NATIONAL GEOGRAPHIC

RESOURCE LIBRARY
LESSON

Fisheries

Students explore issues related to fisheries sustainability and simulate fish monitoring methods commonly used by scientists and resource managers.

GRADES

9 - 12+

SUBJECTS

Biology, Ecology, Earth Science, Oceanography, English Language Arts, Geography, Human Geography, Physical Geography, Mathematics

CONTENTS

3 Activities

ACTIVITY 1: FISHERIES AND SEAFOOD CONSUMPTION | 1 HR

DIRECTIONS

1. Have students identify important fishing regions and their geographic and ecological features.

Arrange students in pairs and give each pair a copy of the Major Fisheries of the World map and chart. Using the Water Planet Mega Map, included in the World Physical MapMaker Kit, point out the five important fishing regions one at a time. Use the information provided in the Teacher Guide for Marine Fisheries Discussion to discuss the geographic and ecological features that characterize the different fishing regions. These features are what make the regions such good fishing areas. During the discussion, have one student from each pair use shading and labeling to identify the regions on their map. Have the other student in each pair fill in the chart. Throughout the activity, have students take turns working on the chart and the map.

2. Discuss the relationship between fisheries regions, fish ecology, and human consumption of seafood.

Explain to students that the types of fish found in these regions depend on the habitat and food sources that are available. Some fish are primary consumers, while others are top predators. Some, like salmon, pollock, and cod, live in cold ocean waters; others, like tuna and mackerel, adapt to warmer waters. Groundfish include cod, sole, rockfish, haddock, and flounder, which spend a part or all of their life on or near the bottom. Others, like herring and anchovies, live near the surface. State that numerous factors have contributed to what is being called a "global fisheries crisis." Ask: *What do you think that means?* Elicit from students that many global fisheries are overfished and threatened by multiple human impacts, including improvements in fishing methods and technology, as well as increases in the number of fishing fleets, coastal human populations, and demand for seafood. Scientists estimate that humans have removed as much as 90 percent of the ocean's large predatory fish, including sharks, swordfish, and cod. In some countries, up to 70 percent of the protein consumed comes from seafood.

3. Show students the Impact of Seafood interactive and have them complete their worksheets.

Project the National Geographic Impact of Seafood interactive and have students watch the introductory video by Enric Sala. Then click on the Seafood Decision Guide tab and have students select one fish or invertebrate to use in demonstrating how the interactive works. Discuss with them what is meant by the trophic level, sustainability ranking, toxicity level, and omega-3 content. Use the seafood decision guide to research the sustainability of one type of seafood from each of the five major fishing regions. Have student pairs label the location of the fisheries on their maps and fill in the chart with the seafood names and sustainability levels. Examples of seafood by region are listed on the teacher guide. Then have students click on the interactive's World's Seafood Footprint tab and record the catch levels and consumption levels for each of the five major fisheries regions. Students should use a scale of low, medium, and high. Move the cursor to compare and contrast levels of catch and consumption between the U.S. and other countries. To help students visualize how fisheries have expanded over the last 60 years, click on the Where Fish Are Caught link located on the lower left corner of the World's Seafood Footprint page.

4. Have students reflect on what they learned.

On their own paper, have students reflect on what they learned in writing. Ask:

- *How do the locations of the world's fisheries relate to levels of human population and seafood consumption?*
- *Why would raising consumer awareness help to alleviate some of these problems?*
- *Do you think you or your family would change your seafood choices if you knew more about these issues?*

Discuss student responses as a class and explain that raising consumer awareness would prevent overfishing of marine animals whose populations are not sustainable—like some of the seafood species they just researched. Then show them the other educational resources that are available on the Impacts of Seafood website. Be sure to point out the links to the Additional Seafood Guides and explain that these resources are helping educate people all over the world so that they can make more responsible seafood choices.

Modification

Use the Impact of Seafood interactive to research locally fished species.

Informal Assessment

Use student worksheets and free response answers to assess their comprehension of the issue of overfishing.

Extending the Learning

If possible, have students watch the documentary film *The End of the Line: Imagine a World Without Fish*.

OBJECTIVES

Subjects & Disciplines

Biology

Earth Science

- Oceanography

Geography

- Human Geography
- Physical Geography

Learning Objectives

Students will:

- identify major fishing regions on a world map
- describe key geographic and ecological features that make these areas good fishing regions
- identify the sustainability level and geographic distribution of selected seafood species
- discuss what the global fisheries crisis is and how human populations and consumption impact it
- reflect on how people can make more sustainable seafood choices

Teaching Approach

- Learning-for-use

Teaching Methods

- Discussions
- Hands-on learning
- Information organization
- Visual instruction

Skills Summary

This activity targets the following skills:

- 21st Century Themes
  - Global Awareness
- Critical Thinking Skills
  - Analyzing
  - Understanding
- Geographic Skills
  - Acquiring Geographic Information
  - Analyzing Geographic Information
  - Answering Geographic Questions
  - Organizing Geographic Information

National Standards, Principles, and Practices

NATIONAL GEOGRAPHY STANDARDS

- **Standard 14:**

How human actions modify the physical environment

- **Standard 8:**

The characteristics and spatial distribution of ecosystems and biomes on Earth's surface

NATIONAL SCIENCE EDUCATION STANDARDS

- **(9-12) Standard F-3:**

Natural resources

- **(9-12) Standard F-4:**

Environmental quality

- **(9-12) Standard F-5:**

Natural and human-induced hazards

OCEAN LITERACY ESSENTIAL PRINCIPLES AND FUNDAMENTAL CONCEPTS

- **Principle 5c:**

Some major groups are found exclusively in the ocean. The diversity of major groups of organisms is much greater in the ocean than on land.

- **Principle 5i:**

Estuaries provide important and productive nursery areas for many marine and aquatic species.

- **Principle 6b:**

From the ocean we get foods, medicines, and mineral and energy resources. In addition, it provides jobs, supports our nation’s economy, serves as a highway for transportation of goods and people, and plays a role in national security.

- **Principle 6c:**

The ocean is a source of inspiration, recreation, rejuvenation and discovery. It is also an important element in the heritage of many cultures.

- **Principle 6d:**

Much of the world’s population lives in coastal areas.

Preparation

BACKGROUND & VOCABULARY

Background Information

Humans once thought the ocean offered never-ending abundance; however, overfishing is causing extreme imbalances in marine ecosystems. Scientists predict that if fishing rates continue as they have been, all of the world's fisheries will have collapsed by the year 2048. Although fisheries management, law enforcement, and increased use of aquaculture can help prevent such a steep decline, illegal fishing and a lack of awareness on the part of seafood consumers continue to add to the problem.

Prior Knowledge

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Recommended Prior Activities

- Fisheries Sustainability

Vocabulary

Term	Part of Speech	Definition
fishery	*noun*	industry or occupation of harvesting fish, either in the wild or through aquaculture.
upwelling	*noun*	process in which cold, nutrient-rich water from the bottom of an ocean basin or lake is brought to the surface due to atmospheric effects such as the Coriolis force or wind.

FUNDER

ORACLE

ACTIVITY 2: FISH TAGGING AND MONITORING | 1 HR

DIRECTIONS

1. Discuss how and why scientists monitor fish populations.
Ask students to brainstorm a list of reasons scientists might want to monitor the populations of marine organisms like fish. Write students' responses on the board. Prompt them to include reasons such as understanding population dynamics and migration patterns, knowledge of breeding sites and feeding habits, and management strategies such as setting catch limits or providing species protection. Then ask:

- *What difficulties are researchers likely to encounter while trying to observe fish in the ocean?* (large schools, constant swimming, tracking movement throughout the water column or migration to different locations, distinguishing one fish from another, lack of technology or resources)
- *How might scientists go about monitoring fish?* (tagging, tracking, mark and recapture, collection, and data collection)

Explain that two common methods used to monitor fish populations are movement mapping, or tracking, and mark and recapture. Tracking is a process in which marine biologists and resource managers use technology to tag fish and map their movements. Mark and recapture is a process where a small group of a particular fish species is captured, marked or tagged, and then released so they can be recognized during a later recapture. These methods help scientists better understand the numbers and distributions of fish populations.

2. Introduce the fish mark and recapture simulation activity.
Tell students that fish tags are important tools for assessing fish populations. Conducted properly, tagging can provide information on movement patterns, seasonal variations, harvest levels, and birth and mortality rates—all of which can lead to healthier fish stocks. Divide students into teams of three. Tell students that they will conduct a simulation to estimate the population of *Carassius auratus* (goldfish) within a specific area using the mark and recapture method. Explain that after a population of fish has been captured, marked, and released, scientists then go back and recapture another sample of fish from the same area; some of which may be marked and some of which may not be marked. A simple ratio is then calculated to represent the total population of the species. The population size can be estimated from as few as two visits to the study area, but more than two visits are desired for increased accuracy. If needed, demonstrate the mark and recapture process, including the completion of a data table section, before students conduct the experiment on their own.

3. Have students conduct the first trial in the fish mark and recapture simulation.
Have each team assign team members the roles of marker, trapper, and data recorder. Give each team a copy of the Fish Mark and Recapture Simulation worksheet. Have each team go to a station with two different colored markers and a medium-sized bowl containing approximately 200 goldfish-shaped crackers and approximately 50 fish-shaped pretzels. Explain to students that the goldfish-shaped crackers represent goldfish, their target species, and the fish-shaped pretzels represent bycatch, or the unwanted portion of a fishing catch. First, have teams guess the number of goldfish in the bowl and record it under the "original estimation" column of the data table. Then have the trapper close his or her eyes and scoop a sample from the bowl. Have the marker write the letter M on all goldfish in the sample. Have the data recorder record the number of goldfish (M) and the number of fish-shaped pretzels (bycatch caught). Return the fish back to the bowl and mix thoroughly.

4. Have students conduct the second trial in the fish mark and recapture simulation.
Have the trapper collect a second, larger sample of fish. Have the marker write the letter C on all goldfish and the letter R on the goldfish that were recaptured. Have the data recorder use the data table to record the number of fish that were captured (C), the number of fish that were recaptured (R), and any bycatch.

5. Ask students to estimate the size of the population.
Once students have conducted two trials, have them estimate the size of the target species population (N) using the following formula:

 # target fish caught in Trial 1 (marked M) × # target fish caught in Trial 2 (marked C) ÷ Total # recaptured fish in Trial 2 (marked R) = Estimate of target species population (N)

Write the following example on the board: Scientists catch and tag 100 salmon in the initial catch (M), and they mark all of these fish. When they collect a second catch (trial 2), they capture a total of 70 salmon (C), of which 10 are marked (R).

100 fish caught and tagged in Trial 1 (M) × 70 fish caught in Trial 2 (C) ÷ 10 recaptured fish that had tags (R)

(100 × 70) ÷ 10 = 700 (Or, there are approximately 700 target species, salmon, in the population.)

6. Ask students to calculate the percentage of bycatch.

Have groups calculate the percentage of bycatch in their total catch for each trial using the following formula and multiplying the result by 100:

Bycatch Total (Bycatch Trial 1 + Bycatch Trial 2) ÷ Total # fish caught (M + C + # Bycatch Trial 1 + # Bycatch Trial 2) = Bycatch Ratio

Bycatch Ratio × 100 = Percentage of Total Bycatch

Tell students that, unlike in a real ecosystem, they can check how well their mark-recapture method worked. Have teams count the actual number of target species (goldfish) in their bowl and write it in the worksheet.

7. Analyze the data as a class.
Have a whole-class discussion about the data. Ask:

- *Did any team have a population estimate that matched the actual total?*
- *How many of you overestimated in your guess? How many underestimated?*

Ask students if they noticed any errors in their sampling methods or if there were any differences in students' attitudes about the sampling method within their group. Explain that when doing data collection fieldwork in groups, differences in attitudes and methodology can create a "sampling bias" in the data. Tell students it is important to follow established methods closely and conduct as many trials as possible to ensure accurate data.

Modification

In Step 3, you can use colored beans, cut up pieces of straws, paper fish, or other objects instead of edible goldfish-shaped crackers.

Informal Assessment

Have students work independently to solve the following word problem: A group of scientists are studying cod (*Gadus morhua*) populations in the southern Gulf of St. Lawrence to see if they are increasing or decreasing in numbers. The scientists are using fish tag data compiled from a sampling series using the mark and recapture method. To estimate the number of cod in the area, scientists captured 1,500 fish, marked them, and let them go. The next day, they captured 1,675 from the same area. Of these, 270 had been marked the day before. About how many cod are in the Southern Gulf of St. Lawrence? (9,306 cod)

Extending the Learning

Have students follow up on what they learned by writing their responses to the following questions on a separate sheet of paper and discussing their answers as a class.

- *Why might a scientist use an estimate instead of counting each and every individual?* (Catching every individual fish in a population is impractical.)
- *What are advantages and disadvantages of using the mark and recapture method?* (Advantage: Scientists are able to estimate population size when it is too difficult to count individuals; Disadvantage: Estimates are not always accurate. They depend on the number of individuals in the area where the population is sampled being indicative of how many organisms can be found in one spot for the entire population.)
- *What factors must scientists consider when choosing a monitoring method?* (program's objectives, cost, animal size, tag size and color, number of animals to mark, area of study, effects on the animals)
- *To sample fish populations in the field, what types of instruments or tools would a scientist need?* (nets or traps, computer, maps, GPS unit)

OBJECTIVES

Subjects & Disciplines

Biology

- Ecology

Earth Science

- Oceanography

Geography

- Physical Geography

- Mathematics

Learning Objectives

Students will:

- explain why researchers study fish populations
- describe two methods used by researchers to study fish populations
- simulate the mark and recapture method

- estimate the size of a fish population and the percentage of bycatch

Teaching Approach

- Learning-for-use

Teaching Methods

- Brainstorming
- Cooperative learning
- Discussions
- Information organization
- Simulations and games

Skills Summary

This activity targets the following skills:

- 21st Century Student Outcomes
  - Learning and Innovation Skills
    - Communication and Collaboration
    - Critical Thinking and Problem Solving
- Critical Thinking Skills
  - Analyzing
  - Applying
  - Understanding
- Geographic Skills
  - Analyzing Geographic Information
  - Answering Geographic Questions

National Standards, Principles, and Practices

NCTM PRINCIPLES AND STANDARDS FOR SCHOOL MATHEMATICS

- **Data Analysis & Probability (9-12) Standard 3:**

Develop and evaluate inferences and predictions that are based on data

NATIONAL GEOGRAPHY STANDARDS

- **Standard 16:**

The changes that occur in the meaning, use, distribution, and importance of resources

NATIONAL SCIENCE EDUCATION STANDARDS

- **(9-12) Standard A-1:**

Abilities necessary to do scientific inquiry

- **(9-12) Standard E-2:**

Understandings about science and technology

OCEAN LITERACY ESSENTIAL PRINCIPLES AND FUNDAMENTAL CONCEPTS

- **Principle 6b:**

From the ocean we get foods, medicines, and mineral and energy resources. In addition, it provides jobs, supports our nation's economy, serves as a highway for transportation of goods and people, and plays a role in national security.

- **Principle 6c:**

The ocean is a source of inspiration, recreation, rejuvenation and discovery. It is also an important element in the heritage of many cultures.

Preparation

BACKGROUND & VOCABULARY

Background Information

Scientists use various methods to study fish populations, including tagging and mark and recapture. The information can aid researchers and managers in evaluating abundance and migration patterns, birth rates, mortality rates, and harvest levels of different marine populations. As with any scientific methodology, error and bias can be introduced and should be addressed appropriately.

Prior Knowledge

["basic algebra"]

Recommended Prior Activities

- None

Vocabulary

Term	Part of Speech	Definition
bycatch	*noun*	fish or any other organisms accidentally caught in fishing gear.
mark-recapture method	*noun*	way of monitoring animal population. A random group of animals is captured, marked with a tag or band, and released before another random group from the same population is captured. Some of the animals from the second group may have been tagged previously. Also called sight-resight, band recovery, and capture-mark-recapture.

FUNDER

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ACTIVITY 3: FISHERIES SUSTAINABILITY | 2 HRS 30 MINS

DIRECTIONS

1. Have students answer pre-assessment questions.
Distribute the Fisheries Sustainability worksheet and give students time to independently answer the questions in Part 1. Then have a whole-class discussion about students' responses.

2. Have students take notes as they watch two National Geographic videos.
Explain to students that they will take notes in Part 2 of the Fisheries Sustainability worksheet as they watch videos. Show students the National Geographic videos "Declining Fish" (3 minutes) and "Herring Hazards" (8 minutes). Then, as a class, discuss what students listed as important ideas, statistics, and key terms.

3. Have students make concept map vocabulary cards to learn more about fisheries sustainability.

Divide students into small groups and distribute the Fisheries Sustainability Vocabulary handout. Read the directions aloud. Have students use the terms to create concept map vocabulary cards. Using index cards or paper cutouts, have them draw triangles on each card and then write the following information in each angle of the triangle: a definition of the term (in their own words), characteristics of the term, and examples of the term. After each group has made all of its vocabulary cards (11 total), have the group number or letter the cards so that they know which term each card represents. Explain that each group will be trading its cards with another group, so they need to make sure that the other groups do not know their numbering/lettering system. After trading cards, challenge students to match each term to its corresponding concept map card. Facilitate group work and address any misconceptions, as needed. Tell students that, during the next class session, they will apply what they have learned to predict the status of several United States fisheries.

4. Have students complete the Fisheries Sustainability Research worksheet.
Divide students into pairs and distribute the Fisheries Sustainability Research worksheet. Have them use the provided NOAA National Marine Fisheries Service FishWatch website to research and predict the status of a variety of United States fisheries.

5. Have students map the fisheries using the National Geographic Water Planet Mega Map.
Ask each group of students to use their completed fisheries sustainability research to map one or more fishery on the Water Planet Mega Map, included in the World Physical MapMaker Kit. Make sure that all of the fisheries are mapped.

6. Have students reflect on what they learned.
Summarize the important information students should glean from their research. The primary issues affecting the sustainability of marine fisheries include overfishing, illegal fishing, habitat damage, bycatch, and management. Marine fisheries in the United States have a status that ranges from sustainable to collapsed or recovering. To be sustainable, a fishery's population must be managed in a way that provides for today's needs without damaging the ability of the species to reproduce and be available for future generations. Have a whole-class discussion. Ask: *What were your fisheries status predictions? Explain your reasoning. Why do you think groups made different predictions?* Have students look back at the questions they answered in Part 1 of the Fisheries Sustainability worksheet. On the back of the worksheet, or on a separate sheet of paper, have each student write about whether or not their answers have changed based on what they learned from the activity and how. Then have a whole-class discussion about their reflections.

Informal Assessment

Assess students' completed worksheets for accuracy. Check students' understanding by asking them to orally restate the observations they made, including key terms, after watching the videos and completing the card activity. Use the provided Fisheries Sustainability Research Answer Key to facilitate group discussion and questioning.

Extending the Learning

Have students research and present information about the sustainability of a managed fishery in their own state. Use the NOAA: Fisheries—Office of Sustainable Fisheries website to find a list of State-Federal Fisheries.

OBJECTIVES

Subjects & Disciplines

Biology

- Ecology

Earth Science

- Oceanography

- English Language Arts

Geography

- Human Geography
- Physical Geography

Learning Objectives

Students will:

- use scientific terminology to describe the sustainability status of marine fisheries
- describe the primary fisheries issues and their effects on the sustainability of various United States fisheries

Teaching Approach

- Learning-for-use

Teaching Methods

- Cooperative learning
- Discussions
- Information organization
- Multimedia instruction
- Research
- Visual instruction

Skills Summary

This activity targets the following skills:

- 21st Century Student Outcomes
  - Learning and Innovation Skills
    - Communication and Collaboration
- Critical Thinking Skills
  - Analyzing
  - Applying
  - Understanding
- Geographic Skills
  - Acquiring Geographic Information
  - Organizing Geographic Information

National Standards, Principles, and Practices

IRA/NCTE STANDARDS FOR THE ENGLISH LANGUAGE ARTS

• **Standard 8:**
Students use a variety of technological and informational resources (e.g., libraries, databases, computer networks, video) to gather and synthesize information and to create and communicate knowledge.

NATIONAL GEOGRAPHY STANDARDS

• **Standard 1:**
How to use maps and other geographic representations, geospatial technologies, and spatial thinking to understand and communicate information

• **Standard 14:**
How human actions modify the physical environment
• **Standard 18:**
How to apply geography to interpret the present and plan for the future.

NATIONAL SCIENCE EDUCATION STANDARDS

• **(9-12) Standard C-4:**
Interdependence of organisms
• **(9-12) Standard E-2:**
Understandings about science and technology
• **(9-12) Standard F-4:**
Environmental quality
• **(9-12) Standard F-5:**
Natural and human-induced hazards

OCEAN LITERACY ESSENTIAL PRINCIPLES AND FUNDAMENTAL CONCEPTS

• **Principle 5c:**
Some major groups are found exclusively in the ocean. The diversity of major groups of organisms is much greater in the ocean than on land.
• **Principle 5i:**
Estuaries provide important and productive nursery areas for many marine and aquatic species.
• **Principle 6b:**
From the ocean we get foods, medicines, and mineral and energy resources. In addition, it provides jobs, supports our nation's economy, serves as a highway for transportation of goods and people, and plays a role in national security.
• **Principle 6c:**
The ocean is a source of inspiration, recreation, rejuvenation and discovery. It is also an important element in the heritage of many cultures.
• **Principle 6d:**
Much of the world's population lives in coastal areas.

Preparation

BACKGROUND & VOCABULARY

Background Information

The primary issues affecting the sustainability of marine fisheries include overfishing, illegal fishing, habitat damage, bycatch, and management. Marine fisheries in the United States have a status that ranges from sustainable to collapsed or recovering. To be sustainable, a fishery's population must be managed in a way that provides for today's needs without damaging the ability of the species to reproduce and be available for future generations.

Prior Knowledge

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Recommended Prior Activities

- Fisheries and Seafood Consumption

Vocabulary

Term	Part of Speech	Definition
bycatch	*noun*	fish or any other organisms accidentally caught in fishing gear.
collapsed fishery	*noun*	fishing industry where the number of fish has been severely reduced or depleted. Also called a depleted fishery.
fishery	*noun*	industry or occupation of harvesting fish, either in the wild or through aquaculture.
recovering fishery	*noun*	fishing industry where catches are increasing after having been reduced or depleted.
sustainable fishery	*noun*	industry of harvesting fish or shellfish that can be maintained without damaging the ecosystem or fish population.
sustainable seafood	*noun*	fish, shellfish, and other aquatic organisms harvested from fish farms or fisheries that can be maintained without damaging the ecosystem.

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