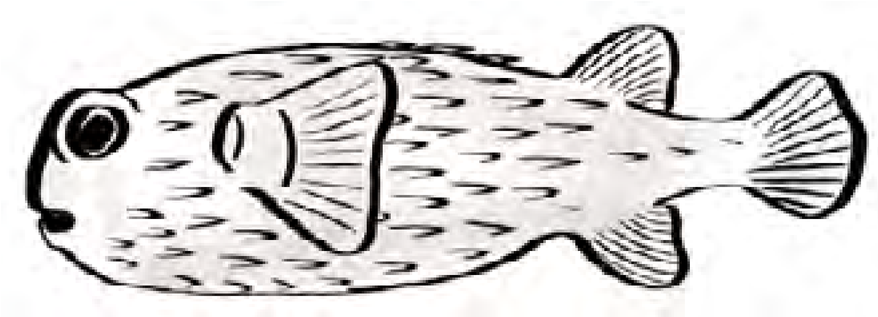
FISH HABITATS

Fishes are highly adaptable creatures. They have not only survived, but thrived, in waters all over the earth, both freshwater and saltwater, from the frigid Antarctic Ocean to hot desert pools, from the deep ocean ***abyss*** to shallow mountain streams. Fishes find their homes in underwater gardens of seaweed, in dark caves, along rocky cliffs and on sandy bottoms. One of the richest fish environments is the tropical reef, where colonies of coral provide the basis for food and shelter for thousands of species.



Grouper

HOW TO READ A FISH



Porcupinefish

As your class becomes more and more immersed in the study of fishes, generalizations and comparisons between species are inevitable. Throughout Theme I you will become familiar with not only the basics of fish anatomy and behavior but also some of the many specializations of fishes. The ability to "read" a fish is an important tool to learn and develop. To read a fish is to use its external anatomy to create theories about its diet, ***habitat***, methods of defense and so on. As you begin to make comparisons and see parallels, the awesome task of sorting through the thousands of species of fishes will become much more interesting and much less daunting. Following is a sampling of all that can be revealed just at a glance:

The shape and size of a fish and its fins can provide many clues as to where it lives and what it might eat. For example, fishes with long, tapered bodies and forked tails, such as barracudas (see poster), swim very fast through the open ocean preying on schools of smaller fishes. Groupers, on the other hand, are not streamlined. They tend to lurk in the shadows waiting for ***prey***. Their tail is fan-shaped, which indicates that they are slow swimmers but capable of making short, quick movements to lunge at nearby prey.

Fishes eat everything from miniscule plants and animals to insects and shellfish and, of course, other fishes. Some fishes even attack prey many times larger than themselves. Studying the size, shape and position of a fish's mouth can provide much information about how and what it eats. (See sidebar on page 19.)

Fish coloration is another physical feature that you can interpret to deduce information about fishes. For example, dull-colored fishes hide by blending into the environment. A mottled-brown fish probably lives on a pebbly sea bottom. Fishes with patterns such as stripes or dots are usually ***camouflaged*** to mimic the environment in which they live. As a defense, brightly colored fishes draw attention to themselves to warn of their poison or foul taste.

Other methods of defense and built-in weapons are often obvious. Most sharks have rows and rows of large, razor-sharp teeth. To escape ***predators***, gurnards have wings that enable them to take brief "flights" above the water surface. Lionfish (see poster) are covered with poison-tipped spines. The long snout of a sawfish is filled with many bladelike teeth. Not only can porcupinefish raise their prickly spines like a hedgehog, but they can inflate their bodies to become even more difficult for predators to swallow.

Something Fishy

There are lots of fishes in the sea, but not all that swims is a fish. Learn what it takes to be a fish and find out why animals such as octopi or dolphins don't fit the bill.

Theme I
Activity 1

FOR GRADES K-2, 3-5

OBJECTIVES

Students will:

- brainstorm about fishes as a preassessment
- make a fish print for comparison and analysis
- determine characteristics common to most fishes

GOALS AND STANDARDS

This activity meets:

- Illinois State Goals in Science: *Goals 1 and 4*
- National Science Education Standards:
  Unifying Concepts and Processes Standard
  K-4 Content Standards A and C
  5-8 Content Standards A and C

TIME

60 minutes

MATERIALS

For each student:

- sturdy white paper larger than the fish to be printed
- smock or paint shirt
- for children who write, a copy of the Fish Diagram on page 10

For each small group:

- whole, unscaled fish (Available at any supermarket. Preferably, provide each group a different species for comparison. Catfish will not work as well as they do not have scales.)
- newspaper or plastic to protect tables
- soap, water, and paper towels
- 3 or 4 colors of tempera paint
- small rollers or paint brushes
- paper or plastic plates larger than your roller

PROCEDURE

1. Begin your study of fishes by asking your students what they know about fishes. Ask such questions as: ***Where can fishes be found?***

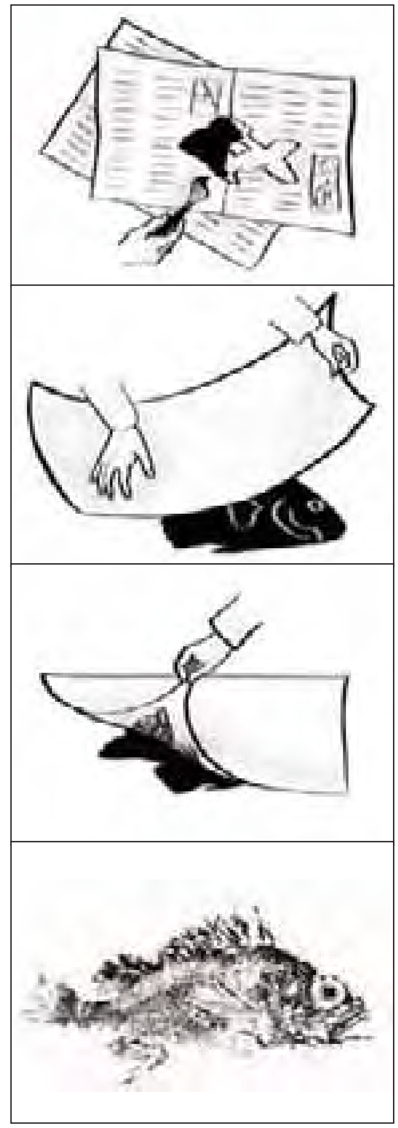
How do they move? How are they like/unlike us? What color are fishes? What do they eat? Ask them to draw a picture of their idea of a fish. This should be done from memory without models so that you can determine their preconceptions. Keep a record of their answers and drawings as a preassessment.

2. Arrange your students in small groups (see Guidelines for Teachers on page 4) and provide each with a fish. Place the fish on the newspaper or plastic and wash gently with soap and water to remove the mucus covering. Give students some time to share ideas with each other and touch the fish if they are willing. You might ask some of the same questions as listed in procedure 1 as well as: ***What do you think this fish eats? How fast does it swim? How does it breathe? With what is its body covered? How are its scales different from our skin?***

3. Distribute paper for each child and the paint (a small amount of each color on separate paper plates) and small rollers or paint brushes for each small group. Each student takes a turn making a print by rolling the roller in the paint or using the brush to apply his or her choice of colors to the fish. Fins might need to be stretched out or pinned down in order to get a good print. Before printing, students should be sure that the fish is fully covered with paint and that there is no paint on the surrounding surface.

4. Students then place the paper squarely on top of the fish, being careful not to move it once it has touched the paint. After pressing down on all parts of the fish to make sure every part is printed, the paper can be lifted by slowly pulling up one end and peeling back the sheet. The fish and surrounding surface will then need to be washed off or wiped clean before the next student applies paint.

5. After the paint has dried, hang the fish prints in the classroom (you may want to keep them up throughout your study for reference) and lead a discussion about how each type of fish is the same or different. Use the Background to discuss the parts of a fish and their basic function. Although it is not visible, include the backbone as an essential element of a fish.

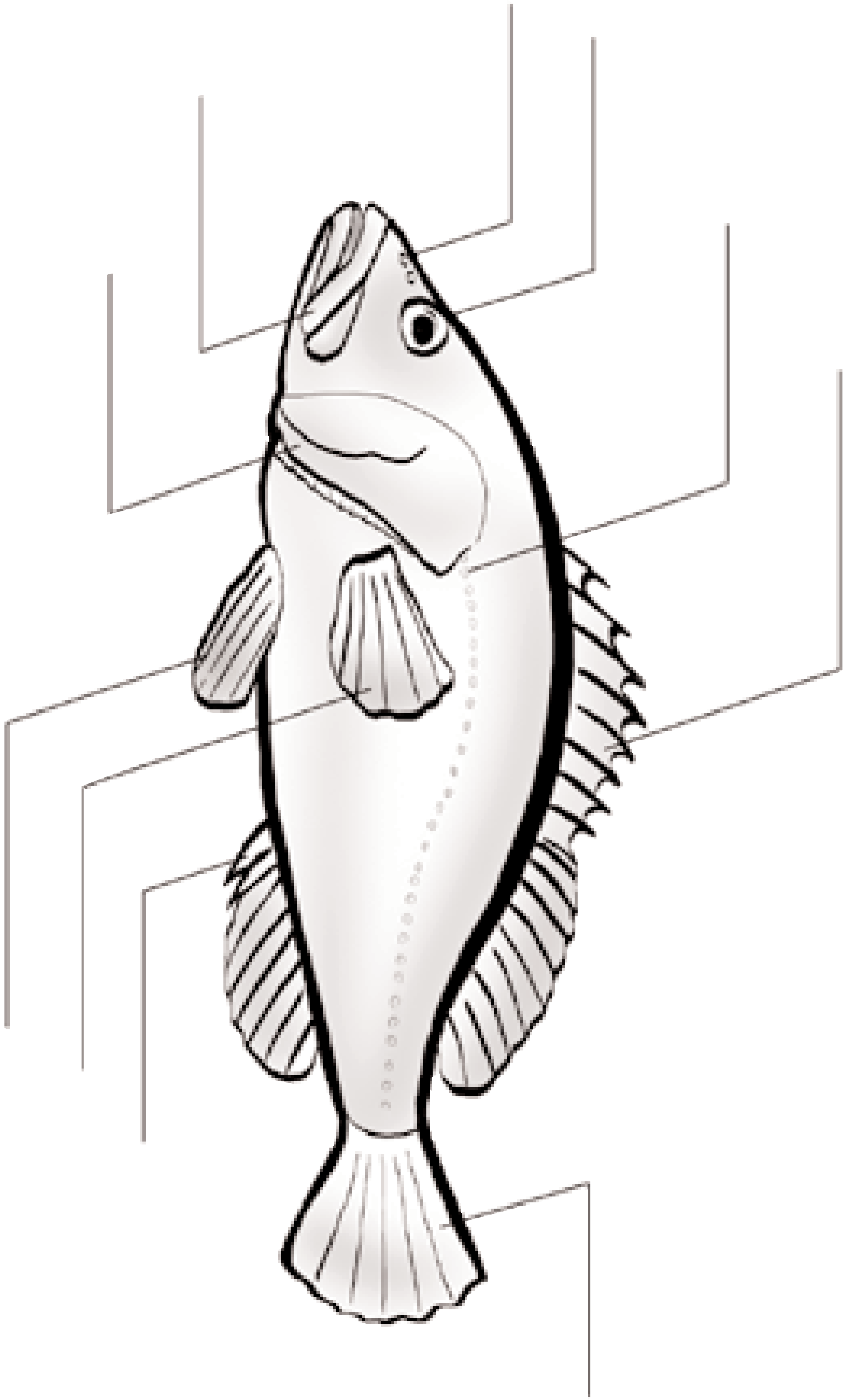


6. For children who write, copy the Fish Diagram on page 10. Or, since each group has a different fish, ask the children to do a line drawing of the fish they printed. Have them work together in their groups to label all the parts of the fish that you discussed. To review at a later time, you might also ask them to label their fish prints.

7. Through this initial activity and discussion, the children should come away with a preliminary understanding of the characteristics that make a fish a fish (see Background):

- Fishes breathe by using their gills to get oxygen out of the water.
- Fishes have scales.
- Fishes have fins used for swimming.
- Fishes are cold-blooded.
- Fishes are ***vertebrates***.

As you progress through your study of fishes, some of the exceptions to these rules will be addressed. You can also discuss why many animals in the ocean are not fish. For example, dolphins do not have scales, are warm-blooded and do not use gills to get oxygen from the water. Octopi do not have scales or fins and are ***invertebrates***, not vertebrates, as they have no skeleton.



Something Fishy

FOR GRADES 6-8

OBJECTIVES

Students will:

- brainstorm about fishes as a preassessment
- learn basic fish anatomy by dissecting a fish
- determine characteristics common to most fishes

GOALS AND STANDARDS

This activity meets:

- Illinois State Goals in Science: *Goals 1 and 4*
- National Science Education Standards:
  Unifying Concepts and Processes Standard
  5-8 Content Standards A and C

TIME

60 minutes

MATERIALS

For each student:

- a copy of Fish Dissection on pages 13 and 14

For each small group:

- a smelt fish (Ask for whole smelt at your local fish store or supermarket.)
- from your Science Lab: scissors, forceps, microscope (if unavailable, use magnifying glass)

PROCEDURE

1. Follow procedures 1 and 2 from previous activity on page 8. (If your students have very little experience with fishes, you might find it useful to complete Procedures 3 through 7 as a more complete introduction to fish anatomy.)

2. Provide each small group with a smelt and the supplies listed above for dissection. Give each student a copy of Fish Dissection on pages 13 and 14 to complete. Students should discuss the answers within their groups.

3. After students have completed their Fish Dissection sheets, discuss their answers as a class, using the key on page 15 as your guide. In particular, make note of the ways we are similar or dissimilar to fishes and the reasons for the differences.

EXTENSIONS

Use books and other resources to investigate why other animals in the ocean, such as coral, crabs, or sea jellies, are not considered fishes.

Research the difference between dolphins that are fish and dolphins that are mammals.

Try your hand at *gyotaku* (see sidebar), Japanese fish printing, using black permanent ink. In addition to paper, try other surfaces for printing such as t-shirts or fabric for making wall hangings.

ADDITIONAL RESOURCES

Bailey, Jill. *Fish: Encyclopedia of the Animal World.* New York: Facts on File, Inc., 1990.

Moyle, Peter B. *Fish: An Enthusiast's Guide.* Berkeley: University of California Press, 1993.

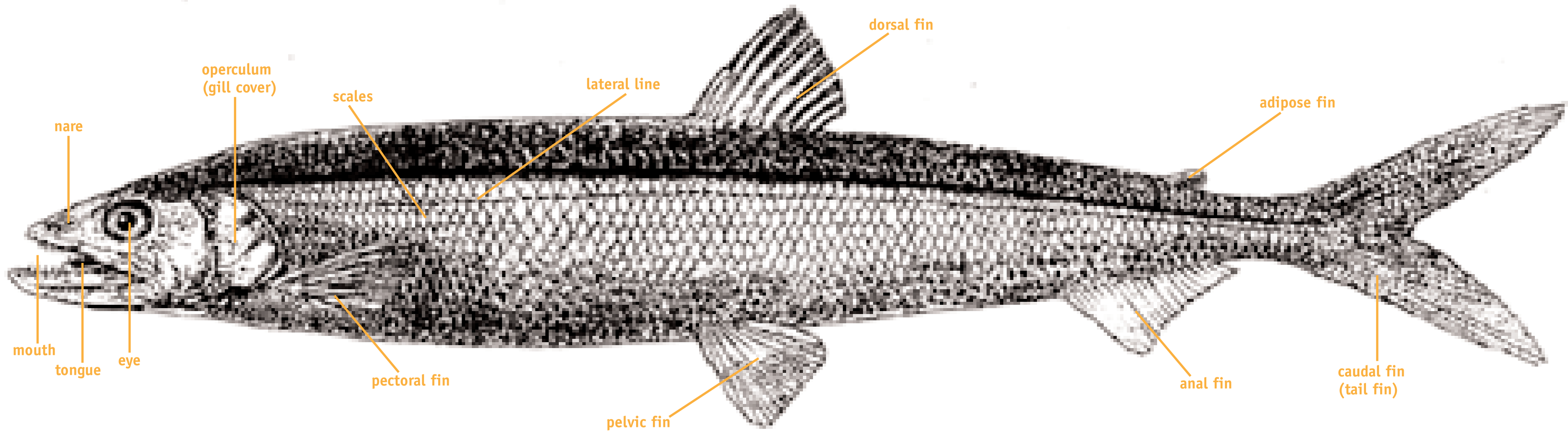
Parker, Steve. *Fish:* Eyewitness Books. New York: Alfred A. Knopf, 1990.

Stratton, Barbara R. *What Is a Fish?* A New England Aquarium Book. New York: Franklin Watts, 1991.

Gyotaku

Gyotaku ("gyo" for fish, "taku" for rubbing), or fish printing, is a Japanese art form that originated in the 1800's with fishers as a way to record their catches. The method is still used today to advertise fish being sold. Traditionally, gyotaku is done in black permanent ink only on cloth or paper.

Fish Dissection—External Parts



Fins

Count all of the fins on the fish. How many did you find? ________________

Can you figure out what each is for? ____________________________

Mouth

Open the mouth and touch the teeth with your finger.

What do they feel like? ____________________________________

Does the smelt have a tongue? ________________________________

Why do you think it does/doesn't? ______________________________

Gill

Find the operculum, or gill cover, on the smelt. Lift it up so you can see the pink gill filaments. What are the gills used for? ______________

Use your scissors to remove a single gill and look at it under the microscope. Notice the fine white strainers on the inside. These are the gill rakers. What do the gill rakers strain from the water?

____

In the box, make a drawing of the gill. Include the gill filaments, the gill arch (the bony structure that supports the filaments and rakers) and the gill rakers.

Eyes

Does the smelt have eyelids? __________________________________

(Hint: Who would win a staring contest, you or the smelt?)

Nares

Look closely for two small nostrils above the mouth. Are the smelt's nares used for breathing or smelling? ____________________________________

Lateral Line

Look for the dotted line that runs from the smelt's head to its tail. This sense tells the smelt what's happening around it by detecting vibrations. What would make a vibration in the water? ____________________________________

Scales

Scales are found all over the body except on the head and fins. Why do fish have scales?

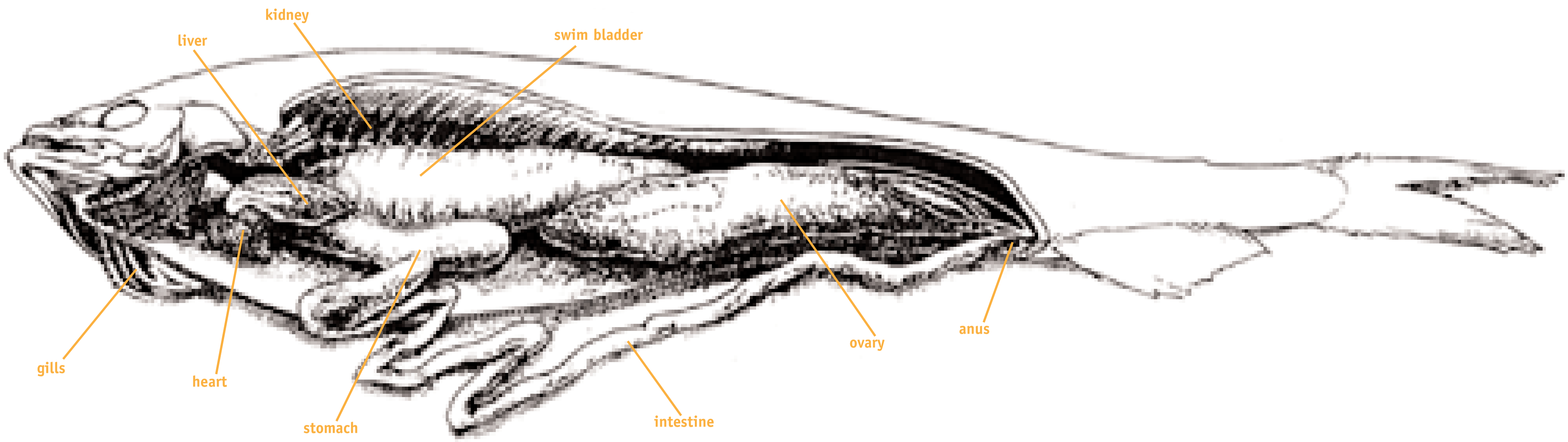
____

Using your forceps, remove some scales. Look at them under the microscope. Draw a fish scale in the box. What do you think the lines could tell you?

____

(Hint: Have you ever seen the inside of a tree trunk after it has been cut down?)

Fish Dissection—Internal Parts



Begin dissecting your smelt by making an incision from the anal opening along the underside of the fish to the lower jaw. Pull open the smelt to view the internal organs.

Reproductive System

Is your smelt a male or female? ____________________
(Hint: Does your smelt have eggs?)

Heart

Find the smelt's heart. Why is it red? ____________________

What is the function of the heart? ____________________

Liver

The liver is the pink-brown organ directly below the heart. What is the function of the liver? ____________________

Stomach and Intestines

Lift up the liver to find the stomach. It is shaped like a V or Y and leads right into the intestine. The smelt's intestines are straight (not coiled) because these fish are meat eaters. Other animals that eat plants, such as humans, have coiled intestines. This is because meat is easier to digest than plants.

What happens to food in the stomach and intestines? ____________________

____

Swim Bladder

Below the intestines is the swim bladder, which helps the fish to float. What does it look like? ____________________

What is inside of the swim bladder? You can burst it to find out. ____________________

____

Kidney

The kidney is the long, black line next to the backbone. Why does the smelt have a kidney? ____________________

____

Backbone

All fish have backbones. Why do you think they need them? ____________________

____

(Hint: Why do you have a backbone?)

FISH DISSECTION— ANSWER KEY

EXTERNAL PARTS

Fins

Smelt have eight fins. (The second pectoral and pelvic fins are not visible in the illustration.) Some fishes have more or less than eight.

Mouth

Unlike most fishes, smelt have a tongue with small teeth on it to allow them to grind food into smaller pieces to make it easier to swallow. (Most fish swallow ***prey*** whole.)

Gill

The ***gill filaments*** allow the fish to absorb oxygen from the water. ***Gill rakers*** are used to strain ***plankton*** from the water. The gill arch is a bony structure that supports the gills.

Eyes

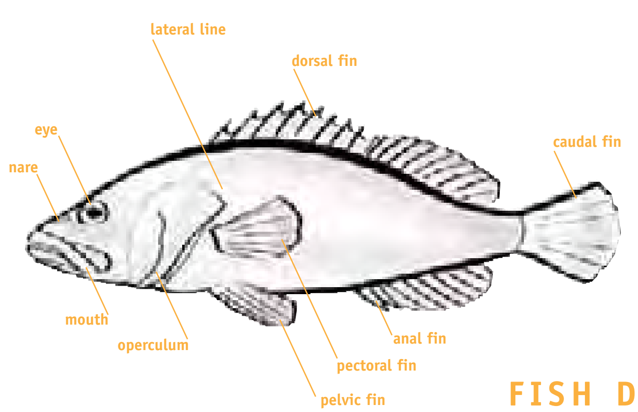
Fishes do not have eyelids. Because we don't live in water like fishes, we need eyelids to keep our eyes moistened and protected.

Nares

The smelt's ***nares*** are used for smelling, not breathing. Instead, fishes have gills for breathing.

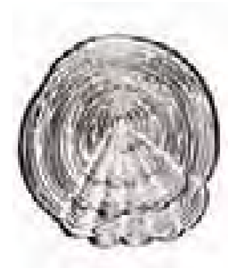
Lateral Line

Anything that moves causes a vibration in water. In other words, the ***lateral line*** is important in both finding prey and avoiding ***predators***. Because fishes can "sense" where other fishes are with their lateral lines, this system helps them move together in schools.



FISH DIAGRAM ANSWER KEY

Scales



Scales provide protection for fishes and act like flexible armor. They also make fishes more streamlined and slippery, and therefore more difficult to catch. Lines on fish scales show seasonal growth, enabling us to gauge the approximate age of a fish.

INTERNAL PARTS

Reproductive System

It is easy to determine the sex of smelt: most females are filled with eggs inside.

Heart

The heart is red because it is filled with blood. As in humans, the heart pumps blood throughout the body. It first moves through the gills where it picks up oxygen and releases carbon dioxide and then continues through the body before returning to the heart.

Liver

The liver cleans and processes the blood and stores vitamins, nutrients, and other food products.

Stomach and Intestines

Food moves from the stomach through the intestines to be digested before it is eliminated from the body.

Swim Bladder

The ***swim bladder***, which looks like a small balloon, is filled with air to help the fish remain buoyant in the water. (See Theme II, Activity 2 for more information about the swim bladder.)

Kidney

The kidney cleans waste particles from the body and excretes them as urine.

Backbone

Fishes need a backbone to support their bodies and help them move through the water.

Read a Fish

Did you know that you can "read" a fish without even using the alphabet? You can learn a lot about a fish just by looking at it.

Theme I

Activity 2

FOR GRADES K-2

OBJECTIVES

Students will:

- interpret how features of fishes can reveal information about them
- begin to develop a sense of the diversity of fishes
- learn to record their findings by starting a Fish Journal

GOALS AND STANDARDS

This activity meets:

- Illinois State Goals in Science: *Goals 1 and 4*
- National Science Education Standards:
  Unifying Concepts and Processes Standard
  K-4 Content Standards A and C

TIME

45-60 minutes

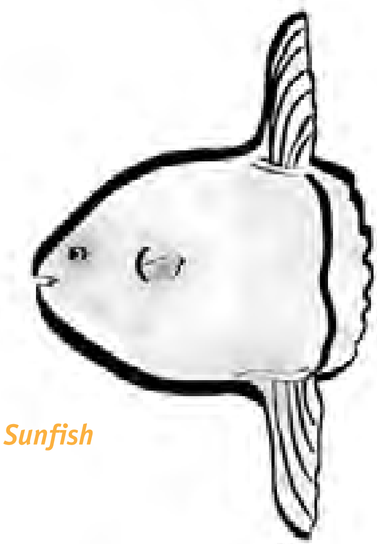
MATERIALS

For each small group:

- two fishes to "read" (Use photos from included poster or from books, or provide live fishes to study.)
- paper and drawing materials
- folder or large paper to make a journal cover

PROCEDURE

1. Now that your students have an idea of the commonalities among fishes, this activity will encourage them to discover some of the amazing ways in which they differ. Arrange the children in their small groups and provide each with two fishes to "read." To illustrate the idea that "a fish is still a fish" despite variances in shape, size, color, number of fins, etc., the two fishes should be quite different from each other. Use the poster provided as the basis of this study but provide supplemental materials such as color photos from books, magazines, or other posters. (The better the quality of the image, the more the children will be able to learn from it. For example, small black-and-white drawings will be much less helpful than large color close-up photos.)



Sunfish

2. Provide time for open-ended discussion in the small groups, encouraging children to ask each other questions about their fishes. Get them started with general questions such as, ***What can you learn about your fish just by looking at it?*** Then ask them to address specific questions that they may or may not have covered. (You may choose to write the questions on the board, create a handout, or simply ask them verbally.)
   - ***Why do you think your fish is colored the way it is? Does it want to hide, or does it want to be seen. Why?***
   - ***Look at its shape and coloring and think about where it might live. (On the bottom? In a cave? In seaweed? In a coral reef? In the deep?)***
   - ***Does the fish swim fast or slow? Look at its size and shape for clues.***
   - ***Look at the shape and size of its mouth. What do you think it eats?***
   - ***Does the fish have any weapons or defensive devices that you can see?***

3. After your students have finished their small group inquiries, lead a discussion with the entire class, allowing each group to talk about their fishes and encouraging comparisons with the fishes other groups were studying. Don't expect accurate answers to all the questions because your students' experience with the topic is limited. Rather, the goal at this point is to encourage

Angelfish

Read a Fish

Theme I
Activity 2

3-5 6-8

FOR GRADES 3-5, 6-8

OBJECTIVES

Students will:

- interpret how features of fishes can reveal information about them
- begin to develop a sense of the diversity of fishes
- learn to record their findings by starting a Fish Journal

GOALS AND STANDARDS

This activity meets:

- Illinois State Goals in Science: *Goals 1 and 4*
- National Science Education Standards:
  Unifying Concepts and Processes Standard
  K-4 Content Standards A and C
  5-8 Content Standards A and C

TIME

60-90 minutes
(can be divided into several shorter time segments)

MATERIALS

For each student:

- a fish to "read" (Use photos from included poster or from books, or provide live fishes to study.)
- paper and drawing materials
- folder or large paper to make a journal cover
- copy of the Fish Journal Entry on page 20

PROCEDURE

1. Follow procedures 1 and 2 from the previous activity on page 16, but give each child a fish to "read" rather than providing only two for each group.
2. Follow procedure 3, also introducing the concepts of ***adaptation***, ***habitat***, ***predator*** and ***prey***, using the Background to guide you.
3. Now that the children have made guesses about the questions, assign them to research the answers more formally. This initial research can provide the basis of a Fish Journal, which each student should keep throughout his or her study of fishes. As the students learn about each type of fish, they should add to the journal, using the same

format so that in the end they have their own "encyclopedia of fishes" as a reference. You may duplicate the Fish Journal Entry sheet provided on page 20, or simplify or embellish to create your own. To assist the students, offer whatever resources are available to you, i.e., school library, public library, encyclopedias, Internet, etc. You also will want the children to design their own folders or covers for the journals so that their pages are not misplaced. This can be done as a separate activity as time requires.

4. Now that the children know the facts about their fishes, provoke their thinking by asking them to present those facts to the class in a creative way. Time may dictate whether this can be done for each child's fish. If not, let the children decide on one or two of the fishes in their group and work together to choose a format to present to the class. For example, they might decide on a talk-show format: "I hear you live in a small hole on the reef. Isn't that claustrophobic?" Or they might decide to draw a comic book, making their fish the superhero. Or they could make simple costumes and role-play the way their fish might behave. Ideally, two or more types of fishes are illustrated in each of these presentations.

EXTENSIONS

Conduct this activity at an aquarium or a fish pet shop with good variety so that live fish can be used and children are able to witness movement and behavior.

Make an inventory of all the information it is not possible to learn or be sure about when simply looking at a fish. What other methods of study could be used?

ADDITIONAL RESOURCES

The Audubon Society Field Guide to North American Fishes, Whales, and Dolphins. New York: Alfred A. Knopf, 1983.

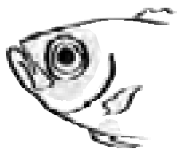
Paxton, Dr. John R., and Dr. William N. Eschmeyer, editors. *Encyclopedia of Fishes.* San Diego: Academic Press, Inc., 1995.

Thorne-Miller, Boyce. *Ocean: Photographs From the World's Greatest Underwater Photographers.* San Francisco: Collins Publishers, 1993.

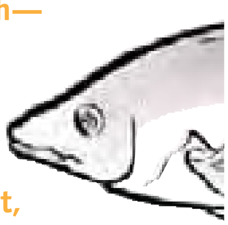
That's Quite a Mouthful!

By looking at the size, shape and placement of a fish's mouth, you can get a good idea of what it eats and where it gets its food. Here are some examples:

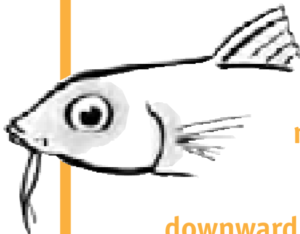
Seahorse—This seahorse has a very small, strawlike mouth for sucking plankton out of the water.



Glasseye snapper—This snapper, which lives in caves, has a mouth that is pointed upward for finding food.



Spanish hogfish—Here's a fish with its mouth directly in front, which is where it finds its food.



Goatfish—Goatfish have mouths pointing downward, enabling them to find their food along the bottom.

FISH JOURNAL ENTRY

Drawing of fish (make the features and coloring as accurate as possible):

Name of fish:

Size:

Special adaptations:

Habitat:

Prey:

Predator:

Build A Fish

Now that you know some of the amazing adaptations of real fishes, it's time to invent your own!

FOR GRADES K-2, 3-5, 6-8

OBJECTIVES

Students will:

- explore some of the many types of ***adaptations*** and the reasons fishes have developed them
- be challenged to invent fishes with adaptations to survive within specific parameters

GOALS AND STANDARDS

This activity meets:

- Illinois State Goals in Science: *Goals 1 and 4*
- National Science Education Standards:
  Unifying Concepts and Processes Standard
  K-4 Content Standards A and C
  5-8 Content Standards A and C

TIME

45-60 minutes

MATERIALS

For each student:

- paper and pencil
- copy of the Fish Journal Entry on page 20

PROCEDURE

1. Your students probably were surprised to learn from Activity 2 how varied fishes are. This activity encourages them to imagine and think about how and why so many different adaptations developed. Begin by discussing and reviewing the idea of adaptation. Make comparisons to adaptations that humans have made, such as walking upright and using our hands to write. (The topic of adaptation will be addressed more thoroughly in Theme III.)

2. To get into the mode of imagining how fishes develop adaptations such as mouth type or body shape, give your students scenarios to challenge their creativity. First, arrange the children in their small groups and assign each to invent adaptations to help a fish survive within certain parameters. For this activity, encourage the children to be creative and not be concerned about whether or not the adaptations exist or are even possible.

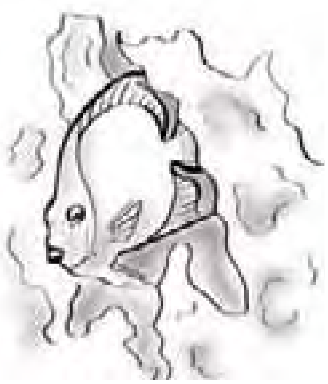
You may choose to use these examples, or devise your own with input from the students. Provide each small group with a different challenge or give some groups the same in order to compare their solutions.

Some possibilities:

- ***What kind of adaptation might your fish have if its food was found only underground?***
- ***What kind of defense might a small fish develop if it was hunted by larger, stronger fishes?***
- ***What if your fish lived in the abyss, in total darkness? What kind of specializations could help a fish find food?***
- ***If your fish were brightly colored, how would it avoid being eaten?***

3. Each group should report back to the class, telling what its challenge was and explaining the solution. As part of this discussion, provide examples of real fishes that have developed adaptations that address these very

Angelfish

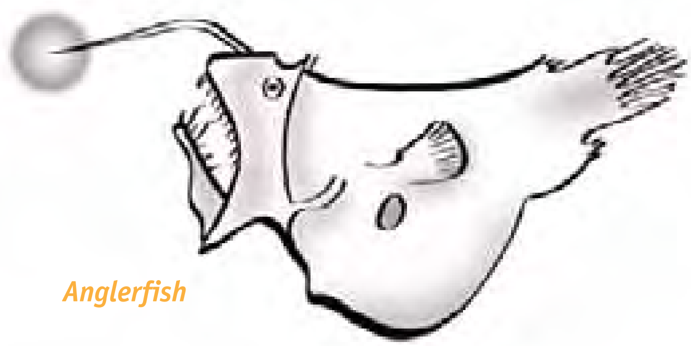


conditions. (For more information, see Background for Theme III on page 39.)

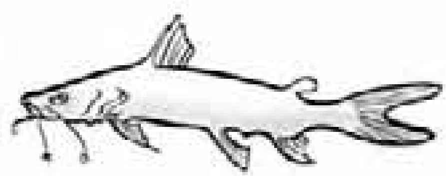
For example:

- ***Catfish*** probe and dig for small crustaceans in the ocean floor using sensitive chin ***barbels***.
- One technique small fishes use for protection is ***camouflage***. ***Frogfishes*** are colored to match the sponges in which they live and are very difficult to spot (see poster).
- In order to find food in the ***abyss***, the ***anglerfish*** can produce its own light.
- Many brightly colored reef fishes, such as the ***angelfish***, are designed to be able to dart quickly into crevices in the reef to avoid ***predators***.

4. To stretch their thinking about possibilities for adaptations even further, tell the class that each group is going to "build" or "design" a fish with adaptations that will enable it to survive within certain parameters. They'll provide random



Anglerfish



Catfish

answers for the following questions for each other to use as the basis for inventing their new fish species. (For younger children, you will need to provide the answers.)

Give each group three small pieces of paper that are all the same size but a different color, for example, blue, yellow, and red. Each group will write an answer for one of the following three questions on the papers:

- On the blue paper: ***What does the fish eat?***
- On the yellow paper: ***Where does it live?***
- On the red paper: ***What are its predators?***

Encourage the students to use their creativity and not be concerned about reality. Emphasize that these are fantasy fishes. For example, a fish might eat apples off trees or might have monsters as predators. It is not important to be entirely realistic but to focus on how evolution can occur and adaptations develop based on opportunities.

5. Fold the answer sheets and place them in three separate piles based on color. Have a representative from each group pick one answer from each pile. The group is then left with the challenge:

   "We have to design a fish that eats ____, lives ____ and is hunted by ____. "

   After the groups have time for discussion, ask each to share their invented fishes with the class.

6. To culminate the activity, have the students make a journal entry with a drawing and explanation of the adaptations they designed for their invented fishes.

EXTENSIONS

Provide resources for children to research real fishes that have developed adaptations in order to survive similar challenges to those presented in the activity.

Pair up students to write a story with illustrations about their two invented fishes meeting in the ocean.

Ask the students to make a drawing of the internal anatomy of their invented fish. How is it the same or different from the dissected smelt?

ADDITIONAL RESOURCES

The Audubon Society Field Guide to North American Fishes, Whales, and Dolphins. New York: Alfred A. Knopf, 1983.

Ganeri, Anita. *Creatures That Glow: Discover the Way that Nature Lights Up the Dark.* New York: Harry N. Abrams, Inc., 1995.

Paxton, Dr. John R., and Dr. William N. Eschmeyer, editors. *Encyclopedia of Fishes.* San Diego: Academic Press, Inc., 1995.

Pfeffer, Wendy. *What's It Like to Be a Fish?* New York: HarperCollins Publishers, 1996.

Eyes in the Back of Its Head?

Flatfishes are so named because they live flat on their sides on the ocean floor. Amazingly, a flatfish is born looking like most other fishes, but in a few weeks it goes through dramatic changes. Its body becomes very thin and flat, and one of its eyes slowly moves across the top of the head until it is on the opposite side of the body. With both eyes on one side, the fish is now blind on the other side. The flatfish lies on its blind side on the ocean bottom for the rest of its life.

Theme II
The Rise of Fishes—Evolution In Action

BACKGROUND

All life began in the sea. As difficult as it is to imagine, the origin of all animals can be traced back to the simplest forms found in the oceans 600 million years ago, when animal life was evolving

Sea squirt larvae

Sea squirt

along two different paths. On one path were the ***invertebrates*** and on the other the chordates, ropelike creatures that evolved into the fishes and eventually the other ***vertebrates***. As the first true vertebrates, fishes played a crucial role in the evolution of all the other vertebrates—amphibians, reptiles, birds, mammals, and eventually even us!

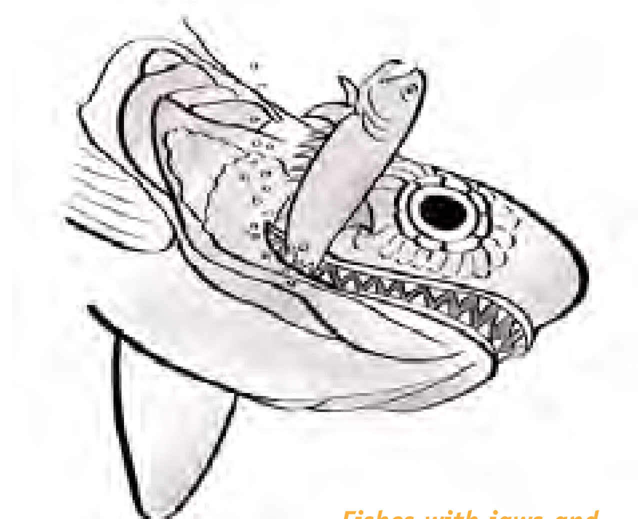
Because they lack direct evidence, scientists can only theorize how these extremely simple, primitive animals evolved into fishes. One theory suggests that the ***sea squirt***, still found in the oceans today, may be responsible. Its name is derived from its feeding technique. Water is sucked in through an opening at the top, passed through a grid where food particles are filtered out and squirted out the side. As adults, these creatures live attached to the sea floor, but ***sea squirt larvae*** are active, free-swimming forms that look like a tadpole with well-developed notochords in their tails. It is possibly this notochord, a flexible, supporting rodlike structure, that evolved into the backbone of the first fishes. Some scientists believe that the earliest fishes may have been a result of sea

Armored and jawless

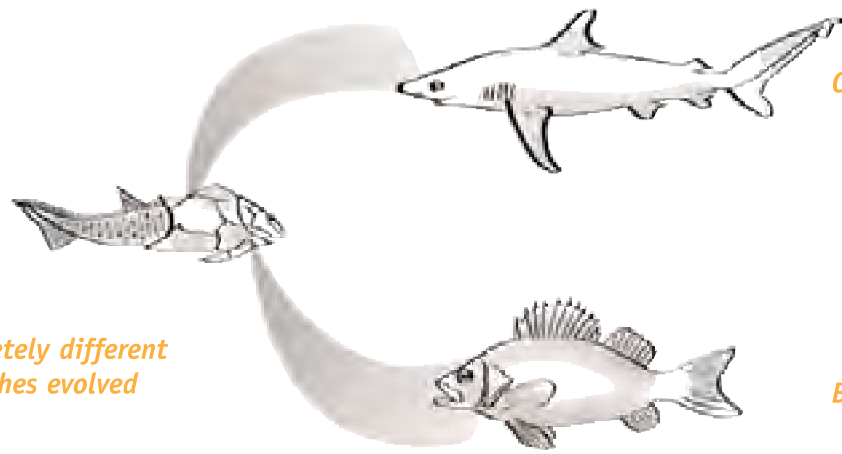
squirt larvae that continued to swim and grow rather than become sedentary adults.

Between 500 and 400 million years ago the first vertebrates suddenly appeared in the fossil record in the form of small creatures armored with a bony structure covering their heads and fronts of their bodies. But how the armor plating came to be is still a mystery. Most likely it developed as defense against larger predators. Although these creatures thrived for 60 million years before becoming mostly extinct, they lacked one important feature of their modern counterparts—they were jawless. Their mouth was circular and immobile. This meant that they could not grasp ***prey***, take bites, or chew. They could only suck in water and filter out food particles.

More than 400 million years ago, ***fishes with jaws and teeth emerged***, making for dramatic changes in eating methods. Rather than simply being able to obtain food by sucking, they could now attack their prey and tear it into pieces before swallowing it. Their new movable mouths allowed



Fishes with jaws and teeth emerged



them to become aggressive hunters, and as such they began to take over the Earth's waters.

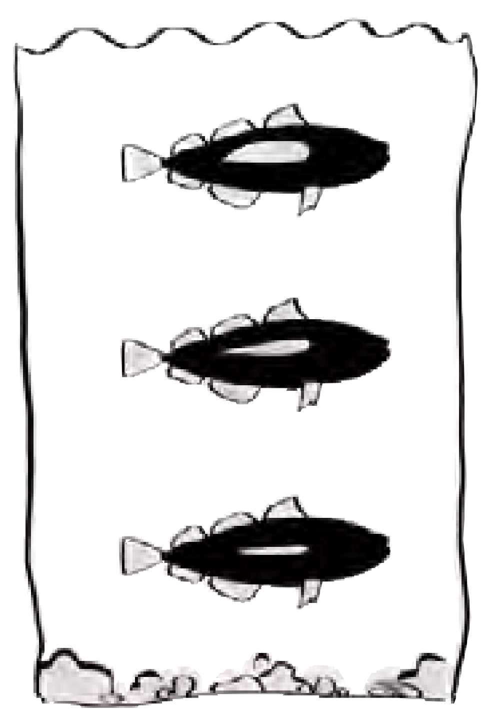
These first fishes with jaws were heavily armored to protect a somewhat frail skeleton. But eventually, ***two new, completely different lines of fishes*** with stronger skeletons evolved—***the cartilaginous and bony fishes***. Cartilaginous fishes, which include the sharks and rays, have a skull and backbone made of cartilage (like that in our noses) that is strong and flexible. Bony fishes developed skulls and skeletons made of bone tissue. Each had advantages and disadvantages, and both types of fishes survive today.

From this point forward, fishes, and bony fishes in particular, began to evolve along many different paths in response to the environment. For example, during the Devonian period, when the Earth's fresh waters were very warm and therefore low in oxygen, fishes adopted the ability to breathe oxygen in the air. (See sidebar about lungfish on page 32.) This group, called the chondrosts, largely died out and were replaced by the more modern and efficient holosts during the Jurassic period. The holosts, in turn, thrived for millions of years before eventually being replaced by the teleosts, the modern bony fishes that dominate the Earth's waters today.

The vast majority of the fishes alive today are teleosts, which have been evolving for about the last 200 million years. With their ever more efficient bony structures and anatomy, they diversified in innumerable ways to spread throughout all the seas and fresh waters of the Earth. The second largest group are the cartilaginous fishes. Although most representatives of other groups have become extinct, many have one or several species alive today. For example, of the many jawless fishes that once existed, two types, the lampreys and the hagfishes, still survive.

NEUTRAL BUOYANCY

One of the key advances that allowed fishes to exploit new environments has been their ability to achieve weightlessness in water. As fishes advanced through the millennia, most developed a special organ called a ***swim bladder***, a large air-filled organ



in their body cavity, that eliminates their weight in water. To maintain buoyancy, air is taken from the bloodstream and added to the swim bladder to ascend to shallow water or removed to descend into deeper water. Neutrally buoyant fishes can hover in the water and swim with much less energy. Humans can imitate this behavior with scuba equipment, which allows us to regulate air in tanks on our backs in order to ascend or descend.

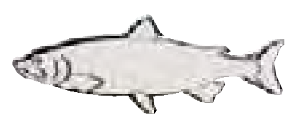
Unlike most bony fishes, sharks lack swim bladders. To keep from sinking, sharks must continue to swim forward in a slightly upward direction. If they stop swimming, they will slowly sink to the bottom. For some sharks and other fishes this is desirable because they live and feed along the bottom of the sea.

CLASSIFICATION OF FISHES

One of the continuing challenges for scientists is the question of how to organize the thousands of different types of fishes. The fact that there is disagreement as to the total number of fish species, with estimates ranging from 20,000 to more than 30,000, is an indication of the complexity of this problem. In general, fishes, like all plants and animals, are organized according to the rules of ***taxonomy*** first developed by Swedish naturalist, Carolus Linnaeus (1707-1778). He assigned each species a two-part name. The second part identifies the species and the first part indicates which species are its closest relatives.

Today's system of classification categorizes each type of plant or animal into seven groupings from most general to most specific: kingdom, phylum, class, order, family, genus, species. It is designed to show relationships among species and is organized according to genetic similarity, which indicates how the animal evolved. Each grouping is a collective unit containing those lower in the hierarchy so that a genus is a group of closely related species, a family is a group of related genera and so on.

Compare humans with these other species:



	Human	*Pacific white-sided dolphin*	*Sockeye salmon*	*Giant Pacific octopus*
Kingdom	***Animalia***	***Animalia***	***Animalia***	***Animalia***
Phylum	***Vertebrata***	***Vertebrata***	***Vertebrata***	Mollusca
Class	***Mammalia***	***Mammalia***	Osteichthyes	Cephalopoda
Order	***Primates***	Cetacea	Salmoniformes	Octopoda
Family	***Hominidae***	Delphinidae	Salmonidae	Octopodiae
Genus	***Homo***	Lagenorhynchus	Oncorhynchus	Octopus
Species	***sapiens***	obliquidens	nerka	dofleini

500 Million Years Old and Still Going Strong

If it weren't for fishes, there wouldn't be alligators, birds, dogs, or even humans! Find out the critical role fishes play in the evolution of other animals.

Theme II Activity 1

FOR GRADES K-2, 3-5, 6-8

OBJECTIVES

Students will:

- comprehend the importance of fishes as the first ***vertebrates***
- gain an understanding of the evolution of fishes in relation to other species
- represent the passage of evolutionary time on a time line

GOALS AND STANDARDS

This activity meets:

- Illinois State Goals in Science: *Goals 1 and 4*
- National Science Education Standards:
  Unifying Concepts and Processes Standard
  K-4 Content Standards A and C
  5-8 Content Standards A and C

TIME

45-60 minutes

MATERIALS

For each student:

- pencil and marker
- ruler and measuring tape

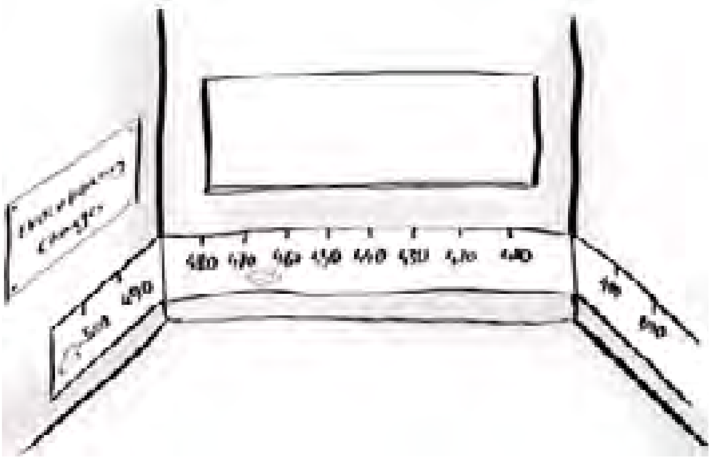
For the class:

- paper strip for time line (Length and width will vary according to your space.)

PROCEDURE

1. Determine the width and length of your time line. You will need to represent 500 million years, so choose the largest scale possible within the limitations of your wall space. Because the children will be drawing on the time line, the wider the paper, the better.
2. To begin, provide some background on the idea of evolution and tell the children you will be making a time line to take a look at how and when fishes and other animals came to be on Earth. For older children who are familiar with evolution you might begin with a discussion

K-2 3-5 6-8



addressing such questions as: ***Where might fishes have come from? Which do you think came first—fishes, dinosaurs, or humans? What causes new types of animals to evolve? Why do some animals become extinct? How can we learn about evolution?***

3. Inform the children of the unit of measurement you have chosen to mark off each million years (i.e., one inch or one centimeter) for a total of 500 million years. Have them work in small groups on the time line, marking each line representing one million years in pencil. After you've checked their work, ask them to go over the pencil lines and add the written numbers (every 10 million years) in marker. If you are using separate strips of paper, you may want to lay out each of the pieces in the correct order and tape together before adding the marker lines and numbers.

4. Use the Background to guide your discussion of evolution as it relates to the time line. Begin with the earliest creatures and move forward towards present time. (See the table below.) As you discuss each evolutionary change, ask the students to draw a sample animal in the corresponding space on the time line. Provide resources with images of the animals or ask the children to research them on their own. As you discuss each animal group, point out its significance. For example, in comparing jawless fishes and fishes with jaws, ask the children to imagine that they were jawless, unable to chew and could only suck food. ***How might that limit their diet? How well could they compete with a creature with jaws?***

5. Simplify the time line as necessary for younger children. For older children, you might like to include the geological time periods during which these changes took place. Refer to one of the resources listed below for more information. You might also like to assign the children to create a small version of the time line to include in their fish journals.

6. Conclude with a discussion emphasizing the importance of fishes as the first vertebrates. Explain: ***Without fishes, there would probably not have been any of the other vertebrates that evolved later—including us! This does not mean that we evolved directly from fishes. There were many permutations and millions of years of changes before that could happen.***

7. Hang the time line in the designated location. Use it throughout the year as a point of reference for your study of other animals.

Millions of years ago	Evolutionary changes	Millions of years ago	Evolutionary changes
500	**Sea squirt**	**250**	**Dinosaurs** **Mammals**
450	**First fishes—jawless**	**200**	**Birds** **Modern fishes—teleosts**
400	**Fishes with jaws** **Sharks** **Bony fishes**	**65**	**Dinosaurs become extinct**
350	**Earliest insects** **First land vertebrates—amphibians** **Reptiles appear**	**5**	**Appearance of humans**

EXTENSIONS

Explore these evolutionary developments in relation to the geological time period in which they evolved. For example, in the Triassic period, when dinosaurs first appeared, what other animals were developing? What kind of competition existed? What was the general climactic situation?

Expand your picture of evolution by asking students to trace the evolution of other animals and then add them to the time line. For example, students could find out the origins of animals they are familiar with such as a bumblebee, chameleon, or horse, or look at those with a long history, such as the cockroach or rat.

ADDITIONAL RESOURCES

Long, John A. *The Rise of Fishes: 500 Million Years of Evolution*. Baltimore, Md.: The Johns Hopkins University Press, 1995.

Parker, Steve. *Fish:* Eyewitness Books. New York: Alfred A. Knopf, 1990.

Wexo, John Bonnett. Prehistoric Zoobooks: *Swimmers*. San Diego: Wildlife Education, Ltd., 1989.

Story of the Coelacanth

The coelacanth is a primitive fish from almost 400 million years ago that was believed to have gone extinct 65 million years ago along with the dinosaurs. But in 1938, a remarkable discovery was made. A specimen of this living fossil was discovered and identified off the coast of Africa. Though scientists were startled by this, local people had been catching them for years, using their rough scales to repair bicycle inner tubes.

Coelacanths belong to the group of fishes closet to the earliest land animals, the amphibians. Notice the similarities between
l fins and the
nd animals.
ke other
fishes,
coelacanths
can also
operate each
ed pectoral
c fin
ntly in the
ner as a
land animal.

Sink or Float

Theme II Activity 2

How do fishes keep from sinking to the bottom or floating on top of the water? Learn how they control the air in their bodies to help them move up and down.

FOR GRADES K-2, 3-5, 6-8

OBJECTIVES

Students will:

- explore how fishes regulate the air in their bodies to move up and down in water
- recognize the importance of the ***swim bladder*** in fish evolution

GOALS AND STANDARDS

This activity meets:

- Illinois State Goals in Science: *Goals 1 and 4*
- National Science Education Standards:
  Unifying Concepts and Processes Standard
  K-4 Content Standards A and C
  5-8 Content Standards A and C

TIME

30 minutes

MATERIALS

For each student:

- baby food jar

For each small group:

- clear container of water as deep and as long as possible, such as an aquarium tank
- food coloring
- two plastic bowls

PROCEDURE

1. Begin the activity with a discussion of how fishes move, focusing on direction such as forward, backward, up, and down. Start by asking the class: ***Why would fishes want to move up or down? Why do they want to live on the top of the water or bottom or in-between?*** Ask the students to think about their own experiences swimming in a pool. ***Could they swim up and down?*** They may have found it difficult to swim downward. This is mostly because our bodies have lots of air inside that automatically makes us buoyant. They may also have noticed the increase of pressure, especially in their ears, in deep water.

2. Use the Background to explain ***neutral buoyancy*** in a way appropriate for your students' age group. You may want to draw a model of how the swim bladder works on the board. (See illustration on page 25.) You might also find it helpful to make an analogy between a swim bladder and a balloon. Both are inflated and deflated, although air inside a swim bladder is controlled automatically. (Those students who participated in the dissection activity will remember seeing the swim bladder inside the smelt.)

3. Arrange the children in small groups. Provide each group with a deep tub of water and each child with a baby food jar and food coloring. Ask the students to imagine that the jar is a fish. Explain that you will be doing an experiment to help learn how a fish moves up and down in the water and how it can hover or stay in the same place. Based on the discussion, they should understand that air is the key factor.

4. Challenge your students to make their "fish" hover in the water and not sink to the bottom or float to the surface. Ask them to make predictions in advance as to how they will accomplish this. Some questions to consider: ***What will their jar do with only air inside and no water? Will it sink or float? What if it is completely filled with water? How much air or water do they need to make it stay in the middle?***

5. Allow time for students to test their theories by trying varying amounts of water in their jars while comparing results with others in their group. Each child should color the water in their jar with a different color of food coloring to distinguish from the others. Fill one of the plastic bowls with water for children to use as their supply for adding water. The other bowl can be used to dump excess water that has already been colored.

6. Conclude by sharing results with the class and discussing how this experiment relates to the way a fish's swim bladder functions. Make note of the subtleties, in other words, how very small differences in the amount of air in the jar can cause it to ascend or descend. Consider what benefits fishes derive from being neutrally buoyant. For example, it requires much less energy to move around, gravity is automatically overcome, and it allows access to food sources that might otherwise be unavailable.

EXTENSIONS

Have the children measure the volume of water (in millimeters) in their "hovering fishes" as compared to the volume of air. What percentage of water to air is necessary to make the bottle hover?

Take a look at other animals who move up and down in the ocean, such as whales that dive to great depths for food, or squid, which live in the deep and come to the surface for food. How are these animals able to move up and down?

Explore how scuba divers use weight belts and air tanks to move vertically underwater.

Compare human bodies to fish bodies. Can we swim as well as fishes? Do we need to? Compare average fat percentages and the amount of air in humans and fishes to begin to understand why we are less suited to the water.

Ask the children to research the question of why dead fish float on the surface rather than sink.

ADDITIONAL RESOURCES

Paxton, Dr. John R., and Dr. William N. Eschmeyer, editors. *Encyclopedia of Fishes.* San Diego: Academic Press, Inc., 1995.

Smith, C. Lavett. *Fish Watching: An Outdoor Guide to Freshwater Fishes.* Ithaca, NY: Cornell University Press, 1994.

The Amazing Lungfish

The swim bladder of primitive lungfishes has developed into a lung that enables them to breathe out of water. One species lives in African rivers and swamps. In the water it breathes with its gills, but in the dry season, it can burrow into the mud and surround itself in mucus to create a waterproof membrane. Every hour or so, the lungfish draws a breath from an airshaft leading from the cocoon to the surface. It can survive in this dormant state for as long as three

years. Because ungfishes ave dapta- ons at allow em to survive out of the water, they are considered important in vertebrate evolution.

How Scientists Group Groupers

Classifying fishes into groups is no easy matter. Test your sorting skills and find out what clues scientists use to keep track of fishes.

FOR GRADES K-2

OBJECTIVES

Students will:

- be challenged to classify diverse objects according to various attributes
- be introduced to fish *taxonomy*
- understand the importance of a universal classification method

GOALS AND STANDARDS

This activity meets:

- Illinois State Goals in Science: *Goals 1 and 4*
- National Science Education Standards:
  Unifying Concepts and Processes Standard
  K-4 Content Standards A and C

TIME

40 minutes

MATERIALS

For each student:

- white paper
- colored pencils or markers

For the class:

- assorted small objects (scissors, tape, crayons, coins, buttons, etc.)
- overhead projector

Theme II Activity 3

PROCEDURE

1. Place the assorted objects on the projector and display on the screen. Challenge the class to think of ways to group the objects. (For example, they might consider what the object is made of, its size, shape, color, purpose, etc.) As you discuss each answer, ask a child to arrange them on the projector in the appropriate groups, drawing circles around each group for clarification. Repeat this process as many times as students are able to come up with new ideas.

   Optional: If you would like to reinforce ideas about classification, extend the activity by asking students to find various ways to group themselves, objects from home, pets, foods, etc.

2. Next, ask each child to draw a favorite fish, making it as accurate as possible in terms of shape, number of fins, color, and size. Older children should also note the fish's diet and habitat.

3. Have the class stand in a circle and hold their fishes so that all can see. Ask the students to come up with as many ways as possible to group their fishes. For each idea, instruct the students to compare their fishes with the others and group themselves accordingly. This will lead to much rich discussion because the choices are rarely straightforward. For example, if the children group themselves by color, where should a multi-colored fish be placed? For more challenge, ask the students to consider two attributes at once.

4. Ask the children to determine which grouping method was best. Probably they noticed that no single method was correct and that it would depend on the reason for grouping them. Point out the difficulty and the many possibilities within even the small sampling of fishes you were considering. Ask: ***What if you were a scientist and needed to figure out how to group or classify thousands of different fishes. Where would you start? What if you wanted to share information with a scientist from another country? How would you know whether or not you were talking about the same fish?***

5. Use the Background to lead a discussion in a way appropriate to your students' age group about how scientists classify fishes. Students should understand the importance of a uniform, international system for classification. Note that fishes and other animals are categorized according to their genetic likeness to each other, which scientists believe indicates how different fishes evolved. Explain that evolution is a detective story. Scientists look for clues by studying fossils and comparing them to living species. But evidence is often incomplete or missing, and theories are created to fill in the blanks. This is partly why there is disagreement as to how many species of fishes exist.

6. Instruct the students to include their fish drawings and any notes from the activity in their journals.

How Scientists Group Groupers

FOR GRADES 3-5

OBJECTIVES

Students will:

- be challenged to classify diverse objects according to various attributes
- be introduced to fish ***taxonomy***
- understand the importance of a universal classification method

GOALS AND STANDARDS

This activity meets:

- Illinois State Goals in Science: *Goals 1 and 4*
- National Science Education Standards:
  Unifying Concepts and Processes Standard
  K-4 Content Standards A and C
  5-8 Content Standards A and C

TIME

45-60 minutes

MATERIALS

For each student:

- white paper
- colored pencils or markers

For the class:

- assorted small objects (scissors, tape, crayons, coins, buttons, etc.)
- overhead projector

PROCEDURE

1. Follow procedures 1 through 4 from previous activity on page 33.
2. Use the Background to lead a discussion in a way appropriate to your students' age group about how scientists classify fishes. Share the examples of the taxonomy of the various species on page 26 to demonstrate how humans are related or not related to a dolphin, salmon, and octopus.
3. The following exercise will help children further understand the usefulness and necessity of the progressively more specific categories of classification. Ask: ***How would you group all of the people on***

Earth according to where they lived? You might start with the most general, the continents, and continue dividing by country, state, city, street name, and street number. Write samples on the board to compare animal taxonomy with the way the students might classify themselves. (See chart.)

Include examples of people from other continents, countries, states, or cities for comparison. Ask children to bring in information about relatives from other places for further comparison. Discuss the fact that there are only seven continents, yet there are millions of addresses. Similarly, there are only five kingdoms to categorize all living things, yet millions of species are described.

4. Explain: ***Grouping people by where they live is only one way to categorize them. It could also be done by studying how they look, how tall they are, what they eat and so on. When classifying fishes and other animals, scientists arrange them according to their genetic likeness to each other, which they believe indicates how fishes evolved. Explain that evolution is a detective story. Scientists look for clues by studying fossils and comparing them to living species. But evidence is often incomplete or missing, and theories are created to fill in the blanks. This is partly why there is disagreement as to how many species of fishes exist.***

5. Ask: ***Why is Latin used as a language to classify fishes when no one speaks Latin?*** Point out the difficulty in using common names. For example, each language uses different words to name fishes. Often, even within the same country, using the same language, fishes have different common names. Because Latin is no longer spoken, it does not change like English, Spanish, or other current languages change. Therefore, it can be accepted universally. After your discussion, children should understand the necessity and importance of a uniform, international system for naming species of fishes.

6. Have the students include their fish drawings and any notes from the activity in their journals.

Classification for humans:		*Classification for a student:*	
Kingdom	Animalia	***Continent***	North America
Phylum	Vertebrata	***Country***	United States
Class	Mammalia	***State***	Illinois
Order	Primates	***City***	Chicago
Family	Hominidae	***Street name***	Main
Genus	Homo	***Street number***	100
Species	sapiens		

How Scientists Group Groupers

FOR GRADES 6-8

OBJECTIVES

Students will:

- be challenged to classify objects by looking at subtle differences
- develop a basic understanding of fish ***taxonomy***
- understand the importance of a universal classification method

GOALS AND STANDARDS

This activity meets:

- Illinois State Goals in Science: *Goals 1 and 4*
- National Science Education Standards:
  Unifying Concepts and Processes Standard
  5-8 Content Standards A and C

TIME

50-60 minutes

MATERIALS

For each student:

- white paper
- pencil
- colored pencils or markers

For the class:

- collection of assorted nails (no two exactly alike)
- container for nails

PROCEDURE

1. To begin, each student should have a piece of paper folded in half and a pencil. Present the container of nails and ask each child to choose one. Have the class trace their nails hidden on the inside of their folded papers. On the outside of the paper, tell them to describe the nail and give it a name.

2. Place only those nails that have been chosen in a pile on a large piece of paper in front of the classroom. Mix up the pile and then ask each student to come up and find his or her nail, keeping track of how long it takes. Students can test against their tracings to see if they were correct. Most students should not have trouble finding the correct nail.

3. Again place the nails in the pile. Have the students trade papers with someone they weren't sitting near. By using only the description and the name (without looking at the tracing inside), have each student find the nail that corresponds to the paper he or she is holding. Again note how much time it takes. It will probably take students much longer to find the correct nail, and some may not succeed. Ask: ***Why did it take so much longer to find the correct nail the second time? Why was it more difficult?*** They should notice that the names are of very little help and because the nails are so similar to each other, the descriptions don't provide enough information. Ask: ***What can we do to make sure anyone could find any nail with this sheet?***

4. Follow procedures 2 through 4 from activity on page 33.

5. Follow procedures 2 through 6 from previous activity on page 35.

EXTENSIONS

Ask students to research the taxonomy of other animals to study relationships between various species. For example, they might be surprised to learn that humans are as closely related to elephants as some fishes are to each other.

Have students invent their own systems for classifying items that are of interest to them such as classmates, cars, sports, magazines, etc.

ADDITIONAL RESOURCES

The Audubon Society Field Guide to North American Fishes, Whales, and Dolphins. New York: Alfred A. Knopf, 1983.

Bailey, Jill. *Fish: Encyclopedia of the Animal World.* New York: Facts on File, Inc., 1990.

Paxton, Dr. John R., and Dr. William N. Eschmeyer, editors. *Encyclopedia of Fishes.* San Diego: Academic Press, Inc., 1995.

Ichthyology

Scientists who study fishes are called ichthyologists. An ichthyologist uses fish taxonomy to study everything from fishes' origins, to reproduction and distribution, to habits and habitats.

To learn about fishes, an ichthyologist studies them in their natural habitats, does dissection, or may raise species for specific study.

Theme III
Fish Adaptations

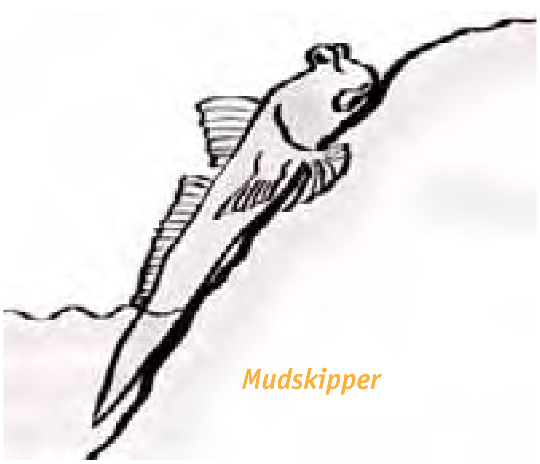
BACKGROUND

An ***adaptation*** is an inherited characteristic that improves an individual's chance for survival and reproduction. All animals, even humans, have adaptations, but fishes demonstrate more diversity than any other group. The range of fish adaptations is almost unimaginable: from using electricity as a way to detect ***prey***, to carrying eggs in their mouths to incubate and protect them. Chances are, if you can imagine it, there is a fish that has it. There is a fish that fishes, a fish that spits water at insects to catch them, and even a fish that "skips" on the mud out of the water in search of food. Following are just a few of the many physical and behavioral adaptations developed by fishes:

PHYSICAL ADAPTATIONS

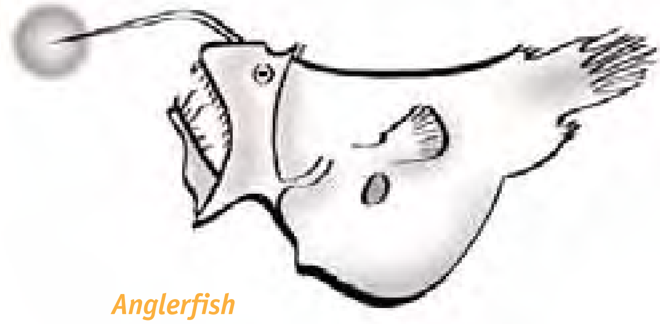
What kind of shape are you in?

Most fishes are shaped as you might expect—like a fish. But to fool the eye, some have adopted unusual shapes in order to "disappear" into their surroundings. Stingrays are flat as pancakes to blend into the sea bottom (see poster). Eels are shaped like snakes and can slither backwards into holes in the reef for protection (see poster). Stonefish look like a clump



Mudskipper

of rocks and have weeds and anemones growing on their skin for ***camouflage***. The leafy seadragon, a relative of seahorses, is covered with fleshy leaflike appendages that mimic the surrounding seaweed (see poster).



Anglerfish

Fins are for swimming...

...and a lot more! Although movement through water is the primary purpose of fins, they have adapted into many specialized forms. The fins of some fishes, like the sculpin, have developed into limbs almost like legs so that they can "walk" along the ocean floor. Part of the anglerfish's dorsal fin has become adapted to be a fishing lure. The remora's first dorsal fin has been modified into a sucking disk, enabling it to attach itself to sharks and other large animals for a free ride and leftovers from its hosts' meals. Thresher sharks have developed enormously long tails that can be used to corral schools of small fish and then thrash at them for an easy meal.

On a scale of one to 10

Most fishes are covered with a thin layer of transparent, overlapping scales designed to protect the fish while still allowing flexibility. However, the scales of some fishes have adapted in unique ways. Because eels back themselves into holes in the reef for protection, they are devoid of scales that would only get caught up on the walls (see poster). Sharks' bodies are covered with ***dermal denticles***, scales that have developed into small teeth. Porcupinefish have rows of prickly spines that become a dangerous weapon when the fish puff themselves up.

BEHAVIORAL ADAPTATIONS

A rainbow of colors

As we have already seen, there is an enormous variety of colors and patterns found on fishes. These differences in coloration can help species recognize each other quickly, but there are many other reasons coloration is significant. Oftentimes, fishes within the same species vary dramatically in coloration because of gender or age. The juveniles of some species have camouflage patterns that protect them when they are young, but these patterns disappear in adulthood.

Thresher shark

Some fishes have coloration to attract attention or advertise a special service. Potential ***predators*** recognize these colors and avoid eating the animal. For example, the bright coloring of the lionfish warns of venomous spines (see poster). Cleaner wrasses pick bits of food and parasites off other fishes (see poster). In exchange for this service, large fishes avoid eating wrasses, even as they clean inside their mouths.

There are also many types of camouflage used to confuse or hide from predators. ***Cryptic*** coloration enables an animal to blend in with its background. In some cases, the fish can change its color according to the surroundings. Example: trumpetfish. In other cases, it remains the same color, but rarely moves. Example: juvenile butter sole (see poster). ***Disruptive*** coloration breaks up the body shape of an animal and conceals it against a background or as it moves from place to place. This is common in coral reef fishes. Example: clown triggerfish (see poster). ***Directive*** coloration hides a vulnerable part of an animal's body or directs a predator's attention to a less vulnerable area. Bands that hide the eye and false eyespots are examples of this type of camouflage. Example: butterflyfish (see poster).

Do fishes go to school?

Most fishes, at least for part of their lives, do swim in schools. A school of fish can number from two individuals up to a million, depending on the species. The ability to school is aided by each fish's ***lateral line***, which enables it to sense the exact location of its neighbors and maintain consistent spacing. Fishes that swim in schools are better able to both hunt for food and escape from predators. Schooling provides safety in numbers, because it is difficult for predators to attack one fish in the midst of thousands.

Fishes as parents

As you might expect, fishes have developed a number of different reproductive patterns. The most common method is for the female to release millions of tiny eggs into the water where the male fertilizes them. The large number of eggs will ensure that at least some of the offspring will survive, even though most will become food for other animals. Other species build nests, in which the female lays eggs and the male fertilizes them. Cichlids and some other species are "mouthbrooders" (see poster). They protect the eggs, and later the offspring, by keeping them in their mouths and away from danger. Male seahorses incubate several hundred eggs from the female in a pouch on the front of their bodies. The offspring fend for themselves as soon as they are born. Some sharks have live births, like mammals, while others lay egg cases in which one or two baby sharks will develop. Some fishes can even change their sex in order to facilitate reproduction.

Horn shark egg case

A Fish is A Fish...Or Is It?

Does a cowfish moo? Does a seahorse gallop? Explore fishes named after other animals.

Theme III Activity 1

FOR GRADES K-2, 3-5, 6-8

OBJECTIVES

Students will:

- consider the ways fishes obtain their common names
- explore a wide variety of fishes' ***adaptations***

GOALS AND STANDARDS

This activity meets:

- Illinois State Goals in Science: *Goals 1 and 4*
- National Science Education Standards:
  Unifying Concepts and Processes Standard
  K-4 Content Standards A and C
  5-8 Content Standards A and C

TIME

40 minutes

MATERIALS

For each student:

- white paper
- colored pencils or markers

For the class:

- fish photos and resource books

PROCEDURE

1. Begin with a discussion about how fishes acquire their common names. Ask the children to imagine they've discovered a new species of fish. How would they name it? Many fishes are named because of the way they look, but some are named for their discoverer, their ***habitat***, or their special adaptations or behaviors. For example, mudskippers "skip" across the surface of the mud. Grunts make a grunting sound as they grind their teeth together. Ask students to think of any fishes they know that are named after other animals. They should remember those that were already studied, such as catfish and lionfish.

2. Arrange the class into their small groups and tell them you are going to play a game. Using the lists on pages 42 and 43, provide each

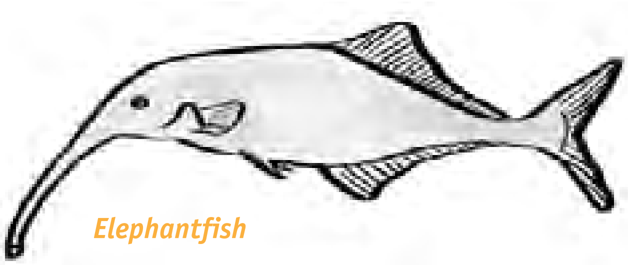
group with the names of two fishes with animal names. Choose one real fish species and one fictional species. Each group creates a drawing of how they imagine each fish might look, and then votes on which one they believe represents an actual fish.

3. As each group finishes its two drawings, inform the students which is the real fish and share a photo or drawing. Ask them to redraw the real fish in a more accurate fashion using the image you provided as a guide.

4. For younger children, discuss within the group the reason for the fish's name. You will notice that most fishes with names of other animals look like that animal in some way. The exception to this is the mosquitofish, so named because it feeds on mosquito larvae. Ask older children to make theories and then check in available resources to see if they were correct. You might also have them research further information about the fish such as its diet and habitat. They should consider such questions as: ***Do the fishes use their "animal" features in the same way as the animal for which they were named? For example: Does the elephantfish use its "trunk" for the same purpose as an elephant? Can a frogfish jump like a frog?***

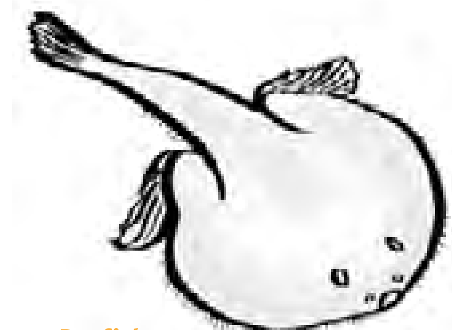
5. Have each group share all three drawings with the class and explain the origin of the name of the species as well as all they've learned about the fish. You may want to create a display in your classroom using the drawings.

6. Instruct each child to do an additional accurate drawing of the real fish, complete with all they learned about its adaptations, to include in their Fish Journals.


Elephantfish

Fish Species with Animal Names:
Cowfish
Cowfish got their name from their cowlike facial features, especially the spines that look like the horns of a cow. They are armored with plates of bone under their skin for protection. To feed, cowfish stand on their heads and squirt jets of water at the sand to expose their ***prey***.

Elephantfish
One look at this fish will tell you where it got its name. Elephantfish are found in the freshwaters of Africa. They use their trunklike snouts to probe in muddy bottoms for food such as worms, insects, and mollusks.

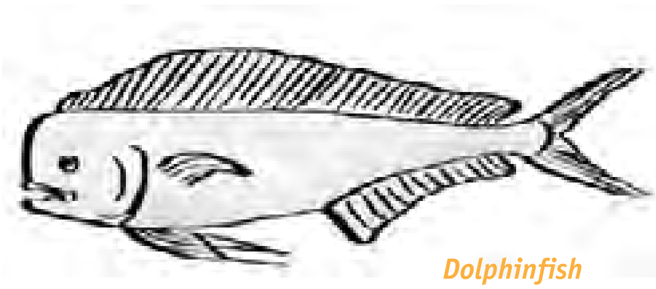

Batfish

Frogfish
Frogfish belong to a group of fishes called anglerfishes, and were named for the "fishing lure" permanently attached to their heads, used to catch prey. The frogfish was also named for its unusual fins that are shaped like frog legs, and its froglike lunges for prey. Frogfish are masters of ***camouflage***, able to simulate their background of sponges or algae-covered rocks (see poster).

Batfish
Scientists who named these fish thought their pectoral fins looked like the wings of a bat. These fins, along with their pelvic fins, make them well adapted for walking along the sea bottom. Batfish, like frogfish, are part of the anglerfish family. They also rely on camouflage, blending into the sandy bottom to keep themselves hidden from both prey and ***predators***.

Dolphinfish

These fish don't exactly look like dolphins, but they possess some of the dolphin's traits. Large (up to 1.5 meters, or five feet) and fast swimmers with an elongated, streamlined form, they share the offshore habitat of the open ocean with the mammalian dolphin. Dolphinfish are well known for their beautiful colors of bright blue, gold, and green that change rapidly when the fish are excited.



Dolphinfish

Butterflyfish

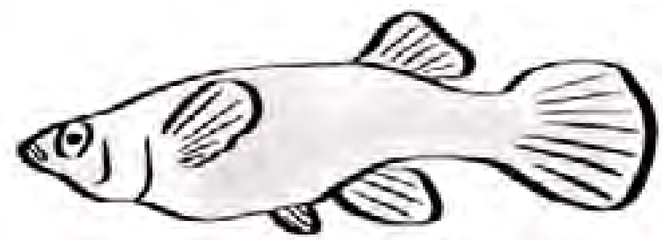
The disklike shape and colorful patterns of this beautiful fish are reminiscent of a butterfly (see poster). Their tall, flat bodies enable them to slip easily between branches of coral and into crevices on the reef. With small mouths and bristlelike teeth, they feed on small ***invertebrates*** including coral polyps. Most have a dark stripe over each eye, to disguise them and confuse predators.

Lizardfish

Lizardfish look and act like reptiles. They can be found on the sandy seafloor with their heads propped up in a lizardlike pose as they wait to ambush their prey. When disturbed, lizardfish bury themselves up to their eyes in the sand. They use their pelvic fins as legs to walk along the sea bottom.

Mosquitofish

This tiny fish was given its name not because it looks or acts like a mosquito, but because it feeds on mosquito larvae. In recent years, it has been introduced into non-native freshwater habitats to control mosquito populations. But this practice has proven disastrous for local fish populations, because the mosquitofish also feed on the larvae and the young of the local fishes.



Mosquitofish

Use the following fictional species or invent your own:

mousefish
spiderfish
chameleonfish
giraffefish
monkeyfish
penguinfish
ladybugfish
flamingofish

Lizardfish

EXTENSION

Provide resources for the children to find fish species named after other familiar objects, and ask them to research the name origins. Some interesting possibilities include: guitarfish, garden eel, firefish, clownfish, trumpetfish, drumfish, moonfish, needlefish, and soapfish.

ADDITIONAL RESOURCES

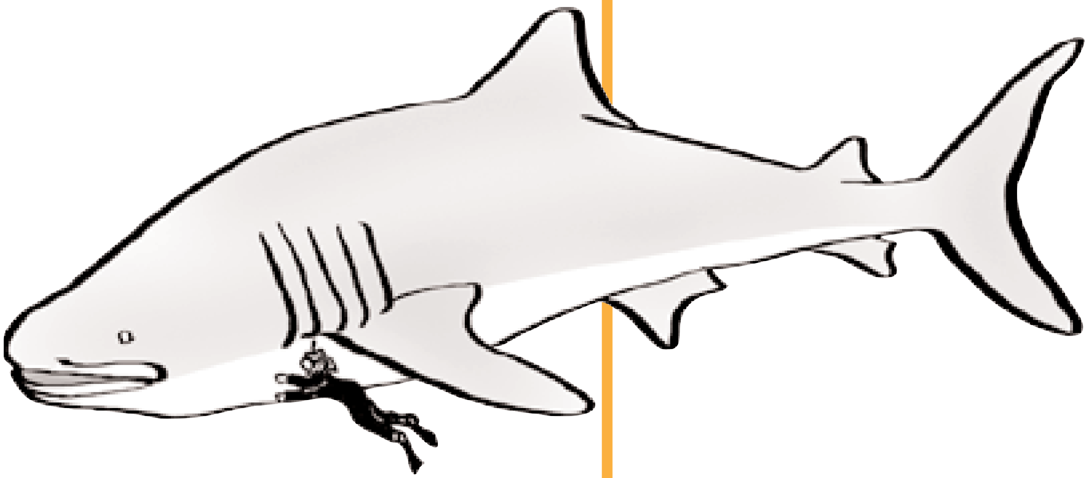
Bailey, Jill. *Fish: Encyclopedia of the Animal World.* New York: Facts on File, Inc., 1990.

Paxton, Dr. John R., and Dr. William N. Eschmeyer, editors. *Encyclopedia of Fishes.* San Diego: Academic Press, Inc., 1995.

Quinn, John R. *Fishwatching: Your Complete Guide to the Underwater World.* Woodstock, Vt.: The Countryman Press, Inc., 1994.

A Whale of a Shark

It's easy to guess why this giant shark is called a whale shark. It's the largest fish in the sea and is so big (18 meters, or 60 feet) that it really looks like a whale. But unlike some sharks, it is completely harmless and feeds on only the tiniest prey: microscopic plankton.



Hide and Seek

Many fishes have found remarkable techniques for "disappearing" into their surroundings. This mastery of camouflage helps fishes confuse both predators and prey.

Theme III Activity 2

FOR GRADES K-2, 3-5, 6-8

OBJECTIVES

Students will:

- create underwater scenes incorporating ***camouflage*** techniques
- learn three types of coloration ***adaptations:*** cryptic, disruptive, and directive

GOALS AND STANDARDS

This activity meets:

- Illinois State Goals in Science: *Goals 1 and 4*
- National Science Education Standards:
  Unifying Concepts and Processes Standard
  K-4 Content Standards A and C
  5-8 Content Standards A and C

TIME

40 minutes

MATERIALS

For each small group:

- several colors of cellophane
- several sheets of clear plastic for use on the overhead
- markers for use on the overhead

For the class:

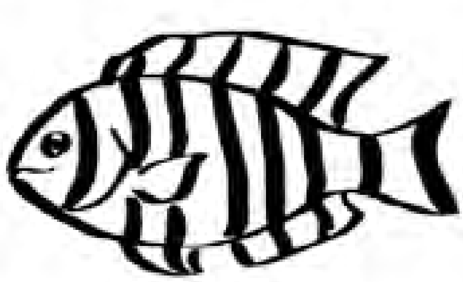
- photos and resource books
- overhead projector

PROCEDURE

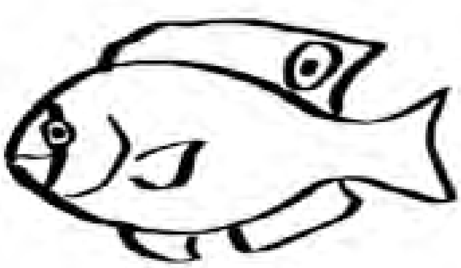
1. Using the Background, lead a discussion about cryptic, disruptive, and directive coloration of fishes appropriate for your students' age group. Include examples from the poster and other sources. For younger children, focus on the purpose of each type of coloration adaptation, rather than the names for each.

2. Arrange children in their small groups, and assign each to work with one of the three types of camouflage: cryptic, disruptive, or directive. Provide each group with clear plastic sheets and several colors of

Cryptic coloration



Disruptive coloration



Directive coloration

cellophane as well as markers for use on the overhead. Inform them that their assignment is to create an underwater scene, to be shown on the overhead projector, that demonstrates that form of camouflage. For example, students might use layers of various colors of cellophane to create a coral reef in which to place a butterflyfish. Details of the fish and surrounding environment can be added with the markers. According to the age group of your students, you can choose whether you would like the students to use real or imaginary fishes and ***habitats*** as the basis for the assignment. Older children should utilize the correct species in the appropriate habitat, whereas it is more important that younger children understand the general concepts of camouflage. Photos and resource books, as well as the poster, should be made available for reference.

Some examples:

Cryptic—trumpetfish, juvenile butter sole (see poster), flounder, stonefish

Disruptive—sergeant major, banded butterflyfish, clown triggerfish (see poster)

Directive—twinspot wrasse, foureyed butterflyfish (see poster), threespot damselfish, spotted drum

Working on a surface of white paper helps to visualize the creation better. When a group's creation is completed, have the group view it on the overheard projector before showing it to the class. The creation will look different when lit on the overhead than when simply lying on a table. This way the group can prepare better for later "testing" the class on their "fish-sighting" skills.

3. To demonstrate the various types of coloration, students should present their end result to the class. Tell the class that they are ***predators*** looking for their next meal. Turn the overhead projector light on for just a few seconds and then ask the class to identify what they had seen. Ask: ***In which direction was the fish swimming? Where was the fish hiding? Why was it difficult to tell?***

4. Students should include explanations of the various types of camouflage in their journals along with examples of each.

EXTENSION

Investigate the color of fishes in relationship to the various depths of water in which different colors of light penetrate. In general, light waves penetrate water least on the red end of the spectrum (less than 10 meters, or 30 feet) and most on the violet end (up to 80 meters, or 250 feet). How does this affect fishes? What color should a fish be to hide in deep waters?

ADDITIONAL RESOURCES

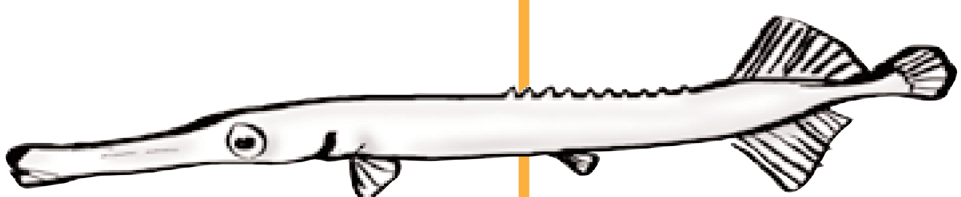
Holing, Dwight. *Coral Reefs*. San Luis Obispo, Ca.: Blake Publishing, 1990.

Moyle, Peter B. *Fish: An Enthusiast's Guide*. Berkeley, Ca.: University of California Press, 1993.

Wilson, Roberta, and James Q. *Pisces Guide to Watching Fishes: Understanding Coral Reef Fish Behavior*. Houston, Tx.: Pisces Books, 1992.

Trumpetfish Don't Blow Their Own Horns . . .

...but they do use their trumpetlike mouths to suck in and "vacuum" up prey. Trumpetfish are adept at changing color, a skill they use to blend into the background. To hunt, they "shadow stalk" (swim as close as possible to a larger fish, adopting its coloration). This provides a shield for the trumpetfish, enabling it to ambush its prey.



What's For Dinner?

There is no scarcity of food in the water, but finding it and catching it are often quite tricky. Challenge your memory skills as you explore some of the tricks of the "fishing" trade.

Theme III Activity 3

FOR GRADES K-2, 3-5, 6-8

OBJECTIVES

Students will:

- learn some of the many *adaptations* developed by fishes to obtain food
- match various species of fishes with their diets

GOALS AND STANDARDS

This activity meets:

- Illinois State Goals in Science: *Goals 1 and 4*
- National Science Education Standards:
  Unifying Concepts and Processes Standard
  K-4 Content Standards A and C
  5-8 Content Standards A and C

TIME

45-60 minutes

MATERIALS

For each student:

- copy of the game cards on page 50 and 51
- copy of Fish Food on page 52
- scissors
- optional: colored pencils or markers
- optional: two pieces of heavy paper or tagboard

For the class:

- optional: lamination machine

PROCEDURE

1. Discuss: ***What do fishes eat? What is there to eat in the ocean, in a river, in a lake?*** Be it a floating insect, crawling crab, seaweed, microscopic plankton, or giant whale, fishes have found a way to make a meal of it. Tell the students that they are going to make and play a game to find out some of the ways fishes have adapted in order to find food.
2. Arrange students in their small groups and distribute a copy of the two sheets of game cards to each child. After cutting out the 16

cards, they should discuss with their group which fish might eat which food. Have them place the cards next to each other in pairs, matching each fish with its food.

3. To check their answers, use Fish Food on page 52 as your guide. Depending on the age of your students, provide the answers verbally, or distribute a copy of Fish Food to each child as a resource. Lead a discussion about each of the fishes and their adaptations for eating, showing photos when possible. Point out that even though the game cards only show one type of food for each fish, most fishes take advantage of more than one food source. To make the game more authentic, you may want to have them color the cards, using the poster or other photos as a guide. After they are familiar with each of the species and the food that it eats, they are ready to play the memory game.

4. Have your students play in pairs or small groups. They should shuffle all the cards and spread them out face down on the table, then take turns drawing two cards to see if they can match the fish with its prey. In order to win the pair, the student needs to explain how the fish eats its food, and the classmates must agree. For more challenge, they can make additional pairs. You might assign each group to research a certain number of species, and to create new cards to photocopy and add to the game.

5. To make the cards last longer, glue them to a heavier paper or tagboard and/or laminate them.

EXTENSION

Challenge students to create their own memory or board game based on other types of fish adaptations, such as variations on fins or reproductive behaviors.

ADDITIONAL RESOURCES

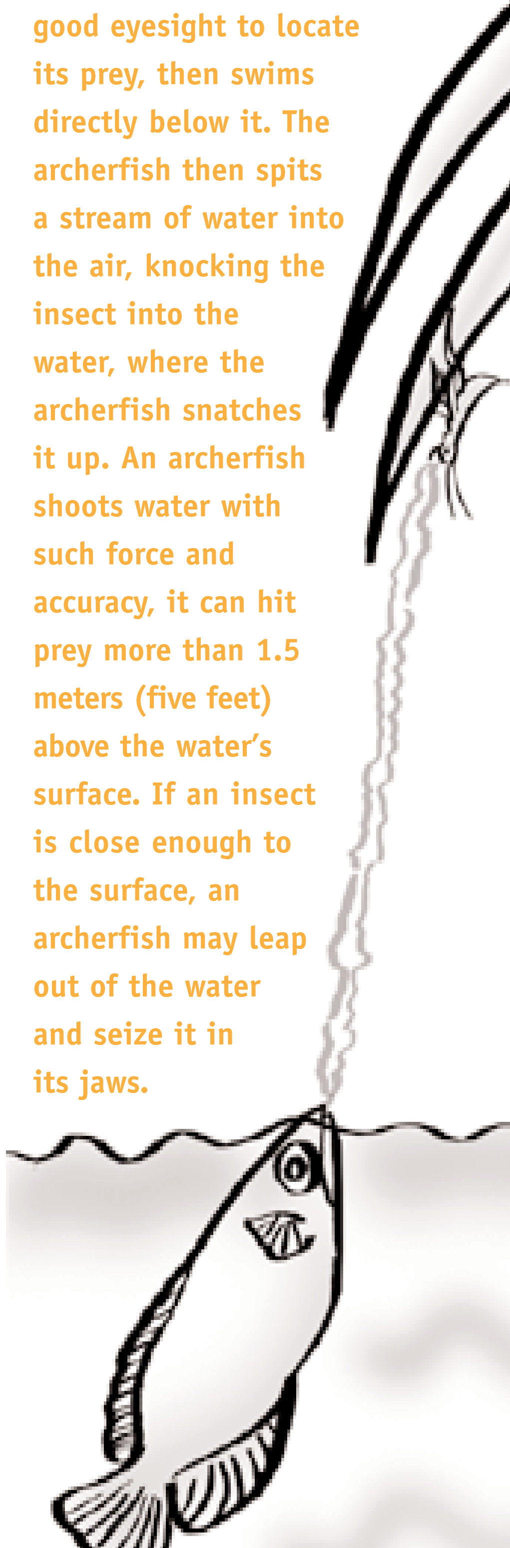
Christie, David A. *Remarkable Animals.* Gothenburg, Sweden: Johnston and Company, 1987.

Moyle, Peter B. *Fish: An Enthusiast's Guide.* Berkeley, Ca.: University of California Press, 1993.

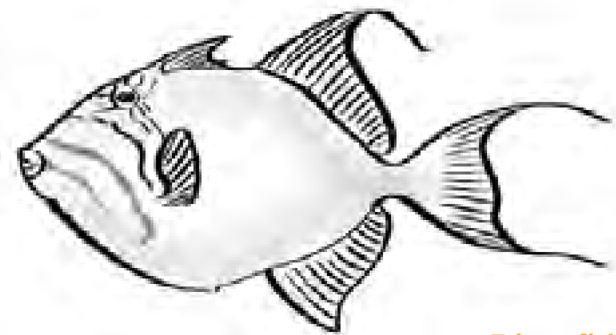
Parker, Steve. *Fish:* Eyewitness Books. New York: Alfred A. Knopf, 1990.

Archerfish—a Spitting Image

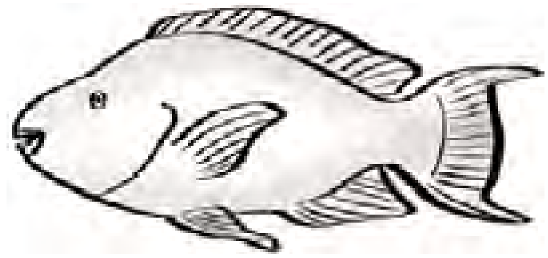
Large eyes, an upward-directed mouth, and a strong tongue are all special adaptations an archerfish has for catching insects. It uses its exceptionally good eyesight to locate its prey, then swims directly below it. The archerfish then spits a stream of water into the air, knocking the insect into the water, where the archerfish snatches it up. An archerfish shoots water with such force and accuracy, it can hit prey more than 1.5 meters (five feet) above the water's surface. If an insect is close enough to the surface, an archerfish may leap out of the water and seize it in its jaws.



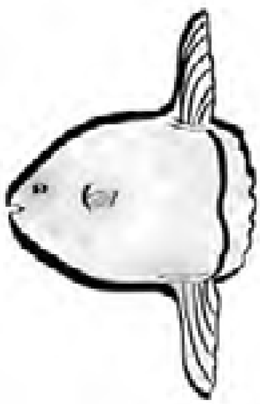
What's for Dinner—Fish Game Cards



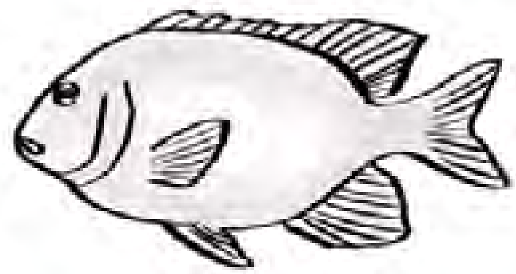
Triggerfish



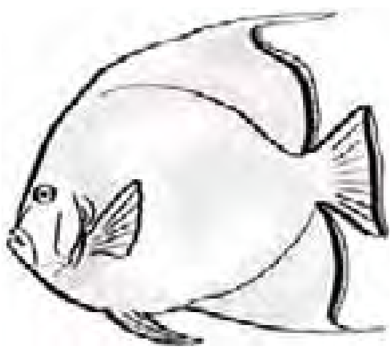
Parrotfish



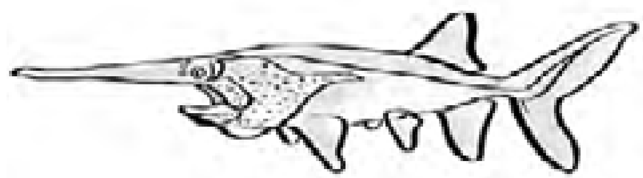
Sunfish



Damselfish



Angelfish



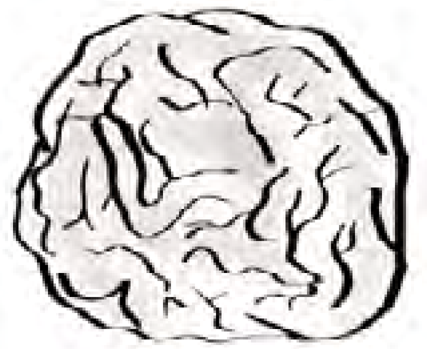
Paddlefish

Closeup of mouth

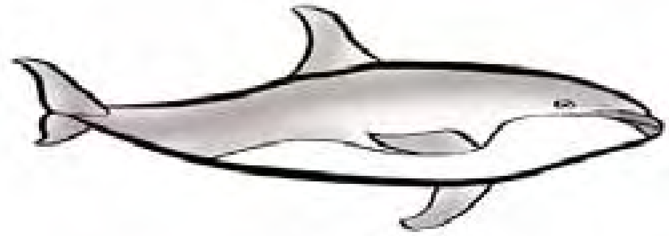
Cookie cutter shark

Mudskipper

What's for Dinner—Food Game Cards

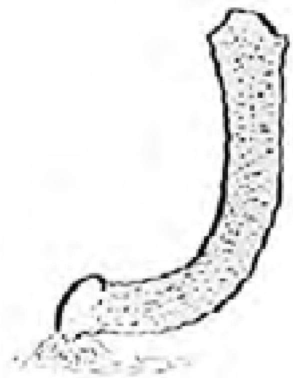


Coral

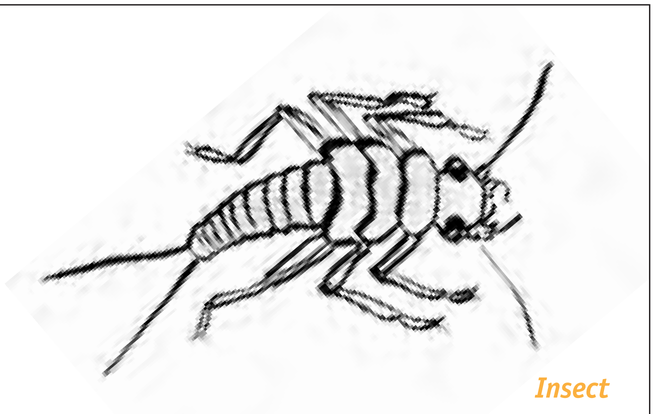


Dolphin

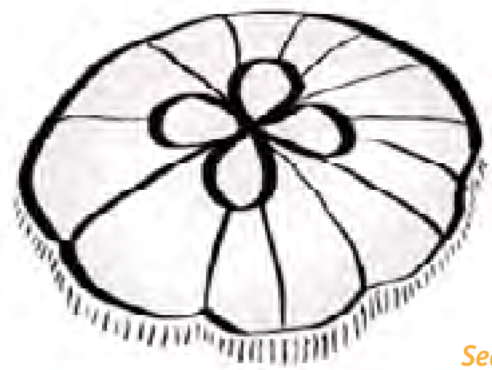
Algae



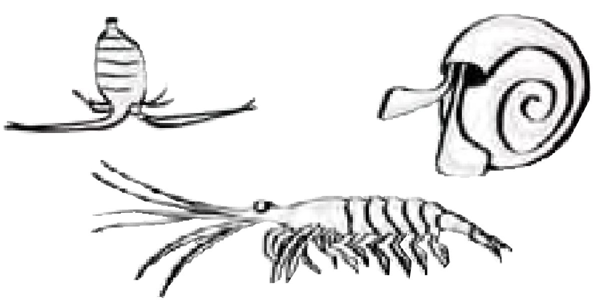
Sponge



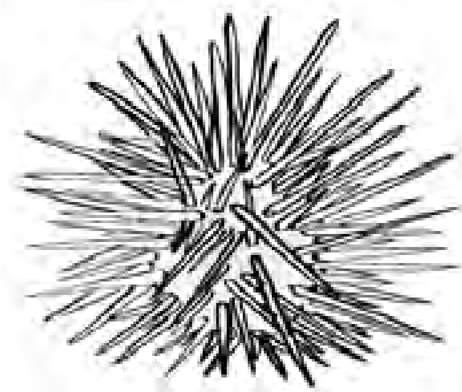
Insect



Sea jelly



Plankton (magnified)



Urchin

Fish Food—What's for Dinner Answer Key

Fish: **Triggerfish**
Food: **Sea urchins**
Sea urchins are well protected from most fishes by their sharp, pointy spines. But the triggerfish is able to overturn an urchin and expose its soft underside by blowing a powerful stream of water at it (see poster). The triggerfish gets its name from a spine in its dorsal fin that it can lock in order to wedge itself into a hole in the reef for protection.

Fish: **Angelfish**
Food: **Sponges**
To us, a sponge may not sound like a tasty dinner, but angelfish thrive on them. Sponges, abundant on the reef, are animals that pump large volumes of water through their bodies to extract bits of floating food such as plankton.

Fish: **Parrotfish**
Food: **Coral**
If you were underwater, you could hear a parrotfish's loud, crunchy chewing even before you could see it (see poster). With their powerful "beaks," parrotfish nibble the reef to scrape off algae and bits of hard coral, all of which is ground to a powder by strong throat plates.

Fish: **Paddlefish**
Food: **Plankton**
Paddlefish are freshwater fish easily identified by their long shovel-shaped snout (see poster). They feed by opening their huge mouths and straining plankton from the water through gill rakers. Their snout serves as a sensory organ to locate swarms of microscopic prey.

Fish: **Sunfish**
Food: **Sea jellies**
For a sunfish, dinner usually involves lots of "jelly." It feasts on sea jellies, but because jellies are mostly water and not very nutritious, the sunfish needs to eat them in large quantity to maintain its large body size (up to three meters, or almost 10 feet).

Fish: **Cookie cutter shark**
Food: **Dolphin**
Despite their small size (maximum 51 centimeters, or 20 inches), cookie cutters prey on some of the largest animals in the sea. Using their incredibly sharp, triangular teeth, they lunge at and grasp large fishes, dolphins, or whales. Twisting their body into their prey, they remove a cookie-shaped plug of flesh.

Fish: **Damselfish**
Food: **Algae**
Fish as farmers? Damselfish cultivate algae within tiny plots on the coral reef. While they don't have to worry about droughts, they do have to drive off intruders with aggressive visual displays and loud clicking noises.

Fish: **Mudskipper**
Food: **Insects**
As their name suggests, mudskippers are able to "skip" across the mud using their muscular tail and side fins. Mudskippers are among the few fishes that are able to leave the water and breathe air. At low tide they emerge from the water to catch insects in the muddy mangrove swamps where they live.

Theme IV
Fishes in the Future

BACKGROUND

With few exceptions, fishes conservation has been sadly neglected. From our perspective above the water, a healthy, thriving water system and one that is heavily polluted might look exactly the same. Fishes are virtually invisible to us, and perhaps if they were as easy to see and to approach as birds or mammals, their ecological and biological value would be better understood.

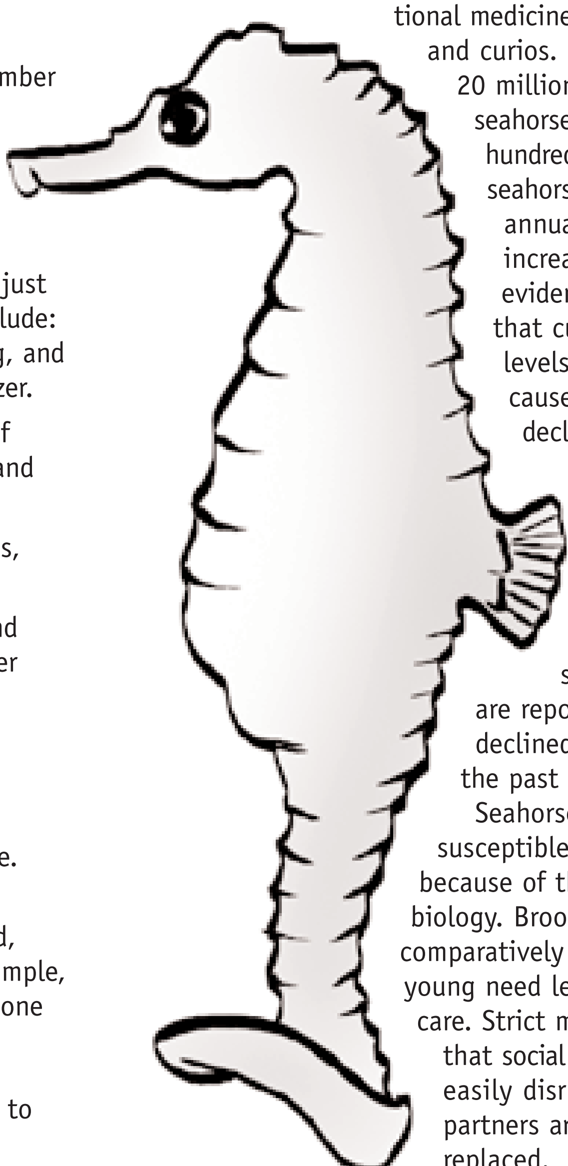
At least 800 species of fishes are currently known to be in danger. However, the actual number is probably much higher, as extinction is occurring faster than species can be recorded. The threats to fishes and their ***habitats*** are numerous:

- Pollution is finding its way into the water just about everywhere. Sources of pollution include: oil spills, industrial waste, garbage dumping, and runoff from farms contaminated with fertilizer.
- Urban development and the construction of dams blocking fish migration are altering and destroying fishes' habitats.
- Natural changes, such as droughts or floods, can also alter and destroy habitats.
- Overfishing is a serious problem. As demand increases, many fishes are unable to recover the losses.
- Deforestation near lakes and rivers greatly alters the ecosystem of the water.
- The introduction of nonnative species to a water system can upset the natural balance. (See Activity 2 on page 58.)
- Distribution of some species is very limited, making them especially vulnerable. For example, some species of cichlids are found in only one lake. (See Activity 2 on page 58.)

Because it is unlikely that we could put a stop to all of these detrimental activities, the question seems to be one of balance. How do we use the sea to our advantage without such disadvantage for the fishes and other marine life? How can we become smarter about what we dump into the sea and what we remove from it? With some imaginative thinking and willingness to work together, there may be ways for fishes *and* humans to thrive.

PROJECT SEAHORSE

One example of a conservation effort showing success is Project Seahorse. Seahorses are heavily fished throughout the world for use in traditional medicines, aquariums, and curios. At least 20 million dried seahorses and several hundred thousand live seahorses are sold annually. Demand increases steadily, but evidence indicates that current fishing levels already have caused marked decline of seahorse populations. In the village of Handumon in the Central Philippines, for example, seahorse catches are reported to have declined about 70% in the past ten years.



Seahorses are particularly susceptible to overfishing because of their unique biology. Brood sizes are comparatively small, and the young need lengthy parental care. Strict monogamy means that social structure is easily disrupted, and lost partners are not quickly replaced.

Low mobility and small home ranges restrict recolonization of depleted areas.

Seahorse fisheries, such as the one in Handumon, provide important income for many subsistence fishers. But with seahorse numbers declining, this income could soon dry up. Tackling this problem requires interest and cooperation from local fishers, villagers, and officials, as well as collaboration with scientists. Dr. Amanda Vincent of McGill University in Montreal and Dr. Heather Hall of the Zoological Society of London are two scientists leading Project Seahorse. This integrated program of conservation and management initiatives works to ensure long-term survival of wild seahorse populations, their relatives and their habitats, while recognizing the needs of people who depend on them. The Shedd Aquarium is collaborating with Project Seahorse to conduct research on seahorse husbandry and to develop conservation and education programs.

Some initiatives of the project include:

- Handumon has established a marine sanctuary where no fishing of any species is permitted, with an adjacent zone restricted to traditional fishing methods. Catches around the sanctuary are reportedly increasing.
- Newly-caught pregnant male seahorses are now held in cages until they give birth, whereupon the young escape to the sea before the males are sold.
- Philippine biologists and villagers are cooperating in recording individual seahorses and population demographics.

In addition to maintaining seahorse populations, the Project is committed to helping villagers find alternative livelihoods, such as seahorse culturing and seaweed farming. The Shedd Aquarium has developed a program with the villagers to make local handicrafts, which are merchandised at the Aquarium.

Catch as Catch Can

As worldwide demand for food fishes increases and fishing becomes more efficient, "bycatch" or unwanted catch, becomes a more serious problem.

Theme IV Activity 1

FOR GRADES K-2, 3-5, 6-8

OBJECTIVES

Students will:

- be introduced to techniques of commercial fishing and the problem of *bycatch*
- simulate net fishing to become aware of the bycatch dilemma and consider solutions

GOALS AND STANDARDS

This activity meets:

- Illinois State Goals in Science: *Goals 1, 2 and 4*
- National Science Education Standards:
  Unifying Concepts and Processes Standard
  K-4 Content Standards A, C, and F
  5-8 Content Standards A, C, and F

TIME

40 minutes

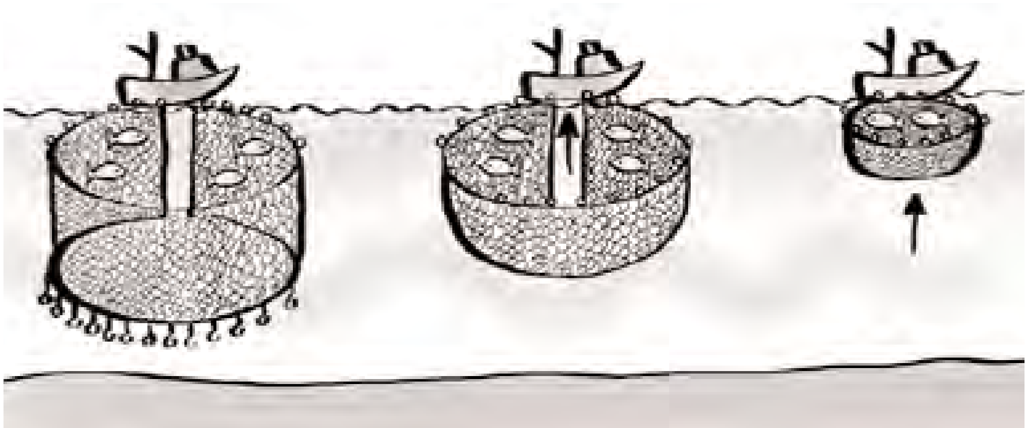
MATERIALS

For each small group:

- various small floating objects
- 3 or 4 pieces of plastic mesh with various sized openings such as fruit bags, onion bags, etc.
- large container of water such as a dishtub

PROCEDURE

1. In this activity, students will be "fishing" with mesh nets for small objects that represent fishes and other marine animals. To prepare for the activity, cut 3 or 4 pieces of mesh with various sized openings for each small group. The mesh should be rectangular in shape and large enough for students to skim the surface of the water. The small objects should also be variously sized to approximate the difference in scale between, for example, shrimp and dolphins. You will need to experiment with the nets and objects to make sure that some of the objects go through some of the nets. Anything small that floats will work: coffee beans, coconut flakes, small cereals, etc. Also, objects that can be cut or adjusted work well. For example, birthday candles



or crayons can be cut into smaller pieces. Scraps of foil can be rolled or pressed into any size desired. You will need one type of object to represent each of the following:

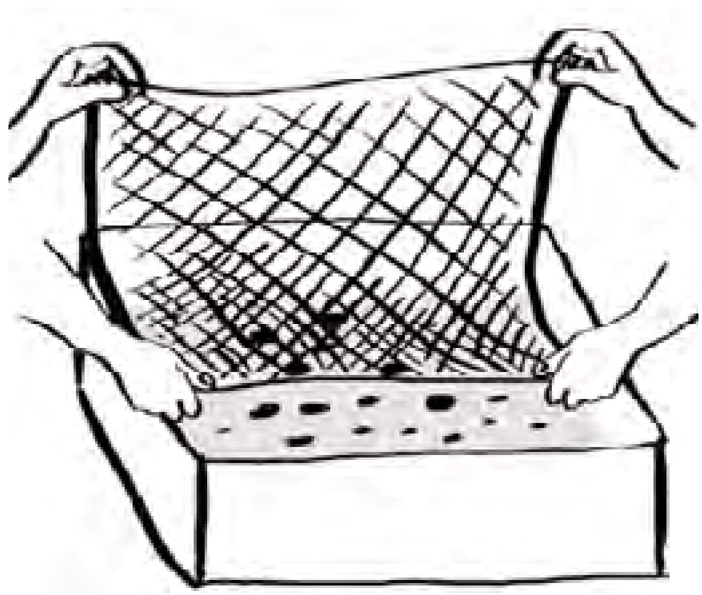
- ***Targeted animals—shrimp, cod, tuna (The actual size of cod and tuna will vary quite a bit, but cod is generally much smaller than tuna.)***
- ***Bycatch—dolphins, sea turtles, seabirds***

2. Begin by asking: ***Where do most of the fishes we eat come from? How are they caught?*** Explain to the class that the majority of fishes are caught in the ocean by commercial fisheries using large nets. One type of net used is the purse seine (see illustration). The net, lined with floats at the top and weights on the bottom, is dropped in the water to create a large circle. The bottom edge is then pulled tight into a bag-like shape trapping fishes and anything else that was in the water. The net is then pulled tighter and tighter until the catch is brought on board.

   Although this system is very efficient for catching large numbers of the targeted fish, it also can trap many other fishes as well as dolphins, turtles, and seabirds. Because these animals also prey on the targeted fish, they are often attracted to the area where they get caught on nets or hooks as they try to eat the fish. This extra, unwanted catch is known as bycatch, and the dead or dying animals are usually tossed back into the water. Bycatch is a serious problem, accounting for as much as one-fifth of all catch.

3. Tell the children that they are going to simulate fishing with nets to demonstrate the problem of bycatch. Organize students in their small groups and provide each with a tub of water, pieces of mesh and floating objects. Point out that most fishes don't really float at the top although many animals caught as bycatch are found near the surface. For example, dolphins come up often for air, and birds rest on the surface.

4. Have the students place all of the floating objects in the water. Inform them and write on the board which objects represent the targeted



animals and potential bycatch (see Procedure 1). Their challenge is to find the net that will catch the most of each targeted animal with as little bycatch as possible. Have them take turns working in pairs, each holding one end of the net and dragging it across the surface of the water (see illustration). They should "fish" for each of the target animals and decide which net works best. It is important to use a consistent technique for each attempted catch.

5. Ask: ***Which type of fishing resulted in the most bycatch?*** Is it possible to avoid all bycatch? Students will probably notice that the smaller the targeted animal, the more difficult it is to avoid bycatch. This is why shrimp fisheries have one of the highest levels of bycatch. Ask children to consider ways to solve this problem. After the children have expressed their ideas, share and discuss the sidebar.
6. Have the children explain the experiment and results in their Fish Journals.

EXTENSIONS

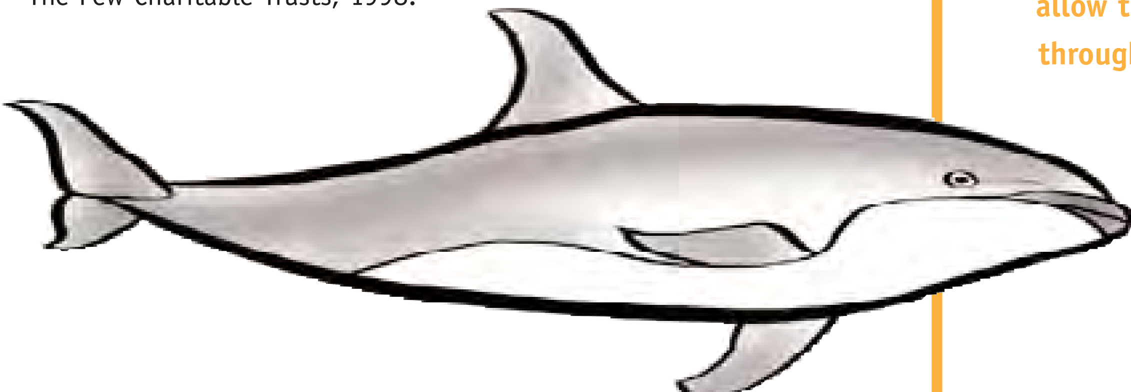
Assign students to search the Internet for current information on bycatch.

Conduct the same activity focusing on just one species of fish but of different sizes to represent the fish in various stages of life. For example, use a birthday candle cut into three different sizes to represent a fish larva, juvenile, and full grown adult. Discuss the ramifications of catching the fish at each stage. For example, if all the juveniles are caught, how will the species replenish itself?

ADDITIONAL RESOURCES

Thorne-Miller, Boyce, and John Catena. *The Living Ocean: Understanding and Protecting Marine Biodiversity*. Washington, D.C.: Island Press, 1991.

Video: *Unwanted Catch*. New England Aquarium and The Pew Charitable Trusts, 1998.



They're Not Caught on "Porpoise"

Because dolphin feed on targeted fish such as tuna, they are often entangled in fishing nets. Until recently, hundreds of thousands of dolphins were killed each year as bycatch. Although this number is now much lower, many thousands are still victim to the nets. One solution is the use of deterrent devices such as a pinger. This instrument emits a high-frequency noise that steers dolphins away.

In shrimp fishing, bycatch victims are often sea turtles. As a result, American shrimp boats in the Gulf of Mexico are now required to use TEDs, or turtle excluder devices. These are special nets with openings that allow turtles to slip through. When used properly, TEDs can greatly reduce turtle bycatch.

There are Lots of Fish in the Sea—Let's Keep it that Way!

Theme IV Activity 2

Many factors threaten the future of fish populations. Take part in a debate to look for solutions.

FOR GRADES 3-5, 6-8

OBJECTIVES

Students will:

- learn of some threats to specific fish populations
- debate solutions while considering multiple points of view

GOALS AND STANDARDS

This activity meets:

- Illinois State Goals in Science: *Goals 1, 2 and 4*
- National Science Education Standards:
  Unifying Concepts and Processes Standard
  K-4 Content Standards A, C, and F
  5-8 Content Standards A, C, and F

TIME

45-60 minutes

MATERIALS

For each student:

- copy of Conservation Issues on page 60

For the class:

- optional: resources for the students to conduct research on endangered species

PROCEDURE

1. Use the Background to begin a discussion about conservation issues and some of the environmental concerns that threaten the future of fish populations. Thoroughly discuss Project Seahorse as an example of a complex problem with unique solutions. Point out that the solutions required innovative thinking as well as compromise from all sides involved.

2. Tell the students that they will be participating in a debate about issues that threaten the survival of certain species of fishes. Two conservation issues are presented on page 60: the introduction of a non-native species, the Nile perch, into Africa's Lake Victoria and shark finning. Use these issues as the basis of the debates and/or have the children do their own research on a topic of interest to

3-5 6-8

them. Each child will play the role of someone involved in the scenario. It is his or her job to argue or defend the position assigned whether or not he or she agrees with it. Depending on the number of students and your goals, divide the class into groups. For example, if you have 20 students, you might divide the group in two so that half can debate each issue. With 32 students, you could have four groups of eight, two debating each topic. For younger children, narrow down the number of roles and have more children playing the same roles.

3. Provide time for the children to work together in their groups to discuss ideas in advance of the debate. Allot a specified amount of time for each debate in the range of 10 to 20 minutes.

4. During the debate, those who are involved should be in a group at the front of the class. The rest of the class should act as observers and should not participate or ask questions until the allotted time is up. At that point, encourage the class to offer their opinions or ask questions of the debate panel. Remind students that there are no right or wrong answers to these complicated issues. Rather, all of the parties involved need to take the other's perspective into consideration and be willing to compromise and be open to creative solutions.

5. Ask the students to write a position paper on their own true opinion to be included in their Fish Journals.

EXTENSION

Research other issues threatening fishes such as pollution, oil spills, overfishing, fish farming, and the impact of dams.

ADDITIONAL RESOURCE

Moyle, Peter B. *Fish: An Enthusiast's Guide.* Berkeley: University of California Press, 199

Simon, Noel. *Nature in Danger: Threatened Habitats and Species.* New York: Oxford University Press, 1995.

http://www.wwf.org/yoto/sharks3.htm
Article: Sharks in Trouble.

Will the Great Barrier Reef Continue to be Great?

Extending for more than 2,000 kilometers (1,250 miles), the Great Barrier Reef off the east coast of Australia comprises the world's largest system of coral reefs. Home to thousands of species of marine plants and animals, it is an incredibly complex and important marine ecosystem. However, this natural wonder is being threatened by the growing popularity of the area and the increase of industry and agriculture on the nearby mainland. With millions of tourists comes more sewage, more boats causing damage to the fragile reefs and pets that attack turtle nesting grounds and bird colonies. Increased industrial and tural development ulted in pollution mages the reef erefore affects the and other animals.

CONSERVATION ISSUES

The Nile Perch in Lake Victoria

At one time, Lake Victoria, Africa's largest lake, supported an amazing array of native fish species found nowhere else on Earth. These species were mostly small cichlids, some of the most specialized of all fishes. For example, some cichlids play dead in order to lure prey close by, others nibble on hippopotamus dung for nutrients, and still others hide inside snail shells. These specializations evolved so cichlids could take advantage of all the lake's available resources.

In 1960, Africa's largest freshwater fish, the Nile perch (two meters, 6.5 feet), was introduced into Lake Victoria. Because of its enormous size, the Nile perch has a voracious appetite and eventually wiped out more than 300 species of cichlids. Almost two-thirds have become extinct and the remainder have been dramatically reduced in number.

From simply a commercial-fisheries perspective, the introduction of the Nile perch into Lake Victoria was a success. Western fisheries managers regard the Nile perch as far superior to the cichlids because of its size and tasty meat. The result is that the perch have brought more cash into the local economy, although this will probably not last into the future due to overfishing.

The local people traditionally sun-dried their fish but because the Nile perch is so oily, it must be smoked instead. This requires wood to fuel the fire, a process that is contributing to deforestation.

Some questions to consider: ***Is it important to save the cichlids? How can they be saved? Is there a way to stop cutting down trees used for smoking the perch? What happens if the perch is overfished? Who should make the choices? Are there other solutions not being considered?***

Roles for debate: ***fishers, local government agents, Western consumers, evolutionary scientists, environmentalists, local store owners, for managers***

Shark finning

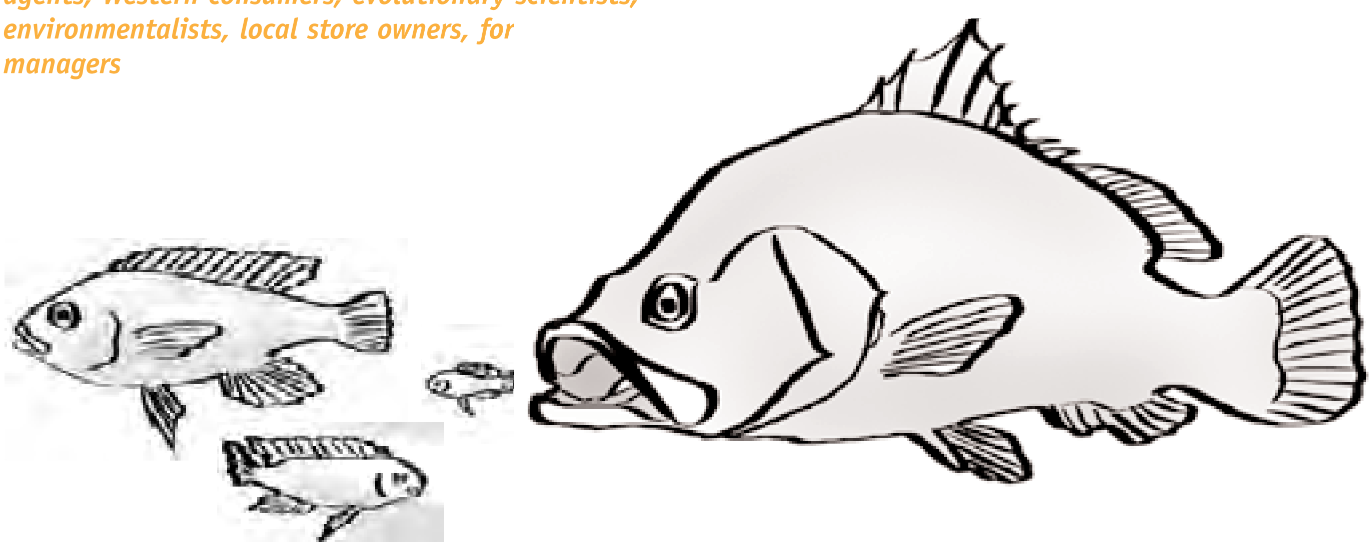
Unfortunately, sharks have a reputation as fearsome predators and are not valued for the important part they play in the food chain of the ocean. Therefore very little attention has been paid to shark fishing practices and numbers. Dramatic increases in recent years in international demand is causing a rapid decline in shark populations in many parts of the world. In Hawaii alone, 50,000 blue sharks are killed every year. Sharks are more and more the victims of bycatch as other fishing industries grow. Sharks have also become a much more popular target of recreational fishing boats.

Although sharks are fished for many purposes, by far the most valuable commodity is the shark's fins which can fetch up to $25 per pound. This is because they are considered a prized delicacy in many Asian countries for making shark-fin soup which sells in restaurants for as much as $150 per bowl. Many times the fin is obtained in a process call "finning" in which the fin is sliced off the body and the shark is thrown back into the water. Unable to swim, the shark drowns.

Sharks are particularly vulnerable to this exploitation because they have a long life span and slow reproduction cycles. They do not reach sexual maturity until late in life and have few offspring. As a result, recovery from overfishing is a very difficult process.

Some questions to consider: ***How would the loss of shark species affect the health of the oceans? Should limits be placed on shark fishing? Should shark finning be illegal? Who should decide? Are there other solutions not being considered?***

Roles for debate: ***commercial fishers, recreational fishers, environmentalists, government agents, restaurant owners, shark-fin soup consumers***



Fishes Fiesta

Wrap up your study of fishes with a look at your favorite fish and a Fishes Fiesta!

Theme IV Activity 3

FOR GRADES K-2, 3-5, 6-8

OBJECTIVES

Students will:

- review what they have learned during their study of fishes and relate it to conservation
- write a story about a particular fish species with both fiction and nonfiction components

GOALS AND STANDARDS

This activity meets:

- Illinois State Goals in Science: *Goals 1 and 4*
- National Science Education Standards:
  Unifying Concepts and Processes Standard
  K-4 Content Standards A and C
  5-8 Content Standards A and C

TIME

60-120 minutes
(can be divided into shorter time segments)

MATERIALS

For each student:

- materials for making a fish book (markers, crayons or paint, paper, etc.)
- adhesive nametag

For the class:

- reference books and materials
- ingredients for making fish snacks

PROCEDURE

1. Begin your final fishes activity by asking the children to refer back to the drawings they did at the beginning of their study of fishes. They will probably be surprised to see much they have learned during the course of your exploration. Lead a discussion to review the major themes found in the Activities and Backgrounds. Emphasize conservation and the future of fishes by discussing ways that each student can make a difference. This could include not eating threatened species, informing others about endangered species, or writing government

officials about their concerns. Instruct students to write their ideas about conservation in their journals.

As your study of fishes draws to a close, decide how you would like to proceed with the journals. For example, children could trade journals to share ideas, or they could be presented to parents at conferences or another event. You may want to utilize them for assessment in such areas as progress in their study of fishes, problem-solving skills, writing skills, etc.

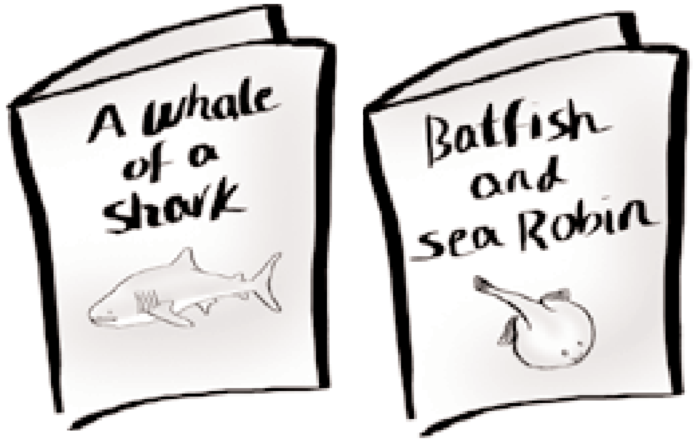
2. Ask each child to decide which was his or her favorite fish as the basis of a book they will each write and illustrate. Tell them to begin their books with a fictional story using their favorite species as the "star." However, even though the story is fictional, they should incorporate accurate information. For example, if their fish is a coral reef species, the setting should not be in a river. At the end of the book students should include as much factual information about the fish, including an accurate illustration, as is appropriate for your age group.

   You may customize this activity. For example, you might prefer that students work in pairs or small groups. You might suggest that the books be made in the shape of the fish or let the children invent their own design. You could offer the option of presenting the information in other formats such as a play or puppet show.

3. Culminate your study with a Fishes Fiesta, a celebration of fishes and a reminder of our responsibility to keep the Earth healthy for fishes in the future. Choose a date and time and decide whether to invite others such as parents or other classes. If others will be invited, make and send invitations.

4. Plan "fishy" snacks such as "seaweed shakes" or "plankton sandwiches" to be invented and created by the children. Snacks should be decided in advance with each small group choosing something to make for the Fiesta. Students will need to discuss supplies with you and arrange a time to make their snack. For example, if they chose to make Jell-o® in fish shapes it would need to be purchased and prepared in advance.

5. Begin the Fiesta with the children presenting their books or other creations to the class and visitors. As part of their presentation, ask them to include actions that they will take to protect the future of fishes.



6. Play ***"Who am I?"*** Beforehand, for each child, write the name of a fish species on an adhesive nametag making the fishes as easy or difficult as you wish. For example, for younger children, you could use only species that are on the poster so that they could refer to it if they have difficulty. Conversely, the game could be made more challenging by not using any of the species on the poster. Stick a nametag on each child's back so that others can read it but the child wearing it cannot. Children need to guess the name of the fish on their backs by asking their classmates questions that can only be answered with "yes" or "no." For example, "Do I live on the coral reef?" or "Do I use camouflage to hide from predators?" If you would like to make it competitive, the object is to figure out the name of the species on the back with as few questions as possible.

7. Eat your "fishy" snacks and enjoy!

EXTENSIONS

As a class, join an environmental group or groups involved in the conservation of fishes.

Begin a campaign in your school to boycott eating species of fishes or other marine animals that are threatened or endangered.

Ask children to organize in groups according to the habitats of their favorite fishes. Each group can then create a mural or display incorporating their fishes into those habitats.

Glossary

abyss: the deepest part of the ocean

adaptation: an inherited trait that increases an organism's chance of survival and reproduction

barbels: fleshy tentacles near the mouths of some fishes used to taste or touch their surroundings

bycatch: animals caught unintentionally in fishing nets

camouflage: the use of color or patterns to blend in with natural surroundings

dermal denticles: toothlike scales covering a shark's body

gill filaments: feathery folds in a fish's gill used to absorb oxygen from the water

gill rakers: stiff bars in a fish's gill used to strain food from the water

habitat: the specific environment in which an organism lives and upon which it depends for food and shelter

invertebrate: an animal without a backbone

lateral line: network of sensory cells interconnected by fluid-filled canals running the length of a fish; canals are attached to nerves that are sensitive to sound or pressure waves

nares: nostril-like organs used for smelling, not breathing

neutral buoyancy: weightlessness in water

operculum: protective bony covering for a fish's gills

plankton: free-floating, often microscopic, plants and animals found at or near the surface of seas and lakes

predator: an animal that hunts and kills other animals for food

prey: an animal that is hunted for food

swim bladder: a large, air-filled organ that counteracts a fish's weight in water

taxonomy: the science of classification

vertebrate: an animal with a backbone

Bibliography

TEACHER RESOURCES

The Audubon Society's Field Guide to North American Fishes, Whales, and Dolphins. New York: Alfred A. Knopf, 1983.

Bailey, Jill. *Fish: Encyclopedia of the Animal World*. New York: Facts On File, Inc., 1990.

Bulloch, David K. *The Underwater Naturalist: A Layman's Guide to the Vibrant World Beneath the Sea*. New York: Lyons & Burford, Publishers, 1991.

Christie, David A. *Remarkable Animals*. Gothenburg, Sweden: Johnston and Company, 1987.

Fautin, Daphne C., and Gerald R. Allen. *Anemone Fishes and Their Host Sea Anemones*. Melle, Germany: Tetra-Press, 1994.

Holing, Dwight. *Coral Reefs*. San Luis Obispo, Ca.: Blake Publishing, 1990.

Humann, Paul. *Reef Fish Identification*. Jacksonville, Fl.: New World Publications, Inc., 1989.

Long, John A. *The Rise of Fishes: 500 Million Years of Evolution*. Baltimore, Md.: The Johns Hopkins University Press, 1995.

Moyle, Peter B. *Fish: An Enthusiast's Guide*. Berkeley: University of California Press, 1993.

Parker, Steve. *Ocean Life*. Avonmouth, Great Britain: Parragon Book Service, Ltd., 1994.

Paxton, Dr. John R., and Dr. William N. Eschmeyer, Editors. *Encyclopedia of Fishes*. San Diego: Academic Press, Inc., 1995.

Quinn, John R. *Fishwatching: Your Complete Guide to the Underwater World*. Woodstock, Vt.: The Countryman Press, Inc., 1994.

Simon, Noel. *Nature in Danger: Threatened Habitats and Species*. New York: Oxford University Press, 1995.

Smith, C. Lavett. *Fish Watching: An Outdoor Guide to Freshwater Fishes*. Ithaca, N.Y.: Cornell University Press, 1994.

Steelquist, Robert. *Field Guide to the Pacific Salmon*. Seattle: Sasquatch Books, 1992.

Thorne-Miller, Boyce, and John Catena. *The Living Ocean: Understanding and Protecting Marine Biodiversity*. Washington, D.C.: Island Press, 1991.

Thorne-Miller, Boyce. *Ocean: Photographs From the World's Greatest Underwater Photographers*. San Francisco: Collins Publishers, 1993.

Wexo, John Bonnett. Prehistoric Zoobooks: *Swimmers*. San Diego: Wildlife Education, Ltd., 1989.

Wilson, Roberta, and James Q. Pisces. *Guide to Watching Fishes: Understanding Coral Reef Fish Behavior.* Houston, Tx.: Pisces Books, 1992.

STUDENT BOOKS

Fiction

George, Jean Craighead. *The Case of the Missing Cutthroats: An Ecological Mystery*. New York: HarperCollins Publishers, 1975.

Lionni, Leo. *Swimmy*. New York: Pantheon Books, 1968.

Lionni, Leo. *Fish Is Fish*. New York: Pantheon Books, 1970.

Seuss, Dr. *McElligot's Pool*. New York: Random House, 1947.

Sharpe, Susan. *Waterman's Boy*. New York: Bradbury Press, 1990.

Turnage, Sheila. *Trout the Magnificent*. Orlando: Harcourt Brace Jovanovich, Publishers, 1984.

Wildsmith, Brian. *Fishes*. New York: Franklin Watts, Inc., 1968.

Nonfiction

Cole, Joanna, and Jerome Wexler. *A Fish Hatches*. New York: William Morrow and Company, 1978.

Cone, Molly. *Come Back Salmon: How a Group of Dedicated Kids Adopted Pigeon Creek and Brought It Back to Life*. San Francisco: Sierra Club Books for Children, 1992.

The Cousteau Society. *The Garibaldi Fish of the Pacific*. New York: Simon & Schuster Books for Young Readers, 1991.

Ganeri, Anita. *Creatures that Glow: Discover the Way that Nature Lights Up the Dark*. New York: Harry N. Abrams, Inc., 1995.

Halton, Cheryl Mays. *Those Amazing Eels.* Minneapolis: Dillon Press, Inc., 1990.

Hirschfeld, Robert. *Nature's Children: Tropical Fish.* Danbury, Ct.: Grolier Educational Corporation, 1997.

Parker, Steve. *Fish:* Eyewitness Books. New York: Alfred A. Knopf, 1990.

Pfeffer, Wendy. *What's It Like to Be a Fish?* New York: HarperCollins Publishers, 1996.

Savage, Stephen. *Salmon.* New York: Thomson Learning, 1995.

Segaloff, Nat, and Paul Erickson. *Explore the Undersea World: Fish Tales.* New York: Sterling Publishing Co., Inc., 1990.

Snedden, Robert. *What is a Fish?* San Francisco: Sierra Club Books for Children, 1993.

Stratton, Barbara R. *What is a Fish?* A New England Aquarium Book. New York: Franklin Watts, 1991.

Taylor, Barbara. *Coral Reef: A Close-up Look at the Natural World of a Coral Reef.* New York: Dorling Kindersley, Inc., 1992.

Watts, Barrie. *Stickleback.* London: A & C Black, 1988.

Zim, Herbert S., and Hurst H. Shoemaker. *Fishes: A Guide to Freshwater and Saltwater Species.* New York: Golden Press, 1991.

VIDEOS

Gregory, Alex, and Dennis B. Kane. *The Living Edens: Palau.* (PBS Home Video). ABC/Kane Productions International, Inc., 1998.

Hall, Howard and Michele. *Jewels of the Caribbean Sea.* (National Geographic Video). National Geographic Society, 1994.

Hutt, David. *Fish.* (Eyewitness Video Series). Dorling Kindersley Vision, 1994.

Shamu and You: Exploring the World of Fish. Sea World/Busch Gardens Video Treasures, 1992.

Unwanted Catch. New England Aquarium and The Pew Charitable Trusts, 1998.

Video Fish Book: A Video Guide to the Fish and Marine Life of the Caribbean, Bahamas and Florida. Miami: Video Fish Book, 1990.

WEB SITES

http://www.mbl.edu
Access to pictures and information about various fishes.

http://www.mcgill.ca/Biology/labs/vincent/seahorse/project.htm
Information about Project Seahorse.

http://www.mote.org
Information about fishes and related research programs.

http://www.seaworld.org/sharks/pageone.html
Information about sharks and their relatives.

http://www.wwf.org/yoto/sharks3.htm
Article: Sharks in Trouble.

For more information about Shedd Aquarium and its education programs, please write, call, fax, or visit our home page:

John G. Shedd Aquarium
Education Department
1200 S. Lake Shore Drive
Chicago, Illinois 60605
phone: (312) 939-2426
fax: (312) 663-1472
http://www.sheddnet.org

John G. Shedd Aquarium is owned and managed by the Shedd Aquarium Society, in partnership with the Chicago Park District. It is accredited by the American Association of Zoos and Aquariums and is a member of the Alliance of Marine Mammal Parks and Aquariums.

Printed on chlorine-free paper