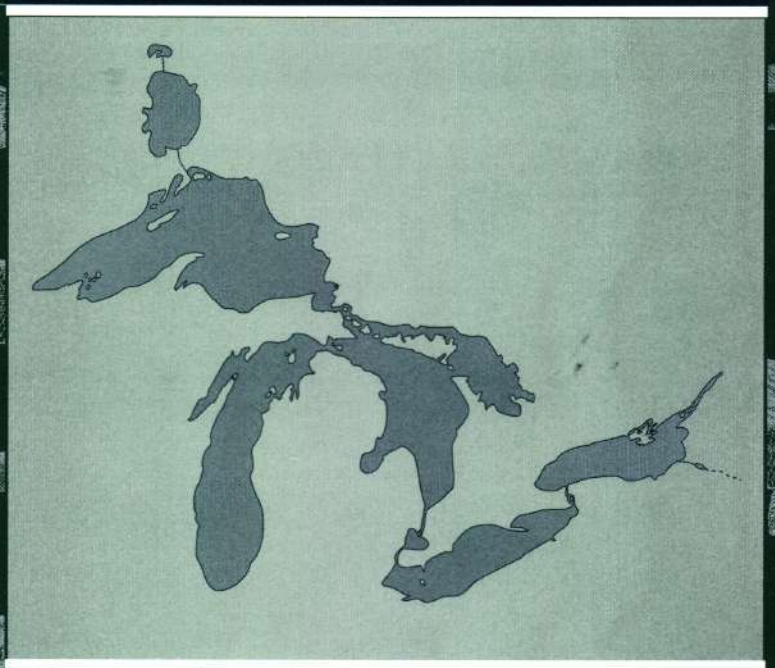
The Life of the Lakes, A Guide to Great Lakes Fishery Education Materials
Michigan State University Extension Service
Shari L. Dann, Ph.D., Department of Fisheries and Wildlife
Issued September 1994
84 pages

THE LIFE OF THE LAKES

A Guide to Great Lakes Fishery Education Materials



The world's greatest freshwater fishery.

Michigan Sea Grant Extension
Michigan State University

The Life of the Lakes

A Guide to Great Lakes Fishery Education Materials

Shari L. Dann, Ph.D.
Department of Fisheries & Wildlife
Michigan State University

Acknowledgements

Production of this guide was made possible by a grant from the National Fish and Wildlife Foundation, Washington, DC.

Author: Shari L. Dann, Ph.D.
Department of Fisheries & Wildlife
Michigan State University

Graphic Design: Ken Dettmer
Graphicom

Graphic Art: Jody Kubitz
Department of Fisheries & Wildlife
Michigan State University

Illustrations: Ned Fogle, Ph.D.
Fisheries Division
Michigan Department of Natural Resources

Carol Allaire
Michigan Sea Grant College Program

Todd Buck

Instructional Media Center
Michigan State University

Research: Three activities are updated and revised from the curriculum *Investigating the Great Lakes Environment: Unit 2, Great Lakes Fishing in Transition* (by Nowak, P., L. Lin and W. Stapp. 1983. MICHU-SG-83-400. Michigan Sea Grant College Program, Ann Arbor, MI.)

Editing: Carol Y. Swinehart
Michigan Sea Grant Extension

Tom Mitchell
Outreach Communications
Michigan State University

Typing: Julie Detwiler
Vernie Nichols

Reviewers: Jody Kubitz
Michaela Zint
Department of Fisheries & Wildlife
Michigan State University

Carol Allaire
Walter Hoagman
Ron Kinnunen
Jim Lucas
John McKinney
Chuck Pistis
Steve Stewart
Michigan Sea Grant College Program

Rosanne Fortner
Ohio Sea Grant College Program

Sally DeRoo
Plymouth Public Schools
Plymouth, MI

Lisa Dzierwa
Cherry Knoll School
Traverse City, MI

Denise Seipke
Greening of Detroit
Detroit, MI

Steve Piersma
Grand Haven Public Schools
Grand Haven, MI

Alan Crook
Ontario Ministry of Natural Resources

Jon Stanley
Dave Walsh
Michael Hansen
National Biological Survey
U.S. Department of the Interior
Ann Arbor, MI

The Life of the Lakes
A Guide to Great Lakes Fishery Education Materials

Table of Contents

Introduction: Purpose of the Guide

This guide is designed for educators working with youth ages 12–18 (middle school and high school youths). The activities, curriculum materials, concepts, discussion questions and teaching ideas are appropriate for middle school and high school settings, and for nonformal youth education settings such as 4–H clubs, other youth organizations, camps, and nature centers. Classroom teachers as well as youth organization volunteers will find a great variety of resources and ideas in this guide. Educators will be able to adapt activities and discussion ideas to their audience's age level and their educational setting. Many activities are designed for cooperative learning by groups of youths. In addition, there are many ideas for independent research/learning projects which might occur over longer periods than the typical class or club meeting. Educators should feel free to use this guide as a "smorgasbord" of teaching ideas -- pick and choose those activities that are most meaningful for the audience, and sequence them in whatever way they wish.

This guide is part of a multi–media educational package. Other components of this package include:

VT-044, The Life of the Lakes: The Great Lakes Fishery ($25.00)

A 55–minute broadcast–quality video program that portrays the Great Lakes fishery today, describes how it has changed since the Great Lakes were formed, and presents the challenges the fishery faces in the future.

E-2440, The Life of the Lakes: A Guide to the Great Lakes Fishery ($7.50)

A booklet with clear, interesting graphics that provides comprehensive background information to supplement the concepts presented in the video. The booklet is packaged with three poster–sized inserts – one presenting a timeline of the history of the Great Lakes fishery, another listing all the fish species found in the lakes and their tributaries, and a map of the Great Lakes basin.

E-2442-2447, The Life of the Lakes: Posters ($1.50 each)

A set of six posters – featuring maps of each lake and one of the Great Lakes basin, text describing various aspects of the fishery and illustrations of some Great Lakes fishes.

To order additional copies of these materials, contact: Michigan Sea Grant Extension, 334 Natural Resources Bldg., Michigan State University, East Lansing, MI 48824, (517) 353-9568.

This guide for educators is divided into several sections. First, a Curriculum Framework outlines key concepts an educator might teach using the topic of Great Lakes fisheries. This framework is intended as a general guide, since many areas within the Great Lakes basin have their own, more specific frameworks for teaching science, social studies and/or environmental education.

Next, a discussion guide is presented to help the educator using the video "The Life of the Lakes." This guide is divided into several sections to provide ideas for discussing the past, present and future of Great Lakes fisheries.

Six activities are provided in this guide to accompany "The Life of the Lakes" video and map/posters. These activities do not duplicate the wealth of existing, high quality educational materials available. Three activities are updated and revised from the curriculum Investigating the Great Lakes Environment: Unit 2, Great Lakes Fishing in Transition (by Nowak, P., L. Lin and W. Stapp. 1983. MICHU–SG–83–400. Michigan Sea Grant College Program, Ann Arbor, MI.)

A set of overhead masters is also part of this guide. These are based on graphics found in the publication "The Life of the Lakes: A Guide to the Great Lakes Fishery." Ideas for their use are found throughout this guide.

Finally, a wealth of teaching materials and specific educational contacts are listed. These should guide educators toward valuable, existing resources of particular interest.

SPECIAL NOTE: One of the narrators of the video "The Life of the Lakes: The Great Lakes Fishery" is Dr. Sylvia Earle, internationally renowned scientist and spokesperson on behalf of the world's waters. (Dr. Earle is mentioned as a role model in Michigan Essential Goals and Objectives for Science Education K–12.) Dr. Earle is a marine biologist, underwater explorer, and former chief scientist of the National Oceanic and Atmospheric Administration (NOAA). Dr. Earle holds the world record for a solo deep ocean dive to 3,000 ft. that was completed in a one–person submersible vessel. Her most recent goal is to reach the greatest ocean depths using new technologies she is helping to design. She has discovered and catalogued previously unknown ocean life and has a sea urchin *(Diadema sylvie)* and an underwater plant *(Pilina*

earli) named after her. Youth might enjoy using magazines and other references to research her work and the work of other prominent aquatic scientists. References to consult include:

Champion of the Deep: Oceanographer Sylvia Earle, by Peggy Orenstein, New York Times Magazine, June 23, 1991.

History of Women in Science for Young People, by Vivian Sheldon Epstein. VSE Publisher, 212 South Dexter St., Denver, CO 80222.

Dr. Sylvia Earle: NOAA's Chief Scientist Fueled by the Possibility of Discovery, by Cathie Cush, Underwater USA, June 1991.

Teaching About Great Lakes Fisheries

The materials provided in this publication were designed to provide teaching outlines/plans for a two–week thematic unit about Great Lakes fisheries for middle school or high school youth. Within this publication are six activities, and the video is segmented into four sections for ease of presentation during typical class or meeting periods. In addition, there is a wealth of ideas for short, warm–up activities as well as for long–term, individual or group study projects. You may want to consult the outline entitled "Factors Influencing Today's Great Lakes Fisheries" (page 43 in "The Life of the Lakes: A Guide to the Great Lakes Fishery") to organize your thoughts for teaching.

The following are some teaching tips.

1. Using the glossary in "The Life of the Lakes: A Guide to the Great Lakes Fishery," the curriculum frameworks (below), and the activities in this guide, identify the concepts you wish to teach. Consult other curriculum materials (see pages 75-76) for additional activities to reinforce these concepts with your youth.

2. Using the information presented in this curriculum package, adapt activities from Project WILD–Aquatic or other curricula with Great Lakes specific information.

3. Work with teachers of other disciplines or other youth club leaders to coordinate activities which are cross–curricular and interweave social studies, science, folklore, math and other subjects.

4. Plan a special Great Lakes fisheries event. This might be timed during Ocean Week, a week designated to celebrate state or provincial history, Coastweeks, Earth Day, Free Fishing Week, or a local event. Teach about Great Lakes fisheries, and have youth share their longer–term study projects with the public during the special event.

5. Help youth tackle "Ways You Can Help Great Lakes Fisheries Into the Future" (listed in "The Life of the Lakes: A Guide to the Great Lakes Fishery").

The following curriculum framework is provided for science activities related to Great Lakes fisheries. It is adapted and modified from *Michigan Essential Goals and Objectives for Science Education K–12.* This framework lists possible goals and objectives for your teaching.

I. Constructing new scientific knowledge pertaining to Great Lakes fisheries:

- A. Generate scientific questions about fisheries, based on experience with video and learning activities.
- B. Investigate fishing technologies.
- C. Use sources of information to help solve problems.
- D. Diagnose possible reasons for failures of systems (i.e., why fisheries declined).
- E. Gather and synthesize information from books and other sources.

II. Reflecting on scientific knowledge of Great Lakes fisheries:

A. Evaluate the strengths and weaknesses of claims, arguments or data pertaining to contaminants in Great Lakes fishes and other issues.

B. Describe limitations in personal knowledge.

C. Show how common themes of science, math, and technology apply to Great Lakes fisheries.

D. Describe the benefits and risks of new technologies or patterns of human activity for Great Lakes fisheries.

E. Describe some general limitations of scientific knowledge regarding Great Lakes fisheries.

F. Discuss the historical development of practices, principles and efforts in Great Lakes fisheries science and management.

G. Describe the historical, political, and social factors affecting developments in Great Lakes fisheries sciences (i.e., How has the formation of the Great Lakes Fishery Commission advanced fisheries management?).

III. Using scientific knowledge to understand the organization of living things:

A. Compare and classify Great Lakes fishes and organisms into major groups.

B. Describe the life cycles of organisms.

C. Explain the process of food storage and food use in organisms (i.e. photosynthesis in phytoplankton).

IV. Using scientific knowledge to understand ecosystems:

A. Describe common patterns of relationships among populations of Great Lakes organisms (predator and prey, parasitism).

B. Predict the effects of changes in one population in the Great Lakes food web on other populations (i.e., predict effects of introductions of exotic species).

C. Describe how all organisms in an ecosystem acquire energy directly or indirectly from sunlight.

D. Describe ways in which humans alter the environment.

E. Explain how humans use and benefit from plants and animals found in the Great Lakes.

F. Explain how energy flows through the Great Lakes food web (i.e. pyramid of biomass, consumers, producers, decomposers).

G. Describe response of an ecosystem to events that cause it to change (i.e. introduction of species, environmental degradation).

The following conceptual framework is provided for environmental education activities related to Great Lakes fisheries. Environmental education frameworks integrate many disciplines (such as math, science, social studies) within an environmental problem–solving context. This framework was adapted from the conceptual framework presented in the popular curriculum, Project WILD.

1. Developing **awareness** of and **appreciation** for Great Lakes fisheries, including fish species, their habitats, and humans interacting with these resources.
2. Understanding the **diversity of human values** (aesthetic, spiritual, ecological, scientific, social, political, commercial, economic, and recreational) related to Great Lakes fisheries.
3. Understanding **ecological principles** related to Great Lakes fisheries.
4. Understanding and taking part in Great Lakes fisheries **management and conservation.**
5. Understanding **cultural and social interactions** with Great Lakes fisheries.
6. Understanding and investigating Great Lakes fisheries **issues, trends and consequences.**
7. Understanding and demonstrating **responsible actions** toward Great Lakes fisheries.

Activities provided in this curriculum guide (pages 12 to 61) and in other curricula address these objectives. Check with your state or provincial department of education for guidelines and objectives for ways to integrate Great Lakes fisheries concepts and issues into your science, social studies and/or environmental education efforts.

Pre– or Post–Video Short Activities and Activities Using Great Lakes Fisheries Map/Posters

• Have youths (in groups) draw pictures of their images of past, present, and future Great Lakes fisheries. Later, compare their images with what they learned from the video or from an activity.

• Ask groups of youths to list or draw images or words that come to mind when they hear the words "Great Lakes fisheries." How would this group's images compare with those of adults? Of anglers? Of a commercial fishing family? After the video, compare the youths' images with those in the video.

• Ask youths to draw the Great Lakes from memory, and to name some of the fishes found in each lake. Compare the youths' drawings with information presented in the video, in the map/posters and/or in the pocket insert listing fishes found in the Great Lakes.

• Have youths tell fish stories related to the Great Lakes. Have them include in their stories information about how the lakes affect them and how they affect the lakes.

• Give each group of youths a Great Lakes fisheries map/poster. Have each group create a poster or banner highlighting the fisheries resources of one of the Great Lakes.

• Give each group a Great Lakes map/poster, a state, provincial or regional map, and a copy of your state's or province's fish consumption advisory (may be printed with other fishing license and regulations information or may be available separately where fishing licenses are sold). Have the youths find areas with fish names, communities which have active commercial or charter fishing enterprises, or lakes/streams with fish consumption advisories. Plot those areas on the map/poster.

• Have groups of youths use the map/posters to create their own "Trivial Pursuit" or "Jeopardy" types of questions. Write the questions on index cards. Play the game!

• Have the youths play a version of "Pictionary" or charades using concepts, fish species, terms learned from "The Life of the Lakes" video, map/posters, and activities.

• After showing the video, have youths write "The Rest of the Story" – a story or timeline with their projections of what will happen to the Great Lakes fishery into the future. Have them include in their story ways that **they** will impact the fishery and water quality in the Great Lakes.

VIDEO DISCUSSION

Great Lakes Fisheries: The Present

Start: Beginning of tape.

Stop: At end of Sandra Andrews (MSU) quote: "Anytime you consume any food you need to be concerned about risks, and that's the same with fish – no more than any other food. You just need to know the facts before you consume the fish."

Time: About 13 minutes.

Background: Pages 5–20 in "The Life of the Lakes: A Guide to the Great Lakes Fishery."

Key words and ideas: Great Lakes, fishery, habitat, spawn, reefs, wetlands, predators, fry, plankton, food web, forage fishes, Native American fishery, Canadian commercial fishery, state licensed commercial fishery, sport fishery, economic impact, nutritional value of fish, contaminants in fish.

Ways to Introduce the Segment:

Tell the group:

- a little about the content of the video and who produced it.
- about how long this segment of the video is.
- something about the narrator, Dr. Sylvia Earle.
- that this segment describes the current status of the Great Lakes fishery.

Ask them:

- what is your image of the current status of the fishery? (See page 7 for additional ideas for pre–video activities.)
- to watch for images of the fishery, who is interviewed and what group they represent, different fish species found in the Great Lakes.

Review and Discussion Questions:

1. How many fish species are there in the Great Lakes and their tributaries? [More than 175 different species.] Did this variety and diversity surprise you? Why or why not?
2. Name the Great Lakes, their connecting waters, and important bays and regions of the Great Lakes. Locate these on the map/posters. Locate these on other regional maps. Can you find towns and other features with fish names on a map of your area?
3. What types of habitats do fishes use for spawning? [Reefs, wetlands, etc.]
4. Describe the Great Lakes food web. How are humans a part of Great Lakes food webs? [Emphasize sport fishery, commercial fishery (including tribal fisheries).]
5. What is a fishery? [The fishes, their environments, and the people who interact with them.] What do tribal fisheries and other commercial fisheries have in common? [Some operations have been in existence for several generations. Species sought are similar. Fishing is a way of life for some families today. Some techniques are similar.] How are sportfishing and commercial fishing similar? How do the two differ?
6. What is the total economic impact of the Great Lakes sport fishery? [$2–4 billion per year— 1980s estimate.] What jobs are created by the sport fishery? What jobs are created by the commercial fishery? How does the sport fishery provide access to thousands of people in the region? [Some fish on their own, other use charter boat facilities.] How does the commercial fishery connect thousands of people to the Great Lakes fishery? [Directly, for those who work in the fishery; indirectly, for those people who are consumers and purchasers of Great Lakes fish and fish products.]
7. What aspect of fish consumption is a major issue currently? [Level of contaminants in fish flesh.]

Related Activities:

Great Lakes Fisheries and the Economy
Fisheries Careers Scavenger Hunt
Great Lakes Food Web

Calculate the percentage of the Great Lakes fishes caught in each lake, by each state; calculate the percentage of the Great Lakes commercial catch by fish species

Make bar graphs of Great Lakes sportfishing and commercial fishing catch

Study the taxonomy of Great Lakes zooplankton, phytoplankton, benthos, and fishes (secondary biology)

Overheads:

Taxonomy of Zooplankton
Taxonomy of Phytoplankton
Taxonomy of Benthic Life in the Great Lakes
Great Lakes Ecology and Food Web
Commercial Fisheries in the Great Lakes
Sportfishing in the Great Lakes: Where it Occurs
Sportfishing in the Great Lakes: What Species Anglers Prefer
Fisheries Science and Management
Pyramid of Biomass and Biomagnification in the Great Lakes

VIDEO DISCUSSION

Great Lakes Fisheries: The Past (Post–Glacial Times to 1950s)

Start: Female Narrator: "The Great Lakes fishery has faced this and many other challenges throughout its history. As the glaciers ... ."

Stop: Male Narrator: "And now the lake trout is reproducing naturally in Lake Superior and, to a lesser extent, in Lake Huron. But it has a long way to go before regaining its former prominence."

Time: Approximately 15 minutes, 30 seconds.

Background: Pages 21–31 in "The Life of the Lakes: A Guide to the Great Lakes Fishery."

Key words and ideas: glaciers, early fishing methods (spears, scoop nets), treaties, effects on fisheries of various factors (immigrants, logging, farming, erosion, dams, mining, sewage, algae, wetlands, manufacturing, population growth, wastes, power plants, canals and locks, exotic species), other fishing methods (gill nets, pound nets, trap nets), peak catch in 1915, fisheries biologists (hatcheries, introduced species), women in the fishery, fishing pressure in WW II era, nylon gill nets, regulations, Welland Canal, sea lamprey, parasite, cooperation among states and Canada, Great Lakes Fishery Commission, TFM – chemical lampricide, re–establishment of naturally reproducing lake trout in suitable habitats.

Ways to Introduce the Segment:

Tell the group:

- about the length of this segment of the video.
- that this segment describes the early history of the Great Lakes fishery.

Ask them:

- if the Great Lakes fisheries of today are better off than or worse than the fisheries of the past?
- to note how the fisheries, fishing techniques, environment, and society changed over time in the Great Lakes region.

Review and Discussion Questions:

1. How old (geologically speaking) is the Great Lakes basin? [Glaciers started retreating from the region only 15,000 years ago, and fish have had only a short time to move into this area.]
2. How did the first European settlers perceive the region's fisheries resources? [Inexhaustible.] What techniques were used to catch fish around the late 1600s and early 1700s? [Seine nets, gill nets.]
3. Settlement brought incredible numbers of new residents into the Great Lakes region. What activities by this increasing population had effects on Great Lakes fish populations? [See key words, above.]
4. Review the major eras of time shown in the "Great Lakes Fisheries Timeline" and the background publication. When did many Great Lakes fisheries experience serious declines? [Different points in time in each Great Lake, but in general, serious declines were obvious by about the 1870s.] In what years did total Great Lakes fish catch peak? [1915–1918.] Why was Lake Superior the last to experience major declines of fish? [Lake Superior had lower human populations along shores and tributaries and is largest of the Great Lakes. And exotic species arrived at a different time.]
5. How did technologies for catching and handling fish change over the different eras? [Pound nets by mid–1800s; steam boats during the 1800s; railroad transportation of fresh fish; trap nets in 1890s; changes in boat engines around 1900.]
6. What were some of the earliest fisheries management practices used? [Hatcheries, limits and quotas on catches, closed seasons during spawning, limits on gear and commercial fisheries.]
7. When and how did the sea lamprey arrive in the lakes upstream from Lake Ontario? [See background publication.] How did it affect fisheries? [Led to decline of lake trout.] How did the U.S. and Canada respond to the crisis created by the sea lamprey? [Formation of the Great Lakes Fishery Commission in the 1950s. International and interstate cooperation on research, lamprey control and fisheries management began.]

Related Activities:

Where Have all the Lake Trout Gone?

Swimming Through Time: Fisheries Timeline

Great Lakes Food Web

Write to the Great Lakes Fishery Commission for their publication outlining fish catch statistics over the years. Make charts for species and lakes of interest.

Identify and research a coastal town in your state or province which historically was a large fishing port.

Overheads:

Great Lakes Ecology and Food Web

Historic and Commercial Fishing Nets in the Great Lakes

VIDEO DISCUSSION

Great Lakes Fisheries: The Recent Past (1960s to Present)

Start: Female Narrator: "Restoration of the lake trout hasn't been the only challenge and goal for fisheries scientists and managers. With the lake trout in jeopardy and other species no longer living in the lakes, the ecology of the Great Lakes was altered again. By the 1960s... ."

Stop: Male Narrator: "Today, the success of Lake Erie's walleye fishery is almost as world–famous as its near–collapse."

Time: Approximately 8 minutes.

Background: Pages 32–37 in "The Life of the Lakes: A Guide to the Great Lakes Fishery."

Key words and ideas: alewife, forage fish, coho and chinook salmon (Pacific salmon), contaminants (PCBs, DDT), fish consumption advisories, eutrophication (overfertilization) of Lake Erie, Great Lakes Water Quality Agreement in 1972 between the U.S. and Canada led to wastewater treatment, walleye.

Ways to Introduce the Segment:

Tell the group:

- about the length of this segment of the video.
- that this segment describes the recent history of the Great Lakes fishery.

Ask them:

- are the Great Lakes fisheries of today better off than or worse than the fisheries of the past?
- to watch for how the fisheries changed over time, how fishing techniques changed, how the environment changed, and how society in the Great Lakes region changed.

Review and Discussion Questions:

1. What other challenges became serious through the 1960s and early 1970s for Great Lakes fisheries? [Alewife invasion and population explosion.] How did resource management agencies respond to the invasion of the alewife? [Introduction of Pacific salmon in the Great Lakes in order to develop a new sport fishery.]
2. What threats to water quality in the Great Lakes became obvious in the 1970s? [Chemicals such as PCBs, DDT, mercury. Some fisheries closed due to mercury contamination. Point sources of pollution included factory discharges; nonpoint sources include airborne pollutants and sources such as agricultural run–off.]
3. How can humans reduce their exposure to fat–soluble organic contaminants (such as PCBs) in fishes? [Filleting, skinning, removing fat, cooking properly.] How much is known at present about the effects of fish contaminants on humans? [Research is just beginning in this area. More will be known in the immediate future.]
4. What threatened water quality and fisheries in Lake Erie in the late 1960s and 1970s? [Eutrophication from nutrients in agricultural run–off and municipal sewage discharge.] How were these problems addressed? [The Great Lakes Water Quality Agreement in 1972 led to more cities developing wastewater treatment processes.] What was the result? [Recovery of the great walleye fishery.]

Related Activities:

Swimming Through Time: Great Lakes Fisheries Timeline

Great Lakes Food Web

Contaminants in Great Lakes Fishes

Interview a parent or grandparent. Ask if they remember hearing about the "Death of Lake Erie" in the 1960s and 1970s. Ask them what else they remember about environmental issues during that time.

Find newspaper and magazine articles written about environmental issues in the 1960s and 1970s. Prepare a report or make a presentation.

Overheads:

Contaminant Trends in Lake Michigan Bloaters

Great Lakes Ecology and Food Web

Aquatic Life in the Great Lakes

VIDEO DISCUSSION
Great Lakes Fisheries: The Future

Start: Female Narrator: "The Great Lakes fishery continues to be challenged... . Cleaning up and preventing pollution is a priority."

Stop: End of tape.

Time: Approximately 16 minutes, 30 seconds.

Background: Pages 38–44 in "The Life of the Lakes: A Guide to the Great Lakes Fishery."

Key words and ideas: Areas of Concern, sea lamprey and lamprey control (sterile male release), St. Mary's River, exotic species, zebra mussel, food web, zooplankton, Bacterial Kidney Disease (BKD) in salmon, coastal wetlands and shoreline development, competition among fishery user groups, coordination of management through Great Lakes Fishery Commission, fisheries management, fisheries research, habitat, ruffe, Bc *(Bythotrephes cederstroemi)*, fish production.

Ways to Introduce the Segment:

Tell the group:

- about the length of this segment of the video.
- that this segment describes future possibilities for the Great Lakes fishery.

Ask them:

- to describe current and future challenges the Great Lakes fisheries will face.
- to imagine or to draw an image of the state of the Great Lakes fisheries in the future.

Review and Discussion Questions:

1. What are some success stories of the Great Lakes fisheries in recent decades? [Decrease in fish contaminant levels, improvements in farming and other land use practices that affect water quality, citizens banding together and increasing public awareness of Great Lakes issues.]
2. What challenges remain? [Sea lamprey control, other exotic species (zebra mussel, ruffe, Bc), dieases such as bacterial kidney disease (BKD), shoreline development and loss of spawning areas, conflict among user groups, coordinating fisheries management and research throughout the region, habitat and forage fish research, understanding how whole ecosystems function.]
3. How are agencies and organizations coordinating their efforts in managing Great Lakes fisheries? [Through the Great Lakes Fishery Commission, through new strategic planning efforts, by involving the public.]

Related Activities:

Contaminants in Great Lakes Fishes
Great Lakes Food Web

Investigate a Great Lakes fisheries issue. Some examples of issues/topics might include:

Contaminants in Great Lakes fishes and fish consumption advisories

Treaty fishing issues

Managing the sea lamprey

Invasion of the Great Lakes by exotic species

Involving the public in improving Great Lakes water quality

Sport fishing vs. commercial fishing issues

Coastal and wetlands development

Consider the following steps in investigating the issue.

1. Identify the issue.
2. What are the research questions about this issue that you want to try to answer?
3. What information will you need to collect to address your questions about this issue?
4. What are important words, terms, concepts you need to define to address your issue questions?
5. Will your investigation include a survey? If so, in what geographic area will you conduct your survey? What beliefs or opinions will you investigate in the survey? How will you collect and organize the data from your survey?
6. Propose possible solutions/resolutions to the issue you investigated.
7. Develop an action plan to work toward solving the issue you identified.

A good resource for educators is: *Investigating and Evaluating Environmental Issues and Actions: Skill Development Modules*, by H. R. Hungerford, R. A. Litherland, R. B. Peyton, J. M. Ramsey and T. L. Volk. 1992. Stipes Publishing Company, 10–12 Chester St., Champaign, IL 61820.

Overheads:

Contaminant Trends in Lake Michigan Bloaters

Pyramid of Biomass and Biomagnification in the Great Lakes

Great Lakes Ecology and Food Web

Aquatic Life in the Great Lakes

WHERE HAVE ALL THE LAKE TROUT GONE?

TEACHING ACTIVITY

Objectives

Youths will be able to:

- graph and interpret data in order to describe trends in lake trout catches and fishing effort from 1929–1970 in Michigan waters of Lake Superior.
- explain that heavy fishing and predation by sea lamprey helped cause the populations of lake trout to decline significantly in the Great Lakes.
- describe other human–caused factors which may have affected lake trout populations (changes in fishing technologies, habitat loss due to land use activities, contamination, construction of canals, etc.).
- explain that the intrusion of the sea lamprey into the Great Lakes may have affected human communities around these lakes (e.g. loss of jobs in the commercial fishing industry).

Methods: graph analysis and interpretation, discussion

Background: Pages 21 to 35 in "The Life of the Lakes: A Guide to the Great Lakes Fishery"

Duration: 50 minutes

Materials

- Data sheet (one sheet per group)
- Graphs of data (optional — if teacher is not having students plot the data)
- Newsprint or other paper
- Examples of graphs (bar, line and pie graphs)
- Blank graph paper
- Markers
- Masking tape
- Great Lakes Fisheries Timeline
- Overheads:
  - Historic and Commercial Fishing Nets in the Great Lakes
  - Graphs of data (optional)
  - Aquatic Life in the Great Lakes

Subjects: math, science (scientific processes), biology, social studies

Procedure

1. Divide the youths into groups of six. Give each group a copy of the data sheet.

For youths who have little skill in constructing and interpreting graphs:

2. Ask the youths to describe a graph. Ask them to describe several types of graphs (bar, line, pie); show examples in current periodicals or other sources such as science or math texts.
3. Have all of the youths participate in determining the scales of the graph; have one youth draw the axes. Have the youths take turns reading off a year and the pounds of lake trout caught in that year, as shown on the data sheet. Make a dot (or have a youth make a dot) on the graph at the intersection of these two values. Connect the dots to each other with a line.

   [NOTE TO TEACHER/YOUTH LEADER: To simplify this part of the exercise, youths with little graphing experience could: a) plot only every third or fourth data point, or b) simply interpret graphs copied and provided by the teacher.]

For all youths:

4. Using the data provided, have the youths construct the following graphs on the blackboard, on a piece of newsprint, or on a computer:
   - Catch of Lake Trout in Michigan Waters of Lake Superior, 1929–1970
   - Sea Lamprey Populations in Michigan Waters of Lake Superior, 1929–1970
   - Lake Trout Fishing Effort in Michigan Waters of Lake Superior, 1929–1970

- Catch Per Effort of Lake Trout in Michigan Waters of Lake Superior, 1929–1970.

5. Have youths look at the "Great Lakes Fisheries Timeline" and write important dates on their graph of "Catch of Lake Trout." Write in the dates for these events:

   Opening of Welland Canal [1829]

   Invention of nylon and its use in nets [1950s]

   Arrival of the sea lamprey in the Great Lakes [1880s; first in Lake Superior in 1946]

   World War II and increase in fishing effort [1939–1942]

   First use of chemical TFM to control sea lamprey [late 1950s]

   Limits on commercial fisheries in Michigan [1962]

   In addition, have the youths use the data tables to write in the following dates on the graph of Catch of Lake Trout:

   Year of greatest fishing effort [1949]

   Year of greatest sea lamprey population [1957]

For youths with extensive math and graph–making experience:

6. Explain to the youths that nylon gill nets were more than twice as efficient in catching lake trout than cotton twine nets. Have youths use the Effort Efficiency data to correct the values for effort and catch per effort (CPE). To do this:
   a. Multiply each year's value for effort by the number in the Effort Efficiency column.
   b. Calculate a new, corrected CPE by this formula: Catch ÷ Corrected effort.
   c. Plot these data.

Talking It Over

1. Ask the youths to explain what the graph demonstrates concerning the pounds of lake trout taken by commercial fishers between 1929 and 1970. When was the catch highest? Lowest? [The catch fluctuated quite a bit, but was at a steady, relatively high level until the late 1940s. Then, the catch declined greatly.] Can we ever know exactly how many fish are in a lake? [No, we can only estimate numbers of fish by the catch sizes or by other research methods.]

2. Have the youths brainstorm a list of possible causes for the decline in *catches* of lake trout. [Less fishing *effort*, heavy fishing (and changes in fishing technologies), or lower populations *(abundance)* of lake trout due to habitat loss (pollution, other factors) or due to sea lamprey predation.] Point out to the youth that unless fisheries biologists know how hard people were fishing for a species, it is hard to draw conclusions about a fish population.

3. Tell the youths that the most common method of harvesting lake trout in Lake Superior has been the gill net. One measure of the amount of peoples' fishing *effort* is 1,000s of feet of gill net set. What was the change in fishing effort for Lake Superior lake trout from 1929–1970? When was effort highest? Lowest? [Moderate through late 1930s, increasing greatly between late 1930s to 1950, then dropping very sharply until 1962.] What changes occurred in fishing technologies between 1929 and 1960? [Introduction of nylon in nets, use of radios.]

4. Tell the youths that now that the fishing *effort* is known, they will look at Catch Per Effort (CPE), or the amount of lake trout caught per thousand feet of gill net each year. Look at the graph "Catch per Effort of Lake Trout in Michigan Waters of Lake Superior, 1929–1970." When did CPE begin to decrease? [Late 1930s and late 1940s — when fishing effort was increasing greatly.] When did CPE reach its all–time low? [1960–61 — after sea lamprey had arrived.] What happened to lake trout CPE during the late 1960s? [Lake trout populations began to recover, and are still at these levels in Lake Superior today.]

5. What trends are shown in the graph of "Sea Lamprey Populations in Michigan Waters of Lake Superior, 1929–1970?" [Sea lamprey appeared there in 1946, increased sharply in the late 1950s, then decreased sharply between 1961 and 1962.] What might be the relationship between the decline of the lake trout population and the increase in the population of the sea lamprey? [The entry of the sea lamprey in great numbers contributed to the decline of the lake trout, the most frequent prey of the sea lamprey. This occurred after the lake trout had already seriously declined due to heavy fishing.]

6. How did declines in lake trout probably affect human communities? [The declines cost people jobs. Fewer commercial fishers operated due to the decline of the lake trout. Other factors such as improved fishing technologies also reduced the number of commercial fishers. Some communities which had high numbers of commercial fishers changed, as well.]

7. The sea lamprey's impact on the Great Lakes was an unintended effect of opening several shipping canals. Could anyone have predicted environmental problems at the times the

Welland and Erie Canals were opened? [Probably not, since people are just now beginning to realize how human activities affect ecosystems. Also, at the time of the canals' construction, waterborne transportation was important in bringing necessary goods for human survival in the North American wilderness. The health of ecosystems was considered much less important at the time.]

8. Could anything similar happen today? [Today, as in 1825, political and economic considerations still weigh heavily when decisions concerning the environment are made. Research and practical experience have given us a much better understanding of how ecosystems work, although we are still a long way from understanding them completely. Governments have established procedures to consider and to regulate possible environmental impacts of human activities. Sometimes these guidelines, because of conflicting interest within our society, are not universally accepted. As examples of recent invaders, consider the ruffe and *Bythotrephes cedarstroemi*, both of which arrived in the Great Lakes during the 1980s in ballast water of international ships. Now, ships bound for Great Lakes ports must exchange their ballast water at sea before entering the St. Lawrence River. Also, ships travelling out of western Lake Superior must take precautions with ballast water so that the ruffe does not get transported to other areas of the Great Lakes.]

9. The sea lamprey population has been cut down significantly, but at considerable and rising costs. Why might costs of sea lamprey control have increased? [There are diminishing returns for greater efforts at control — in other words, it costs more to remove the last few lamprey than to remove the first lamprey. Inflation and increasing costs of handling and using the lampricide TFM also contribute to rising costs. Also, there are great costs in gaining permits and approval to continue to use TFM into the future. New, more cost–effective methods of sea lamprey control may be required. In addition, the financial costs of restoring lake trout through habitat restoration and planting of hatchery–reared trout is substantial and growing. All taxpayers share these costs.]

10. Have the youths play the role of fisheries researchers, and try to design a study of lake trout populations. What data were not known in analyzing the trends in this activity? [Amount and trends in sport anglers' harvest and fishing rates for lake trout; average sizes of lake trout caught.] Tell the youths that graphs *suggest* more than they *prove*. Graphs and data, by themselves, do not provide definitive answers. We must develop hypotheses and draw inferences from the data. This is the process we call scientific investigation. [Note to teacher/youth leader: Encourage youth to think of multiple alternative explanations for their observations. Encourage them to seek information from more than one source and to be aware of variables which were not included in a given study.]

Ways to Learn More

- Display the graphs at a science or county fair.
- Collect more information about changing fish populations in the Great Lakes.
- Write a scientific paper summarizing your results.
- Invite a fisheries biologist to review your data and make a presentation to the group.

NOTE TO THE TEACHER/YOUTH LEADER: Data were provided only for Michigan waters of Lake Superior for several reasons:

- It is one of the few complete data sets where data have been collected or maintained in a consistent manner over these decades.
- Lake Superior most clearly shows the sequencing of the effects of heavy fishing and sea lamprey predation on lake trout. In other Great Lakes, these events happened in different order or at nearly the same time, and scientists are still sorting out the causes for declines in lake trout in these more southerly areas of the lake trout's range.
- It is difficult to draw conclusions from data collected from different management jurisdictions (i.e. different states, Ontario). Each jurisdiction has a different history of management, regulations and research for lake trout. The math and graphing tasks and the interpretation of data are much simpler for youth if data are from one jurisdiction (i.e. from just Michigan).

Teachers and youth leaders are encouraged to obtain other data from their regions, but they may wish to do so only after youths have worked with this clearer data set. To obtain other data, contact your state or province's fisheries management or research agencies (see appendices in the publication "The Life of the Lakes: A Guide to the Great Lakes Fishery").

This activity has been updated and revised from the curriculum *Investigating the Great Lakes Environment: Unit 2, Great Lakes Fishing in Transition* (by Nowak, P., L. Lin and W. Stapp. 1983. MICHU–SG–83–400. Michigan Sea Grant College Program, Ann Arbor, MI.)

Data for this activity were obtained from the following references:

Hile, R., P.H. Eschmeyer and G.F. Lunger. 1951. Status of the lake trout fishery in Lake Superior. Transactions of the American Fisheries Society 80:278–312.

Jensen, A.C. and H.J. Buttner. 1976. Lake trout, whitefish, chubs and lake herring: Yield and effort data for state of Michigan waters of the upper Great Lakes, 1929–1973. Michigan Sea Grant Tech. Rep. 52, Ann Arbor, MI.

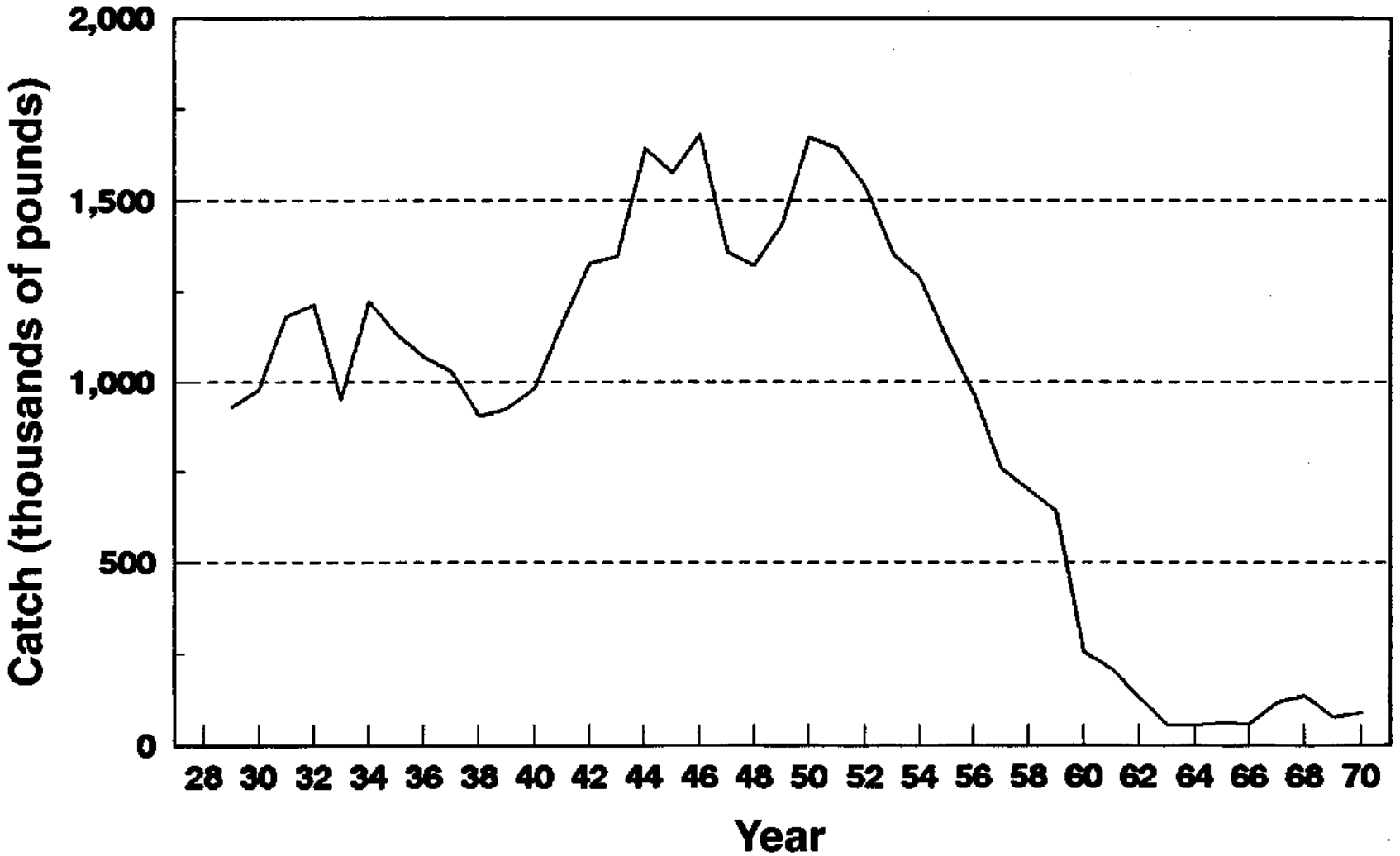
Pycha, R.L. 1962. The relative efficiency of nylon and cotton gill nets for taking lake trout in Lake Superior. J. of the Fisheries Res. Bd. of Canada 19:1085–1094.

Pycha, R.L. and G.R. King. 1975. Changes in the lake trout population of southern Lake Superior in relation to the fishery, the sea lamprey, and stocking, 1950–1970. Great Lakes Fishery Comm. Tech. Rep. 28, Ann Arbor, MI.

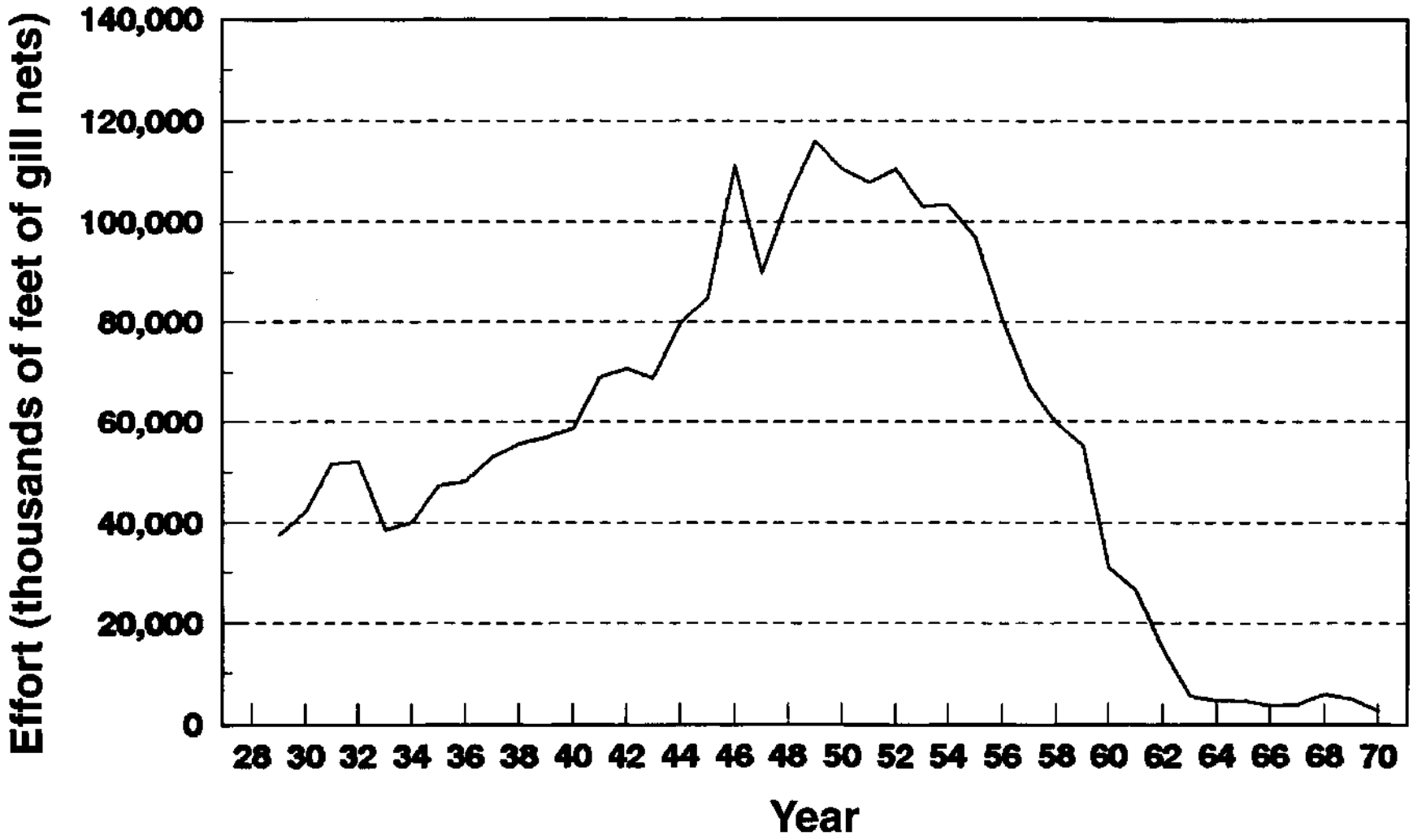
Lake Trout and Sea Lamprey in Michigan Waters of Lake Superior

Year	Licensed Commercial Catch of Lake Trout (lbs.)	Fishing Effort (thousands of feet of gill nets)	Catch Per Effort (CPE) of Lake Trout (Catch÷Effort)	Effort Efficiency	Number of Sea Lamprey (in thousands)
1929	930,215	37,510	24.80	1.00	
1930	976,963	42,352	23.10	1.00	
1931	1,182,071	51,684	22.90	1.00	
1932	1,214,431	52,209	23.30	1.00	
1933	950,696	38,494	24.70	1.00	
1934	1,222,484	40,220	30.40	1.00	
1935	1,131,435	47,437	23.90	1.00	
1936	1,070,505	48,206	22.20	1.00	
1937	1,028,778	52,914	19.40	1.00	
1938	903,954	55,712	16.20	1.00	
1939	923,792	57,148	16.20	1.00	
1940	981,137	58,848	16.70	1.00	
1941	1,166,220	68,999	16.90	1.00	
1942	1,328,915	70,873	18.80	1.00	
1943	1,347,250	68,865	9.60	1.00	
1944	1,644,708	79,777	20.60	1.00	
1945	1,576,251	85,026	18.50	1.00	
1946	1,684,287	111,435	15.10	1.00	(first seen)
1947	1,357,533	89,957	15.10	1.00	
1948	1,323,760	104,952	12.60	1.00	
1949	1,434,212	116,048	12.40	1.00	
1950	1,674,890	110,549	15.20	1.31	
1951	1,644,340	107,953	15.20	1.63	
1952	1,539,057	110,612	13.90	2.25	
1953	1,352,828	103,204	13.10	2.25	1,419
1954	1,287,019	103,434	12.40	2.25	4,224
1955	1,117,406	97,117	11.50	2.25	9,720
1956	970,329	80,425	12.10	2.25	20,757
1957	759,084	66,960	11.30	2.25	31,213
1958	700,367	59,762	11.70	2.25	22,252
1959	641,755	55,340	11.60	2.25	20,276
1960	254,812	31,098	8.20	2.25	22,825
1961	208,688	26,541	7.90	2.25	35,980
1962	132,011	14,722	9.00	2.25	5,610
1963	56,406	5,559	10.10	2.25	7,267
1964	56,169	4,791	11.70	2.25	4,772
1965	60,763	4,793	12.70	2.25	4,922
1966	58,342	3,895	15.00	2.25	3,580
1967	117,520	4,057	29.00	2.25	2,779
1968	135,117	6,009	22.50	2.25	5,109
1969	74,785	5,087	14.70	2.25	4,366
1970	88,053	2,783	31.60	2.25	3,774

Catch of Lake Trout in Michigan Waters of Lake Superior, 1929-1970

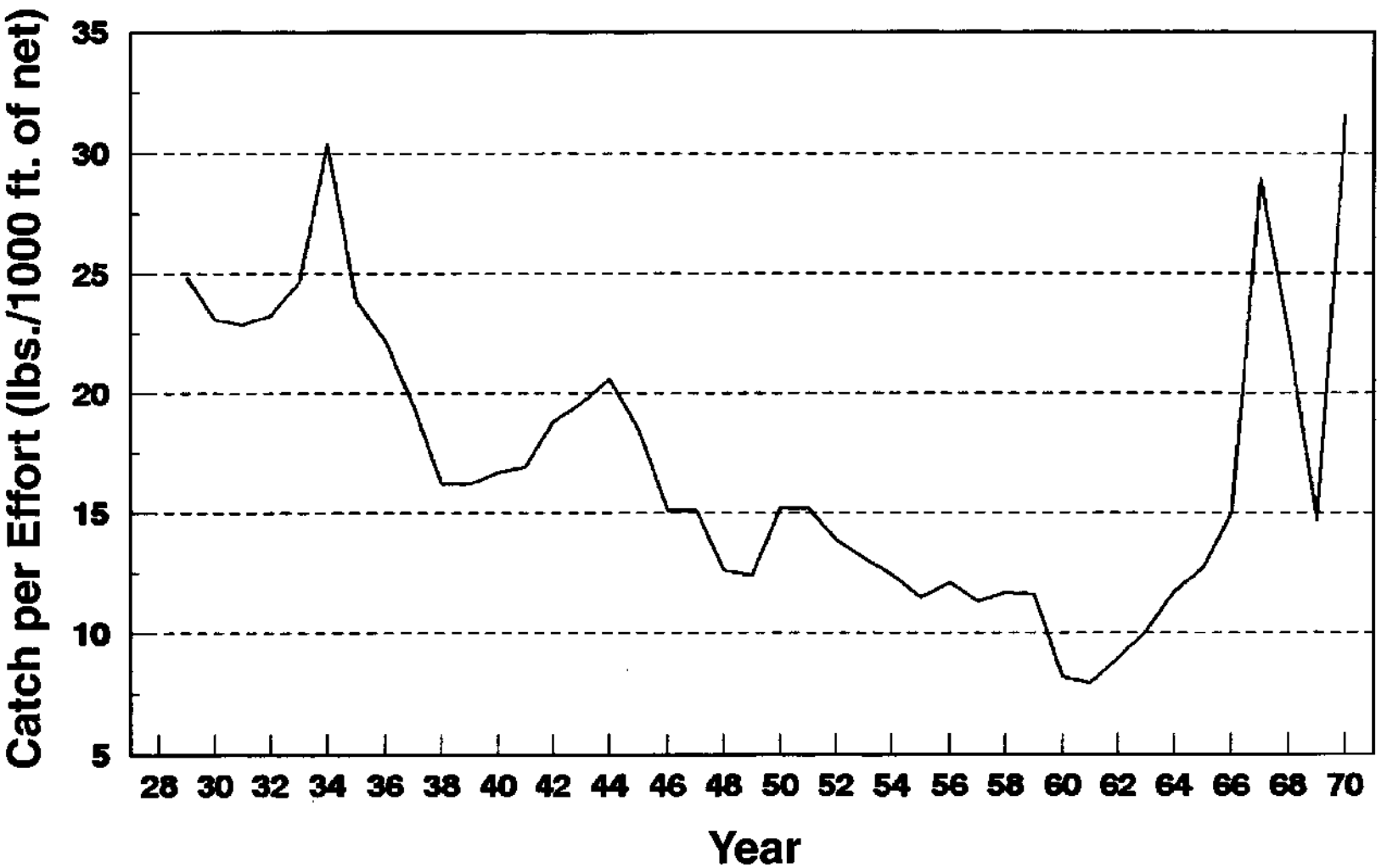


Lake Trout Fishing Effort* in Michigan Waters of Lake Superior, 1929-1970

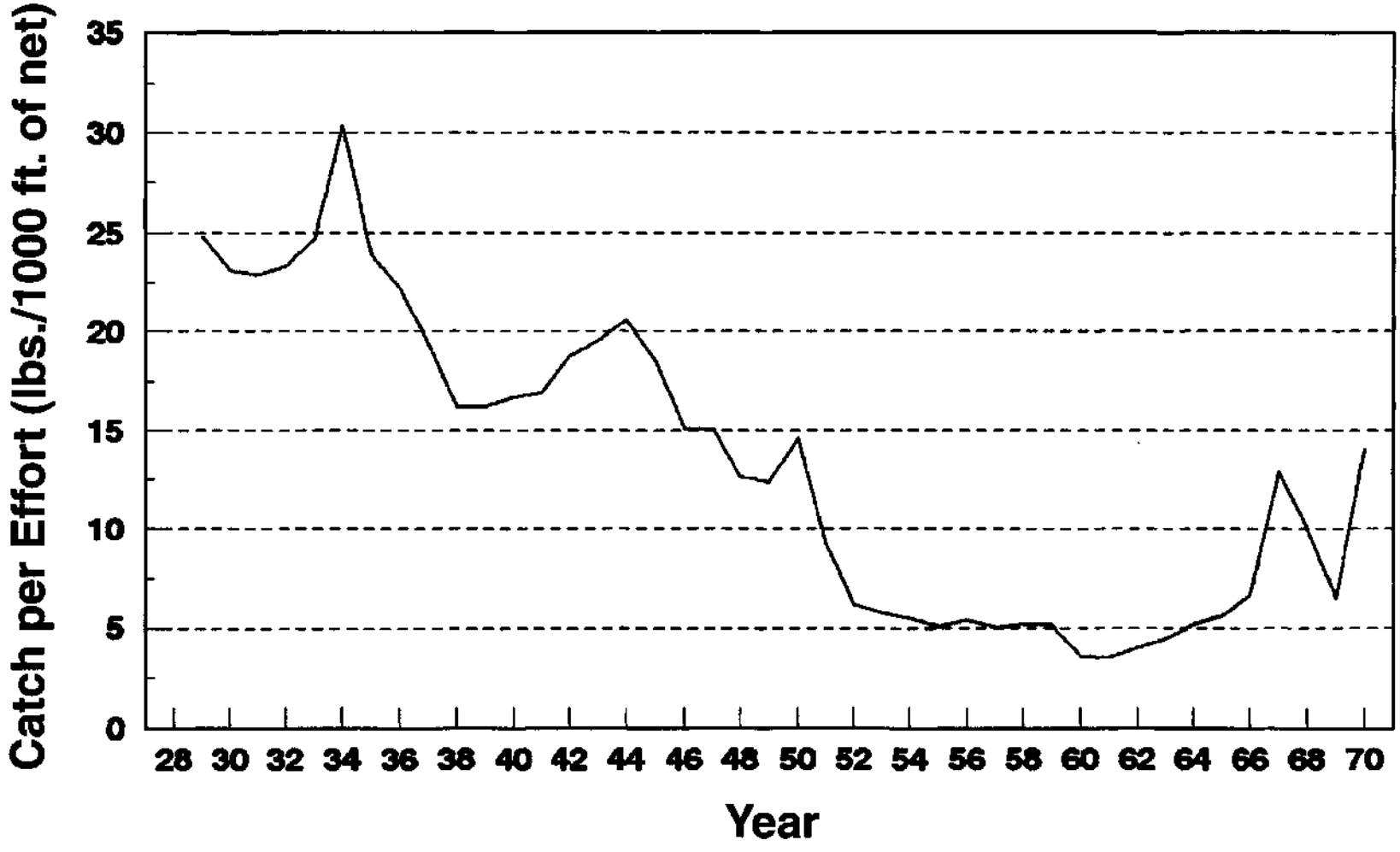


*commercial fishing only

Catch per Effort of Lake Trout in Michigan Waters of Lake Superior, 1929-1970

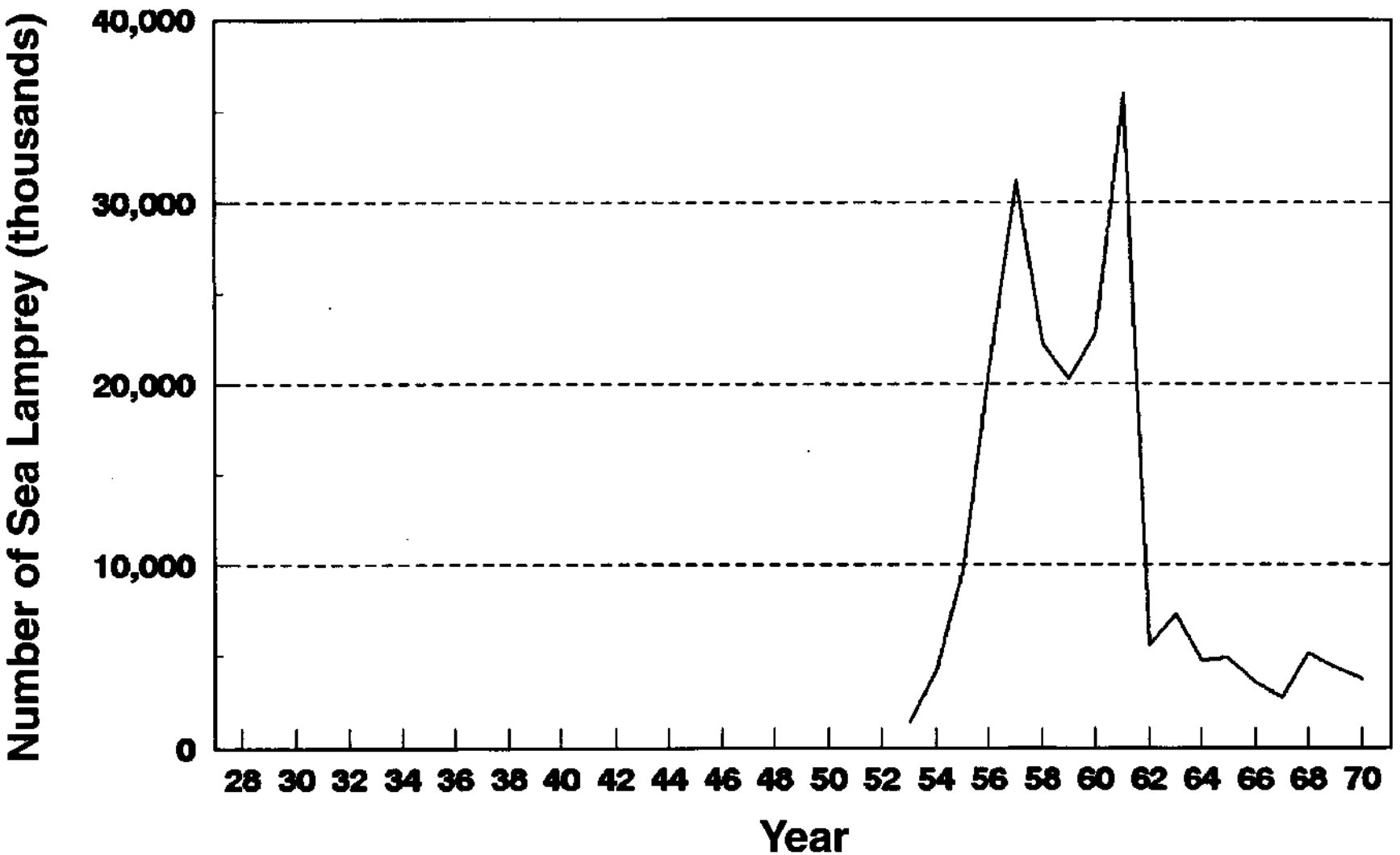


Catch per Effort (Corrected)* of Lake Trout in Michigan Waters of Lake Superior, 1929-1970



*Corrected for net efficiency

Sea Lamprey Populations in Michigan Waters of Lake Superior, 1929-1970



FISHERIES CAREERS SCAVENGER HUNT

Objectives

Youths will be able to:

- appreciate the need for and diversity of careers related to fisheries and aquatic sciences.
- list several types of related careers.
- understand that fisheries professionals work with fish habitats, fish populations and people.

Methods: group activity, discussion

Background: Pages 5 to 14 in "The Life of the Lakes: A Guide to the Great Lakes Fishery"

Duration: about 30 minutes

Materials

- Fishing, outdoor and environmental magazines and catalogs
- Newsprint or other paper
- Markers
- Overhead: Fish Production and Fisheries Science and Management

Subjects: biology, social studies, careers

Procedure

1. Divide the youths into groups of 4–6 youths per group. Give each group several magazines and catalogs, a larger piece of paper and some markers.
2. Tell the group that they will have 10–15 minutes to go on a scavenger hunt. Their job is to use the magazines and other information they may already know (i.e. from the video "The Life of the Lakes" and other sources) to list as many careers they can think of that have to do with fish, fisheries, fishing, or water. (You might provide a prize, such as an educational poster or magazine, to members of the group that lists the most careers.) Have each group write their list on the paper.
3. After the time is over, have each group share their list.

Talking It Over

1. Which group listed the most careers? Was anyone suprised by the number of different careers? Does anyone in the group know someone with one of these careers?
2. Have the group look at their lists. Can you divide the lists into careers that work mostly with fish populations, those that work mostly with fish habitats (including general water–related careers), and those careers that work mostly with people? Do some careers involve work with all three areas? (Share the overhead "Fisheries Science and Management.")
3. What type of preparation is needed for the careers listed? [Emphasize that college–level education is required for nearly all careers. For some careers, advanced college–level work is required.] What type of skills would these careers require? [Computer skills, writing skills, communication skills, problem– solving skills, science skills, legal skills, etc.]
4. What types of careers and skills will be needed to solve fisheries problems of the future?

Examples of Fisheries and Related Careers

- Aquaculturist
- Hatchery manager
- Aquatic educator
- Fishing tackle retailer
- Environmental scientist
- Environmental consultant
- Aquatic ecologist
- Hydrogeologist
- Historian or anthropologist
- Fisheries economist
- Fisheries taxonomist
- Fisheries habitat biologist
- Wastewater technician or engineer
- Geographic information systems specialist
- Archaeologist (identifying fish remains at archaeological sites)
- Fisheries biologist, technician or manager
- Marine biologist
- Naturalist
- Commercial fishermen
- Aquatic toxicologist
- Water quality analyst
- Environmental engineer
- Hydrologist
- Sociologist (studying lifeways based on fishing)
- Fisheries geneticist
- Fisheries population analyst

Ways To Learn More

- Make a collage of pictures depicting careers.
- Write a report about fisheries–related careers.
- Invite a fisheries biologist to speak with your group.
- Write to or interview a fisheries biologist.
- Volunteer to work with a fisheries biologist as a mentor.
- Join a fishing or fisheries–related organization (see background publication).
- Write to the American Fisheries Society for more information regarding careers.
- Find out which universities in your region offer fisheries management programs. Write to them for information.
- Contact a Peace Corps representative in your state. Invite someone who has done fisheries work in an international setting to speak to your group.

Additional Information for Leaders, Teachers and Older Youths

The New Complete Guide to Environmental Careers. 1993. Prepared by the Environmental Careers Organization. Published by Island Press, Box 7, Covelo CA 95428. Inexpensive; a wealth of up–to–date information with addresses of organizations that can provide more information about specific careers.

American Fisheries Society, 5410 Grosvenor Lane, Suite 110, Bethesda MD 20814– 2199. Ask for brochure "Careers in Fisheries."

Peace Corps Recruitment Office, 806 Connecticut Ave., N.W., Washington DC 20526. Ask for brochure "Fisheries."

SWIMMING THROUGH TIME: GREAT LAKES FISHERIES TIMELINE

Objectives

Youths will be able to:

- understand how social, technological and environmental changes have affected Great Lakes fisheries over time.

Methods: group activity, discussion.

Background: Pages 21 to 35 in "The Life of the Lakes: A Guide to the Great Lakes Fishery," "Great Lakes Fisheries Timeline."

Duration: about 40 minutes.

Materials

- The Great Lakes Fisheries Timeline – pocket insert from "The Life of the Lakes: A Guide to the Great Lakes Fishery"
- Cards you write in advance with each timeline date and event (you may wish to make each type of event a different color — environmental changes: green; social changes: red; technological changes: yellow)
- Masking tape
- String
- Extra index cards

Subjects: biology, social studies

Procedure

Alternative A:

1. Give each youth a timeline card. Tell the youths that they will become a "living timeline." Tell them to look at the cards they were given, and then to quietly sort themselves into chronological order. You might have them stand in the appropriate location for the date on their card along a string placed on the floor — labelled with dates in 20–year intervals.
2. Have the youths read from their cards, in chronological order.

Alternative B:

1. Divide the youths into groups of 6–8 per group. Tell the youths that each group will represent life as it was during a certain era in history. Assign each group one era from the fisheries timeline. They are to study the timeline. Have each group pick one or two social changes, technological changes, environmental changes and fisheries changes that were very important in their era, and write those on index cards.
2. Tell the group that you are a time traveller. You are taking a journey back in time to see what the Great Lakes fisheries were really like. Have each group tell you about their era by reading their cards.

Talking It Over

1. Ask the youths to think about the future. What is the rest of the story? How will Great Lakes fisheries change into the future? Encourage them to see a positive future, though challenges will continue.
2. What changes affected the fisheries in the timeline? How fast did change happen at first? When did the rate of change (new technologies, increasing fish catch, increasing waves of settlement) greatly increase? Why did a fast rate of change have a serious impact for fisheries? [Changes happened too quickly for some species or ecosystems to handle. Changes like introduction of exotics happened so quickly that humans could not react.]
3. How does the story of Great Lakes fisheries compare with other historical natural resources events? [Compare with history of forests and

logging in the Great Lakes region, with loss of wetlands, with other regional resources.]

4. Can we return Great Lakes fisheries to a condition like they were in the past? Why or why not? [It would be difficult and costly to restore them exactly to their historical state. Also, it is hard to know what the fisheries were like; fisheries scientists did not know as much in early times as they do now. It may be possible to rehabilitate some fish habitats and populations to a condition somewhat like in the past. Some agencies are working toward these goals.]

Ways To Learn More

- Research more about one particular era or one particular type of historical change (e.g., the construction of canals and locks) and the effects on fisheries.
- Trace the history of sawmills and logging in your watershed.
- Research your family history. Find out what each generation was doing during the different eras of settlement of the Great Lakes region. Were any family members connected with the fisheries?
- Make models of the various net types used in Great Lakes commercial fishing. Learn about knots used by commercial fishermen to mend nets; learn about boating and sportfishing knots.
- Conduct an oral history interview with a person associated with the fisheries. Record "fish stories" using a camcorder or tape recorder. Learn how to tell stories. (A good resource for educators is: Documenting Maritime Folklife: An Introductory Guide, The Superintendent of Documents, PO Box 371954, Pittsburgh PA 15250–7954.)
- Develop a collection of Great Lakes fish recipes that includes traditional, ethnic and regional ways of preparing fish (i.e. smoked fish, planked whitefish, fish boil). Contact your state Sea Grant College program (listed in an appendix in "The Life of the Lakes: A Guide to the Great Lakes Fishery") for information on preparing Great Lakes fishes.
- Attend or organize a community festival about a fisheries resource in your region.
- Visit a maritime museum.

CONTAMINANTS IN GREAT LAKES FISHES

Objectives

Youths will be able to:

Part A:

- explain the concept of solubility.
- explain how and why contaminants end up in fat tissues of some fish.
- suggest how to reduce the intake of contaminants when eating Great Lakes fish.

Part B:

- calculate parts per million concentrations, given the weight of the organism and the weight of substance found in the organism.
- explain the role that governments play in protecting citizens from exposure to contaminants.
- critique an article about contaminants in Great Lakes fishes.

Methods: Part A – experiment, Part B – calculation of parts per million.

Background: Pages 7 to 12 and 38 to 40 in "The Life of the Lakes: A Guide to the Great Lakes Fishery."

Duration: Part A – 20 minutes; Part B – 30 minutes.

Materials

- Per group or pair of youths:
  - 8 iodine crystals
  - Screw–top vial – 77 cc
  - Water – 30 cc
  - Vegetable Oil – 30 cc
- One PARTS PER MILLION: *VERY* SMALL FRACTIONS WORKSHEET per youth
- Overheads: Great Lakes Ecology and Food Web, Pyramid of Biomass and Biomagnification in the Great Lakes, Contaminant Trends in Lake Michigan Bloaters, Aquatic Life in the Great Lakes

Subjects: Part A: chemistry, biology, home economics and health (nutrition)
Part B: math, chemistry, social studies (policy)

Procedure

Part A:

1. Ask: What happens to a teaspoon of sugar when you mix it into a glass of water? [The sugar is dissolved in the water.] What would happen to a pat of butter if you mix it into a glass of water? [The butter would stay in lumps, it would not dissolve.] Explain that the two substances (sugar and butter) illustrate the concept of solubility. Solubility is the ability of one substance to become evenly distributed in another substance. Ask: Is sand soluble in water? [No; it does not become evenly distributed in water, it settles to the bottom!] Tell your youths that they are now going to see that the concept of solubility is important for understanding contaminants in ecosystems.
2. Have the youths (in pairs or small groups) do the following experiment.
   a. Place the iodine crystals in the vial.
   b. Pour in 30 cc of water. Screw the lid back on.
   c. Shake the vial vigorously in an effort to dissolve the crystals.
   d. After a few minutes of shaking, observe any change in color of the water and whether the crystals have dissolved.
   e. Unscrew the lid and pour 33 cc of vegetable oil into the vial. Screw lid back on.
   f. Shake the vial again.
   g. After a few minutes, hold the vial still and observe changes in the color of the water, oil and amount of solid crystal present.

Talking It Over:

1. What happened to the iodine when it was mixed with water? [Some of it dissolved, some didn't. The water turned light brown.]
2. What happened to the iodine and water when the oil was added? [The iodine was extracted into the oil, because it is more soluble in fat than in water. Since there was no more iodine in the water, the water became clear. The oil layer turned pink or purple–brown, indicating the presence of iodine.]
3. In which substance is iodine more soluble, water or oil? [Oil. Iodine is an example of a fat soluble compound. The iodine atoms associate themselves with the oil (fat) molecules and the rearrangement of electrons alter the light absorption of the fluid, causing color change. Many of the potentially harmful contaminants in the Great Lakes such as DDT, PCBs, and dieldrin are also fat soluble. This is true of most halogenated hydrocarbons and non–halogenated hydrocarbons (iodine is a halogen). Because they are fat soluble, they tend to be extracted from the lake water in the process of food consumption.]
4. What type of bodily substance does the oil represent? [Body fat.] The water? [Body fluids such as blood, urine, lymph, saliva, sweat.]
5. Where do you think PCBs turn up in fish and other animals? [In the fat. Fat soluble contaminants may become concentrated in fatty substances in plants and animals. Thus, they end up in higher concentrations in the belly fat and under the skin of such fatty fish as lake trout, salmon and chubs.]
6. Why can't they be "washed out" by blood or urine? [They won't dissolve in these watery fluids. A water soluble contaminant might flush out in the urine fairly soon after the animal is exposed. However, fat soluble substances do not. They tend to build up in fat tissues and are not released unless the fish uses its own fat tissues as a food (energy) source.]
7. How are anglers told about contaminants in fishes they are trying to catch? [When anglers buy their fishing licenses, they receive information about fish consumption advisories. Some state and provincial governments have issued advisories against eating certain fish species caught in certain areas of the Great Lakes and their tributaries. Sometimes states have banned catching specific species of fish. However, this situation changes over time. Many fish that had unacceptable levels of PCBs in recent years now have lower and more acceptable levels. Share the overhead "Contaminant Trends in Lake Michigan Bloaters." Discuss how pollution abatement measures have helped in this decline.]
8. Suppose you want to cook a fish which may have tiny traces of PCBs. What would be the best way to prepare it? [Fillet the fish; remove the lateral line (the dark line under the skin along the side of the fish). Remove all the fat from the fish before cooking. Then broil or bake it and wipe off grease before serving. Avoid frying or boiling the fish, especially in its own juices. Any of these methods would not decrease contaminants such as mercury and other metals which accumulate in muscle tissue.]

Part B:

1. Briefly introduce the activity. Explain that it will show how people talk about contaminants and that they will learn about the math behind the term "parts per million" (ppm).
2. Pass out the PARTS PER MILLION: VERY SMALL FRACTIONS WORKSHEETS (one for each person) and ask youths to read and answer the questions. If some of the questions are above the youths' skill level, you may need to review some math with them.
3. Review the calculations with your youth. [Answers are: whitefish 2.8 ppm; yellow perch 1 ppm; sucker 2 ppm; coho salmon 8 ppm; lake trout 9.4 ppm. The whitefish is over the 2 ppm allowable in interstate trade.]

Talking It Over:

1. Trout and salmon have more fat in their bodies than fishes like whitefish, perch, and smelt. Why might the amount of body fat have something to do with parts per million of PCBs in a fish? [PCBs (and many other substances like DDT, dieldrin, mercury, etc.) are more soluble in oils than in water. Thus, they tend to accumulate in fatty tissues of both fish and other living things. Therefore, fish with fatty bodies tend to have higher concentrations of these substances. Since fat is not excreted like water in urine, the substances tend to stay for long periods in the organisms' bodies.]
2. Why might it be difficult to determine the level of PCBs in humans? [Obtaining fat samples is difficult, but obtaining blood samples is relatively easy. However, since there is a low fat content in blood, one would expect lower PCB levels in a person's blood sample than in his/her fatty tissues.]

3. What questions would you ask about any newspaper articles describing research on human health effects of PCBs from Great Lakes fishes? Let the group develop a brainstormed list. [Aspects to consider about research studies include: Who were the subjects and how many were there? How were PCBs measured? How were subjects exposed to the contaminant (breathing, consuming, skin contact, etc.)? When was the fish consumed and the study done? (Health effects from fish contaminants may take years to appear.) What type of health effects (reproductive, cancer) were studied? What didn't the study consider? What assumptions did researchers make? Were those assumptions valid or realistic?]

4. Governments differ in how they examine health risks from contaminants and in their laws or advisories about fish consumption or sale. What are some reasons that different fish advisories might exist? [First of all, research findings about contaminants vary. Some findings are based on research with animals such as mice or rats. These animals may react differently than human beings. Research tests may vary in the amount of contaminant the animals were fed or exposed to; in some studies, animals may be fed extremely high levels of contaminants, a situation not usual with people who consume relatively low levels over long periods of time. In addition, it may take a long time for the effects of a contaminant to appear; it is difficult to design a study to look at these long–term effects on subjects. Secondly, even if all researchers did their studies in the same way, there are many different ways of calculating the risk (doing a risk assessment) of the effects of contaminants. Finally, governments differ in how they set policies based on scientific studies. Some set advisories for specific bodies of water, and others set advisories for larger areas. Governments set policies in different ways involving the public, and public attitudes vary throughout the region. Some people feel that any amount of a carcinogen (cancer–causing agent) is dangerous. Recently, however, governments throughout the Great Lakes basin have been working together to develop more uniform fish consumption advisories.]

5. Do you know any chemicals that have been banned or restricted by governments? Are those substances still in the environment? Do government control programs really work? [Several government control programs have really helped reduce the amounts of contaminants in our environment. Before the insecticide DDT was banned, levels were very high in Great Lakes fish, especially newly planted salmon. Although DDT levels have gone down much faster than expected, it will be very difficult and costly to get the levels of contaminants down further to approach a level of no contamination. In addition, there will still be residues of some contaminants left in sediments and arriving in the air from distant sources and being deposited in the Great Lakes basin.]

6. In Lake Ontario, a chemical called Mirex got into the fish at levels which the government thought were unsafe for people to eat. The state of New York made it illegal to possess a fish from Lake Ontario, even if you caught it yourself. (The ban lasted until Mirex levels went down in the fish.) In Michigan, on the other hand, the government knew that salmon and lake trout had high levels of PCBs, also a harmful substance. The state of Michigan did not make it illegal to possess these fish. What they did instead was to put advisories in information people received with their sportfishing licenses. These advisories asked people not to eat more than two Great Lakes fish meals per week and asked women of childbearing age and small children not to eat any at all. Which method of protecting people is better? Why? Does the government have the right to control what you eat? [This question should arouse ideas about government regulation. In discussion, get youths to explore the issues implicit in the questions as well as the political aspects.]

Ways to Learn More:

- Find newspaper articles about contaminants in Great Lakes fishes. Read them critically. Write a letter to a newspaper editor.
- Role play or debate a contaminant issue regarding Great Lakes fisheries.
- Get involved in RAP (Remedial Action Plan) activities, if you live near a Great Lakes Area of Concern. (See "The Life of the Lakes" poster series to find out where AOCs in each lake are located.) To find out more about this type of Great Lakes clean–up effort, consult the background publication "The Life of the Lakes: A Guide to the Great Lakes Fishery" for more information.
- Read a copy of your state fishing regulations or the Guide to Eating Ontario Sport Fish. (These are available wherever fishing licenses are sold.) Look for fish consumption advisories. Do library research or talk with biologists to find out what ppm of contaminants fishes in your area have.
- Look at the graph "Contaminant Trends in Lake Michigan Bloaters." What effect did laws controlling use of PCBs have on levels of contami-

nants in fishes? Will Great Lakes fishes ever have no contaminants? [Probably not; implementing "no discharge" of contaminants into the lakes is extremely costly; sediments still harbor some types of contaminants; some contaminants are arriving into the Great Lakes basin by air from distant sources.]

- Assume that a fish has 2 ppm of a contaminant in its flesh. Using the overhead titled "Pyramid of Biomass and Biomagnification in the Great Lakes," calculate the concentration of contaminant (in ppm) in the water in the organism's environment. [Answer: divide 2 ppm by 25,000 and by 2,000,000. The range of concentrations in fish's water environment is .00008 (or $8x10^5$) ppm to .000001 (or $1x10^6$) ppm.]
- Research different contaminants found in the Great Lakes region. (You might write to the International Joint Commission for more information. See address below.)

Additional Information for Teachers and Youth Leaders

- Journal articles — See the background publication "The Life of the Lakes: A Guide to the Great Lakes Fishery" for a listing of journals which have articles on Great Lakes fisheries. Also, consult journals on toxicology.
- Contact the International Joint Commission (IJC) for posters and more information on contaminants in the Great Lakes. IJC, 100 Ouellette Avenue, 8th Floor, Windsor ON N9A 6T3, or IJC, PO Box 32869, Detroit MI 48232–2869.
- View the video, "The Trouble With Toxics." Available from: Michigan Sea Grant Extension, 334 Natural Resources Building, Michigan State University, East Lansing, MI 48824–1222.
- LaMPS Fact Sheet Series: Risk. LaMPs (Lakewide Management Plans for the Great Lakes) Education Project, Michigan Sea Grant College Program, Michigan State University, 334 Natural Resources Bldg., East Lansing, MI 48824.

  Titles include:

  "Overview of Series on Risk: Toxic Chemicals in the Great Lakes"

  "Assessing the Risk to Humans from Toxic Chemicals in the Great Lakes"

  "Human Toxicity Assessment"

  "Human Exposure Assessment"

  "Ecological Risk Assessment"

This activity has been updated and revised from the curriculum *Investigating the Great Lakes Environment: Unit 2, Great Lakes Fishing in Transition* (by Nowak, P., L. Lin and W. Stapp. 1983. MICHU–SG–83–400. Michigan Sea Grant College Program, Ann Arbor, MI.)

PARTS PER MILLION: VERY SMALL FRACTIONS WORKSHEET

Contaminants are chemicals which are found at undesirable levels in organisms or the environment. Scientists and people who make policies measure levels of contaminants in units called "parts per million." In fact, these amounts are so tiny that scientists have trouble measuring them. Special expensive equipment is used to measure parts per million.

Unfortunately, there are contaminants within the bodies of some plants and animals in the Great Lakes. However, the amounts are very small. The amounts are usually expressed as parts per million, or ppm for short.

For example, a scientist might say that a coho salmon has 8 parts per million of PCBs, a contaminant found in the Great Lakes. This would mean that if you divided the fish's weight into a million parts, 8 of those parts would be made up of PCBs.

How much is a part per million? One part per million would be like one drop of chocolate in 64 quarts of milk.

The U.S. Food and Drug Administration sets limits on the amount of contaminants that can be in a food product to be sold. For Great Lakes fish, they have decided that level is 2 parts per million of PCBs. Therefore, fish over the "safety limit" of 2 ppm of PCBs cannot be sold for interstate trade. Most states have similar limits for sales within their boundaries.

When the government sets a level for a contaminant in your food, it does not mean that eating something at that level will kill or harm you. It just means that it could eventually be damaging to eat this food if you ate a lot of it over time. Usually, the "safety limit" is much, much lower than the actual amounts which might be harmful.

Many of our foods have some level of contaminants. For instance, most bacon and ham contains small amounts of chemicals which kill bacteria and preserve the pork.

It is hard to avoid harmful substances; they are all around. Many potentially harmful substances are around because they are "good" for something else. PCBs are useful chemicals that, in the past, were used in making electrical equipment. Pesticides may increase a farmer's crop by killing insects that eat the crops. As you can imagine, solving the problems of contaminants in our air, food, and water is going to be a complex task.

Now try this

You can figure out parts per million with a simple formula:

Weight of fish: = F
Weight of PCBs in fish: = P make sure F & P are in the same units
Parts per million of P in F = X

The formula for figuring out X is:

$$X = \frac{P}{F} \times 1{,}000{,}000$$

So let's take a look at a whitefish that a commercial fisher has caught. The fish weighs 3 kg. The government lab found .009 g of PCBs in the fish. Is the fish over 2 ppm? Let's use the formula to find out.

First, change the weight of the fish to grams, just like the weight of the PCBs. Since 1 kg is 1000 g, then 3 kg = 3 x 1000 = 3000 g.

$$\text{Then, } X = \frac{.009 \text{ g}}{3000 \text{ g}} \times 1{,}000{,}000 = 3 \text{ parts per million}$$

No, the whitefish is not under the 2 ppm limit, and cannot be sold.

Some other fish came in with the catch. Calculate the ppm of contaminants in each fish.

1. Whitefish — Wt. = 2.5 kg; P = .007 g
2. Yellow perch — Wt. = .5 kg; P = .0005 g
3. Sucker — Wt. = 1.5 kg; P = .003 g

Some sport anglers come in with more fish. Calculate the ppm of contaminants in these fish.

4. Coho salmon — Wt. = 6.5 kg; P = 0.052 g
5. Lake trout — Wt. = 7.0 kg; P = 0.066 g

GREAT LAKES FISHERIES AND THE ECONOMY

Objectives

Youths will be able to:

- name several jobs that relate directly or indirectly to Great Lakes fisheries. (Examples: hotel and restaurant owners and employees, tackle shop personnel, equipment manufacturers, distributors and retailers, commercial fishers, boatbuilders, retailers, packagers, transporters, restaurant personnel.)
- plan a sportfishing trip and make a budget for the trip's costs.
- identify and discuss the relative benefits to themselves and society of catching fish on a sportfishing trip and of buying Great Lakes fish in the market.
- suggest reasons why many people prefer to catch their own fish.

Methods: calculation, discussion, research.

Background: Pages 14 to 19 in "The Life of Lakes: A Guide to the Great Lakes Fishery."

Duration: 45 minutes, although you may need to split this activity into two sessions to allow time for youth to research costs of fishing trip.

Materials

- Role cards (1 card for each group)
- One WORKSHEET FOR PLANNING A SPORTFISHING TRIP per group
- Masking Tape
- Newsprint
- Markers
- A road map for your state in the Great Lakes region
- The Life of the Lakes map/poster(s)
- Fishing, boating, and outdoor magazines and catalogs
- Overheads: Fisheries Science and Management, Sportfishing In the Great Lakes: Where It Occurs, Sportfishing in the Great Lakes: What Species Anglers Prefer, Commercial Fisheries in the Great Lakes

Subjects: math, social studies (economics), current issues

Procedure

1. Ask youths for their definition of the term "fishery." Let them discuss this briefly. Show overheads and emphasize the term fishery refers to fish species, people catching fish, and the environment. Tell them that this activity will take a closer look at sport and commercial fisheries in the Great Lakes. They will be planning and budgeting for a sportfishing trip to one of the Great Lakes.
2. Ask the youths to choose a destination for their fishing trip. Some possible locations include: LAKE SUPERIOR (Knife River, MN;Bayfield, WI), LAKE MICHIGAN (Bailey's Harbor, WI; Sheboygan, WI; Leland, MI), LAKE HURON (Alpena, MI; Harbor Beach, MI), LAKE ERIE (Sandusky, OH; Buffalo, NY), LAKE ONTARIO (Rochester, NY; Toronto, Ontario).
3. Explain to the youths that while all of them will be planning a fishing trip for the same location, they will be planning for three different types of vacations. One group will play the role of CAMPERS/ BOAT RENTERS, another will be HOTEL/CHARTER BOAT USERS, and another group will be RECREATIONAL VEHICLE/BOAT OWNERS. Divide the youths into three groups and assign roles.
4. Give each group several sheets of newsprint, some masking tape, a marker, a copy of the WORKSHEET FOR PLANNING A SPORTFISHING TRIP, and that group's role card.
5. Let the youths read their role card.
6. Tell the youths that they will now begin to cal-

culate the costs of travelling to their fishing site, and other costs they will have for their trip. Ask the youths to locate on a road map the destination they have chosen. Then ask them to calculate the distance between their hometown and the destination. On their role cards are instructions for calculating their transportation cost. Have the youths make this calculation, then enter the transportation cost on their group worksheet.

7. Have the groups brainstorm a list of goods (materials) they will need for their fishing trip and write this list on a sheet of newsprint. These items are unavoidable basics such as clothing, food, tackle and transportation. These "essentials" can be chosen in such a way as to minimize costs without lessening the likelihood of catching fish. Next, have the groups brainstorm about the services that they will need while on their trip and write this list on newsprint. Services are things that an angler has to pay other people to do for him/her, such as hotel services or other lodging costs, boat rental, or charter boat services. Tell the groups to reach agreement on which goods and services they think are "necessary" and how to get the best value for their money. Have the groups brainstorm and record "optional" items and services that the group might like to have. These items (such as special gear, special snack foods) would make the trip more convenient or comfortable.
8. Once the groups have agreed upon items needed, transfer these lists to the group worksheet. Have each group find out how much each of the things on their lists will cost. Some of this information may be easy to find. Some of it, though, may be harder to find and will require more time and effort. Use fishing, boating or outdoor magazines and catalogs for costs of some items. Information on clothing, equipment, and recreational vehicles should be available from local merchants. Information on the cost and availability of hotel or motel lodging should be available at a local hotel, motel, or in the public library. You may also contact travel bureaus or tourist associations. State or provincial departments of natural resources will have information on license fees, boat launching and docking, etc. A library will have magazines and newspapers with articles on sportfishing, recreation and travel in the Great Lakes region.
9. Have groups record the cost of each item on their worksheet. Add up all these expenses and record this sum.
10. Have the groups refer back to their role card to find out how many pounds of salmon were caught on the trip. Have groups calculate the cost per pound of fish caught by following the instructions at the bottom of the worksheet.
11. Call or visit a local supermarket or fish market. Find out how much a pound of frozen or fresh salmon costs. Find out where the market fish was caught. NOTE: If you do not find salmon in your market, use the price per pound of lake trout, whitefish or walleye instead.
12. Compare the costs of the market fish with the cost per pound of the salmon caught on the fishing trip.

Talking It Over

1. How do the costs of each group's fishing trip compare? Which was highest, which was lowest? Would each of the trips be worth what you would have to pay for it?
2. Would you prefer to pay the market price for salmon or catch it yourself? Why?
3. What are the benefits to you, and society as a whole, of paying the higher price for the salmon you caught? [Economic benefits to society include community income from sportfishing. Personal benefits of sportfishing might include enjoying being outdoors, escaping routine chores, challenging one's skills and abilities.]
4. What are the benefits to you, and society as a whole, of paying the price of the fish available in the market?
5. In the late 1980s, sport anglers began to catch fewer and fewer salmon from Lake Michigan. The populations of salmon had declined seriously, probably due to a disease called bacterial kidney disease (BKD). What happens to the communities when the population of a sport fish declines? [Business people who make their living from the sportfishing industry (charter boat operators, restaurants, lodging, tackle, boat sales and rentals) find their incomes reduced. The quality of the environment and the status of fish populations are definitely linked to economic and social factors of Great Lakes communities!]

Optional Activity:

1. Ask each group to make a list on a sheet of newsprint jobs that depend in some way on the production of the goods and services for sportfishing. You may want to give them 10–15 minutes to make this list.

2. On another sheet, ask the groups to list jobs which are generated by the *commercial* fishing industry. This will probably be a much shorter list than the list of jobs related to sportfishing. Generally, commercial fishing provides employment for a captain and crew for each fishing vessel, fish processors, truckers, wholesalers, and retail outlet fish handlers. In addition, there are the jobs related to producing equipment needed for commercial fishing and processing the fish.
3. Ask the groups to compare the commercial fishing list with the list of jobs generated by sportfishing.
4. Ask the students to discuss these questions:
   a. How does the difference between the lists explain the difference in cost between fish caught by a commercial fisher and fish caught by a sport angler?
   b. How it is possible that a small number of commercial fishers can produce large quantities of fish more cheaply than a large number of sport anglers? Why do commercial fishers still have a much smaller overall impact on the economy of the Great Lakes region?
   c. Should commercial fishing be discouraged or abandoned by Great Lakes resources managers? What reasons support a continuation of commercial fishing? [The commercial fishery supplies high quality protein to people who do not or cannot fish for sport. Commercial fishing is also an important tool for managing fish populations. Another reason for commercial fishing is that some fish species cannot be caught using sportfishing methods. On the other hand, some people may argue that commercial fishing should be abandoned because it contributes relatively small amounts to the economy. They may also point out that protein is available from land sources and the ocean (although ocean fisheries in some areas of the world are in trouble). Some also point out that sport fishing constitutes a much larger interest group, politically, than commercial fishing (if you do not include commercial fish consumers).]

Ways to Learn More

- Visit a tackle shop.
- Interview anglers to find out why they fish.
- Take your trip!

This activity has been updated and revised from the curriculum *Investigating the Great Lakes Environment: Unit 2, Great Lakes Fishing in Transition* (by Nowak, P., L. Lin and W. Stapp. 1983. MICHU–SG–83–400. Michigan Sea Grant College Program, Ann Arbor, MI.)

ROLE CARD: **CAMPERS/BOAT RENTERS**

You are a family of four planning to go on a sportfishing trip. You are going to a Great Lakes campground where you will spend the weekend. Your vehicle gets 20 miles per gallon of gasoline used. You will camp in a tent, and will rent a fishing boat for two days. You own your own fishing tackle. Include one tenth of the costs of your tent, sleeping bags and other camping equipment. Also add one tenth of the costs of your fishing tackle. Your costs for boat rental will be $35.00 per day (including gas). You will catch enough salmon to weigh five pounds when cleaned (dressed).

Miles to destination: _____ (a)
Miles per gallon of gasoline: _____ (b)
Gallons of gasoline used: (a/b) _____ (c)
Current price per gallon of gas: $_____ (d)
Transportation costs: (c x d) $_____

----------**(Cut along dotted line)**----------

ROLE CARD: **HOTEL/CHARTER BOAT USERS**

You are a family of four planning to go on a sportfishing trip. You are going to a Great Lakes coastal community where you will spend a weekend. You will stay in a hotel or motel and rent the services of a charter boat for two days. Your vehicle gets 20 miles per gallon of gasoline used. Estimate your charter boat costs at $75.00 per person per day. You will catch ten pounds of salmon, dressed.

Miles to destination: _____ (a)
Miles per gallon of gasoline: _____ (b)
Gallons of gasoline used: (a/b) _____ (c)
Current price per gallon of gas: $_____ (d)
Transportation costs: (c x d) $_____

----------**(Cut along dotted line)**----------

ROLE CARD: **RECREATIONAL VEHICLE (RV)/BOAT OWNERS**

You are a family of four planning to go on a sportfishing trip. You are going to a Great Lakes fishing spot where you will spend the weekend. You will sleep in your Recreational Vehicle (RV) and use your own boat. Your vehicle gets 10 miles per gallon of gasoline used. Include in the costs one–tenth of the cost of your recreational vehicle and boat. Also add one tenth of the cost of your fishing tackle. You will catch five pounds of lake trout, dressed.

Miles to destination: _____ (a)
Miles per gallon of gasoline: _____ (b)
Gallons of gasoline used: (a/b) _____ (c)
Current price per gallon of gas: $_____ (d)
Transportation costs: (c x d) $_____

WORKSHEET FOR PLANNING A SPORTFISHING TRIP

Materials Needed		Services Needed		Optional Goods & Services	
Item	**Cost**	**Item**	**Cost**	**Item**	**Cost**
Gasoline (travel to site)					
Subtotal:		**Subtotal:**		**Subtotal:**	

Fish species:

_____

From:

_____

Grand total of costs: $_____ (a)

Pounds of fish caught: _____lbs. (b)

Cost per pound of fish:(a/b) $_____

Cost per pound of fish at store: $_____

GREAT LAKES FOOD WEB

Objectives

Youths will be able to:

- identify important species and components of Great Lakes food webs.
- understand that environmental changes, introduction of exotic species, overharvest and social/technological changes have influenced Great Lakes fisheries over time.

Methods: group activity, discussion.

Background: Pages 5 to 14, 21 to 35, and 40 to 41 in "The Life of the Lakes: A Guide to the Great Lakes Fishery."

Duration: 50 minutes.

Materials

- Cards of species profiles (one card for every youth)
- Extra index cards
- String
- Overheads: Great Lakes Ecology and Food Web, Taxonomy of Zooplankton, Taxonomy of Phytoplankton, Taxonomy of the Benthic Life in the Great Lakes, Pyramid of Biomass and Biomagnification in the Great Lakes

Subjects: biology, social studies

Procedure

1. Have enough species profiles cards for every youth in your group. Make an additional card for each of the following: sunlight, nonliving nutrients, humans. If you have enough youths, make multiple copies of the following cards: phytoplankton, zooplankton, benthos, and forage fishes. Give every youth a card.
2. By stretching the string between youths, first connect the producers (phytoplankton) with sunlight and nonliving nutrients. Next, connect the first level consumers, zooplankton and benthos, to the phytoplankton and to each other. Next, connect the forage fishes into the food web. As you connect each group of organisms, have the youths read the life history information on their cards, and discuss the food web relationships as you go. (You may need to review some terms, such as benthic, pelagic. See glossary in "The Life of the Lakes: A Guide to the Great Lakes Fishery.")
3. Now tell the youths that they will be adding the predator fishes found in the Great Lakes originally (prior to the 1920s). Have the remaining youths look at their cards. Which are "native"? Which species were introduced/exotic and arrived later? Add to the food web: lake trout, walleye, yellow perch, and lake whitefish (the native species). ADD HUMANS TO YOUR GREAT LAKES FOOD WEB.
4. Now we will consider what happened to the fisheries over time. Set the stage by telling the youths that it is the 1920s. The Great Lakes fisheries have already started into decline from logging, dams, growth of cities, and overharvest. But now there are some new challenges, the arrival of exotic species in the Great Lakes. Add the smelt (let the "smelt" read his/her card). Add the sea lamprey. Add the alewife. With each addition, add the organism, then let the added species gently shake his/her string connection to the food web. When the other organisms already in the web feel the motion, have them gently shake their connections. Watch the effects of each introduction eventually spread throughout the whole food web.
5. Tell the youths it is the 1960s, and alewife have become a terrible problem in some areas in the Great Lakes. As fisheries managers, you decide to introduce a predator to help solve the alewife problem. Add Pacific salmon to the web. Watch the effects throughout the web.
6. Now a new problem is becoming obvious. Pollution has led to eutrophication of some areas in the lakes (particularly in shallow bays). (Define

eutrophication.) It leads to tremendous growth of algae (phytoplankton) which are less beneficial to the small organisms that depend on algae for food. As this growth dies and decays, valuable oxygen is used up in the lakes. What are the effects up the food chain?

7. Now we are in the present. Clean–up efforts have improved Great Lakes water quality. What effects occur in the food web? Two new invaders have just arrived in the Lakes. Add the Bythotrephes cedarstroemi ("Bc") and the zebra mussel (one by one) to the food web.) Have the youths hypothesize what will be the effects of these additions.

Talking It Over

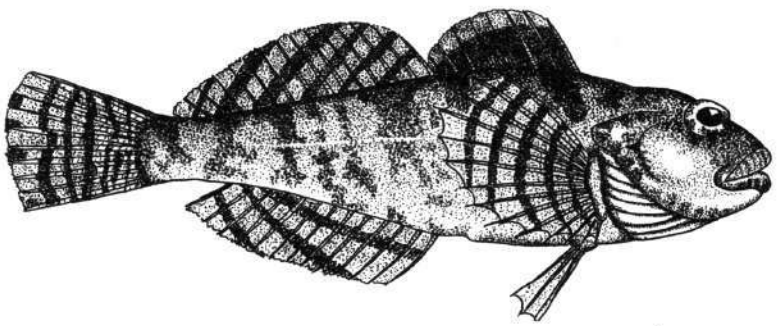
(Note: most discussion occurs as each species and event is introduced into the food web.)

1. Can we return the Great Lakes to the past? Why or why not?
2. Can we ever stop the parade of new exotics into the Great Lakes? Why or why not? What steps can be taken to slow the invasion of exotics? [Ballast water regulation, for example.]

Ways To Learn More

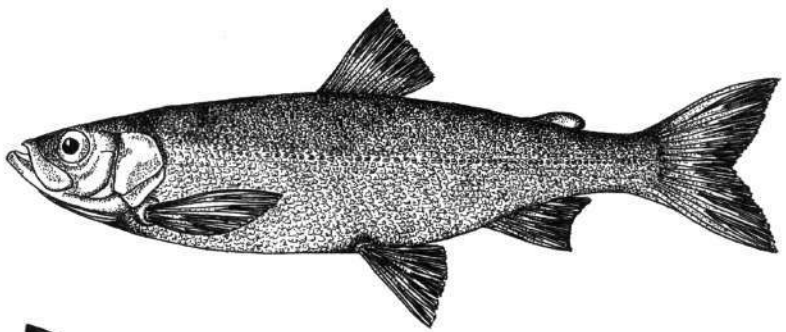
- Research, in more depth, the life history of a Great Lakes organism. For your organism, make a display, write a play, or read a technical article in a journal .
- Visit an inland pond or lake, a stream, or a Great Lakes coastal area. Look for plankton and macroinvertebrates. View them and/or keep an aquarium.
- Examine industries today which rely on stream or river water for cooling, waste dilution or manufacturing. Visit a power generating facility.
- Make a list of personal activities which you may do to help conserve water or improve or maintain surface water quality. Adopt a stream or join a local watershed group.
- Seine an area for fishes. (Note: in order to catch or possess certain fishes, a fishing license or other permits is required. Check with your state or provincial fisheries management agency for regulations concerning fishing, possession of fish, and allowable techniques.) Identify fishes. Keep field notes.

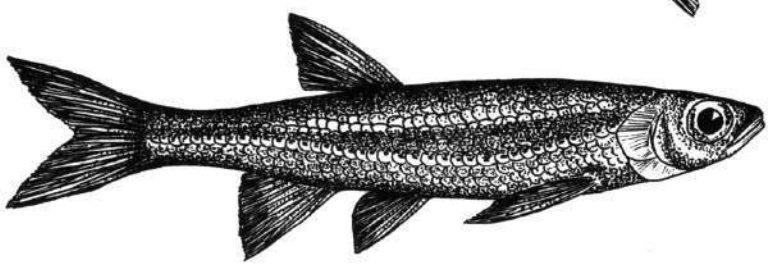
Forage fishes



Sculpins

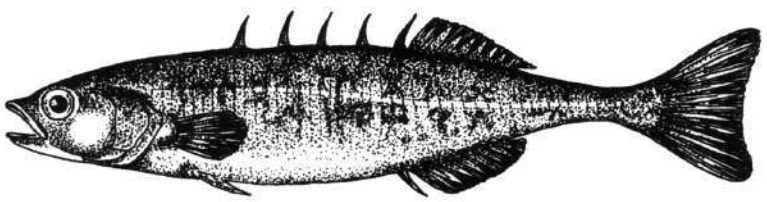
Bloater

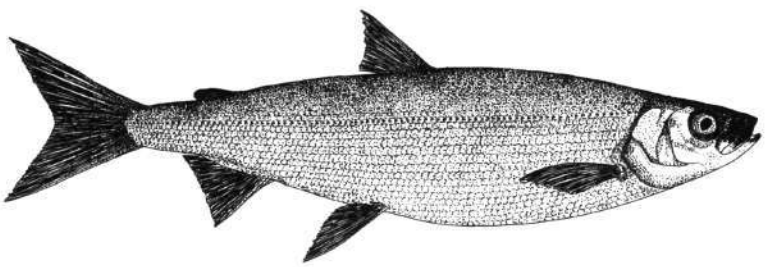




Emerald Shiner

Sticklebacks





Lake Herring

Forage fishes

Description: small fishes which serve as food for larger fishes.

Examples: sculpins — 7 in. or less; large head, stout body; large and fanlike pectoral fins; pelvic fins (usually with one spine) under pectoral fins.

bloater — 8 -10 in.; long, deep-bodied fish with adipose fin.

lake herring — 8 -12 in.; similar to bloater but with more gill rakers.

sticklebacks — 2-4 in.; small, thin fish; dorsal spines unconnected by fin tissues.

emerald shiner — 2-3 in.; silvery, iridescent body.

Adult Diet: mostly plankton, insect larvae, some benthos; larger species may take smaller fishes.

Habitat/Behavior: The usefulness of forage fishes to predators depends on their size and on their location; any fish small enough to fit into a predator fish's mouth is a potential forage fish! There were many species of native forage fishes, some unique to the Great Lakes; they were found virtually throughout the lakes until commercial fishing removed some of the larger species of chubs (ciscoes).

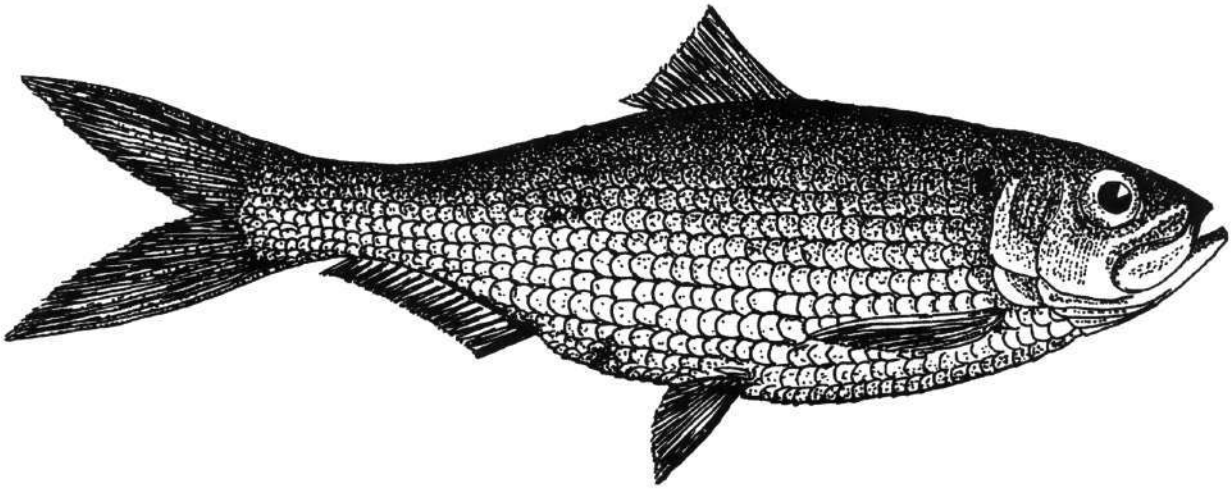
Sculpins — benthic and littoral; some spawn in spring, others in late summer or early fall; mottled and slimy sculpins establish nests under rocks or other debris and deposit eggs on the ceiling of the nest. Deepwater sculpins eat mainly midge larvae and *Diporeia* spp. Spoonhead sculpins eat planktonic crustaceans in deep- water areas, and aquatic insect larvae inshore. Other sculpins eat mainly aquatic insect larvae and crayfish.

Bloater — pelagic and benthic; spawn in February through March. Eat mainly zooplankton, particularly *Mysis, Diporeia* spp.

Lake herring — pelagic; gather in large schools to spawn in late November or early December. Mainly a plankton feeder eating *Mysis, Diporeia* spp.

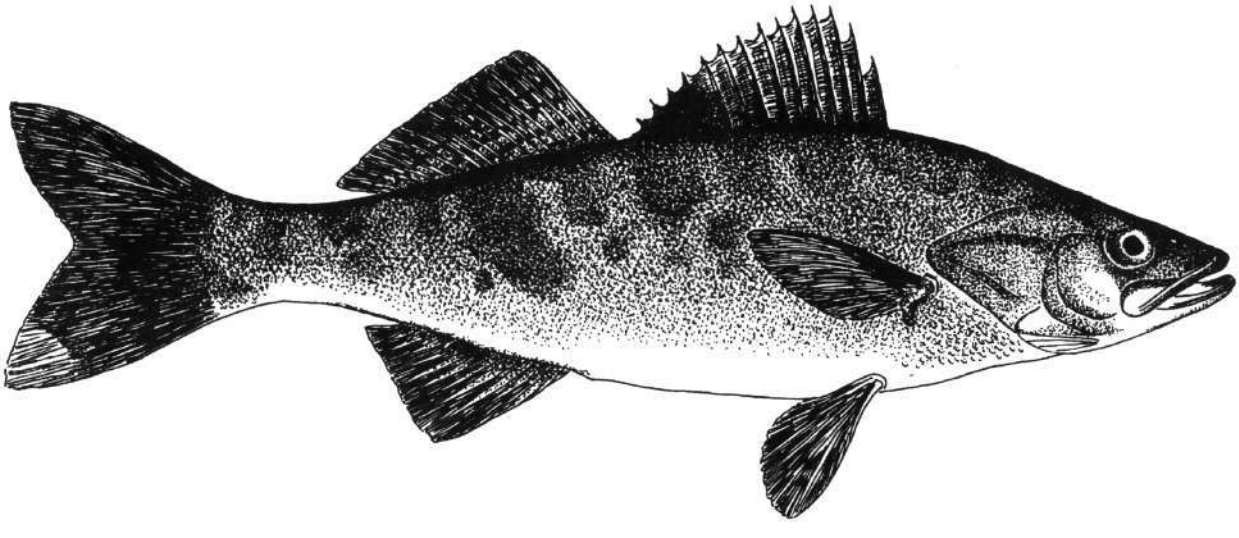
Sticklebacks — littoral and benthic; spawn in spring or summer. Some build nest of sticks or weeds. Eat aquatic insects, planktonic crustaceans.

Emerald shiner — mainly pelagic; spawn in summer. Form schools offshore in summer, move inshore in fall, and in spring; spend days in deep water and move to surface at night. Feed mainly on plankton and algae, and eat some midge larvae.



Alewife

(Cut along dotted line)



Walleye

Alewife

(Alosa pseudoharengus)

Description: 6-8 in.; silvery, iridescent (shifting, rainbow-like color), single black spot behind head at eye level.

Adult Diet: planktivore (plankton-eating); may also eat small fishes and fish eggs.

Habitat/Behavior: mainly pelagic, but also inshore; spawns in shallows in late spring, early summer; strains plankton from water through structures called gill rakers (in gills); schools move inshore to feed at night; die-offs may occur in spring and summer; not native to Great Lakes — invaded from Atlantic Ocean through the Erie Canal into the Great Lakes.

----------**(Cut along dotted line)**----------

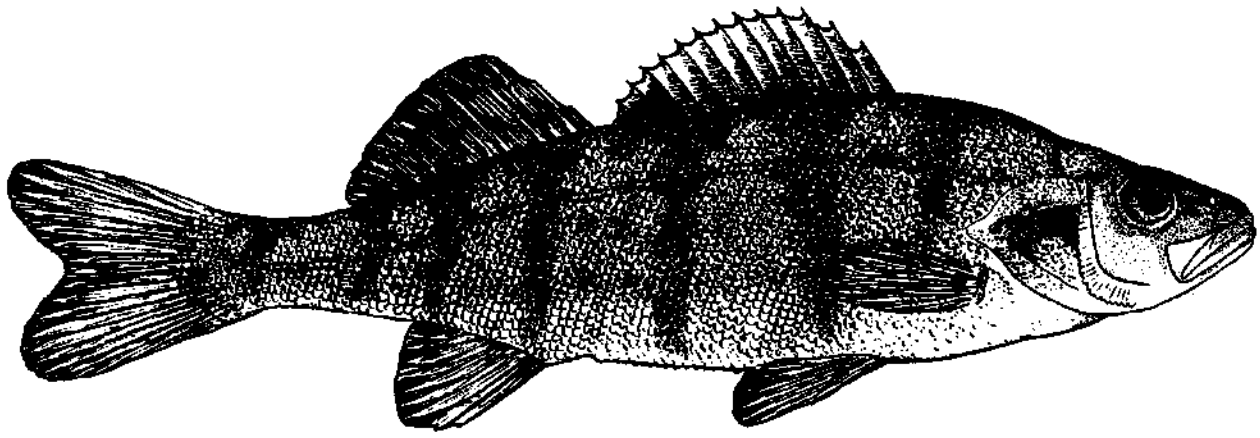
Walleye

(Stizostedion vitreum)

Description: usually 13-20 in.,1-3 lbs. but can grow much larger; dorsal fin with hard-rayed and soft-rayed sections; large eyes and white tip on tail.

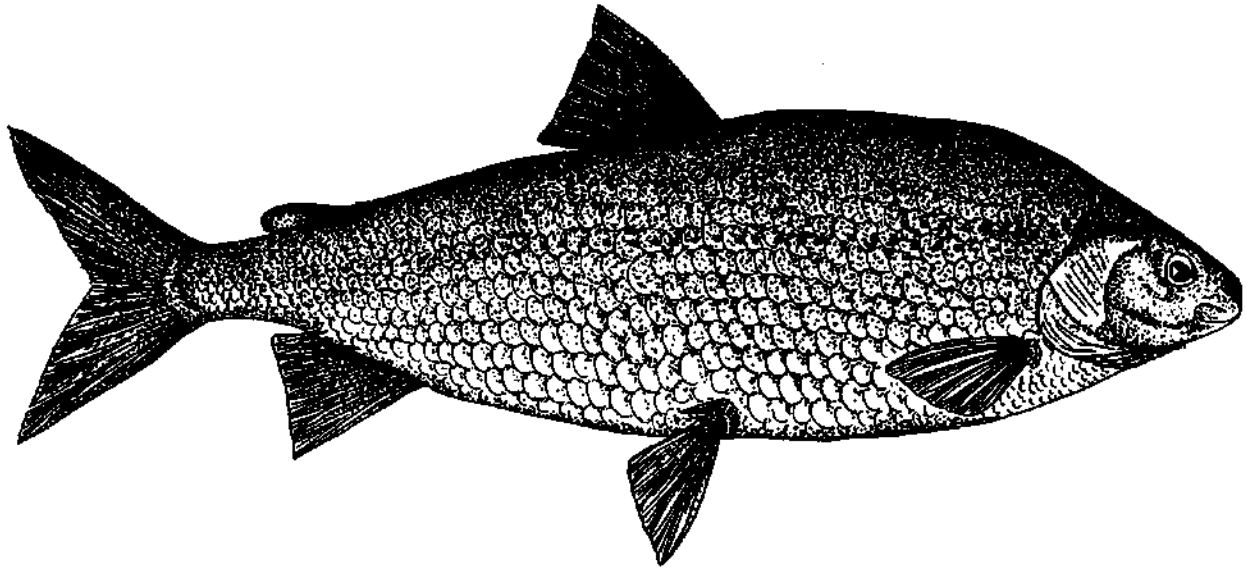
Adult Diet: piscivore (fish-eating).

Habitat/Behavior: benthic, deep pelagic and inshore; spawn in spring or early summer in rivers and lakes over coarse gravel or rocks; found in turbid areas and use plants, boulders, sunken trees for cover; feed at twilight or at night.



Yellow perch

(Cut along dotted line)



Lake whitefish

Yellow perch

(Perca flavescens)

Description: usually 4-10 in.; yellow belly and dark vertical bars on sides.

Adult Diet: forage fishes, aquatic insects.

Habitat/Behavior: benthic and inshore; spawn in late April through early May near aquatic plants.

----------**(Cut along dotted line)**----------

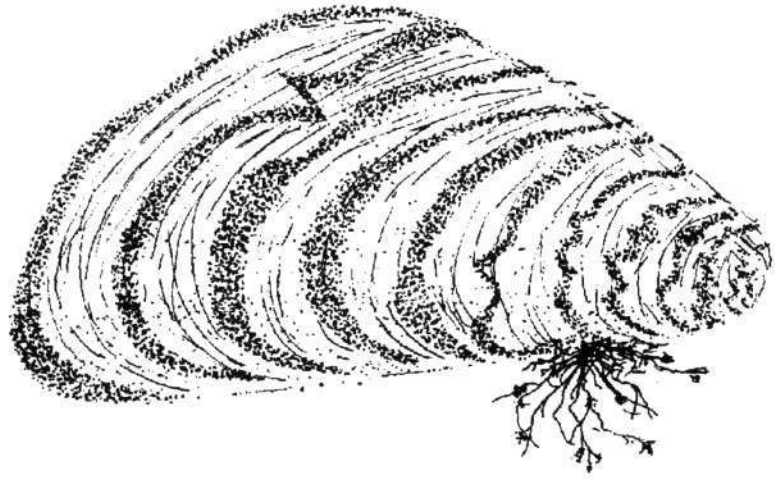
Lake whitefish

(Coregonus clupeaformis)

Description: usually 17-22 in., 1.5-4 lbs.; silvery with pale green-brown back.

Adult Diet: planktivore, also some small fish and fish eggs.

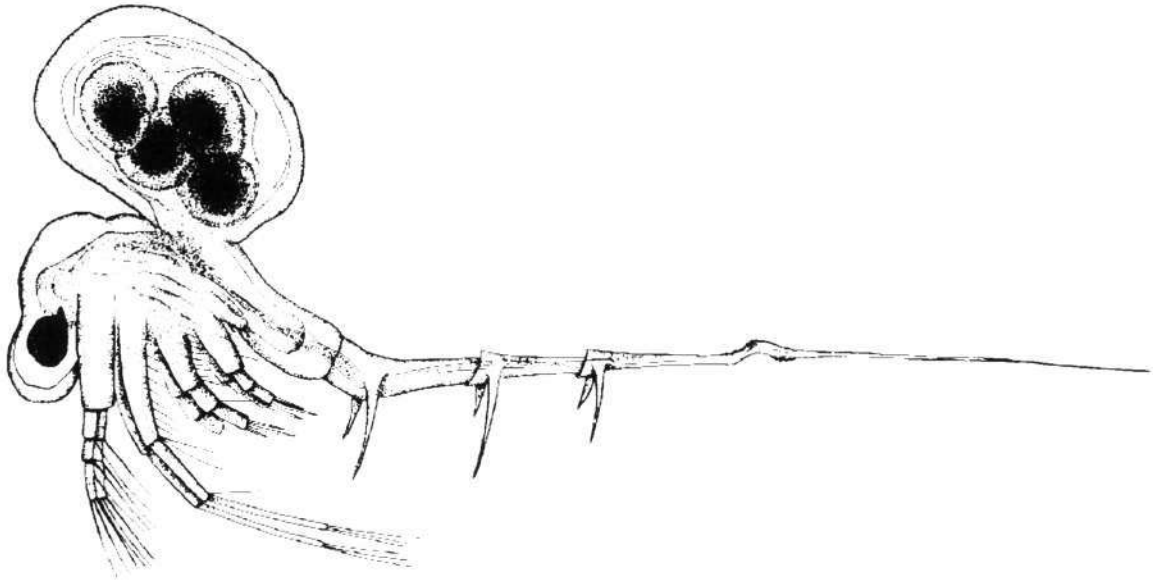
Habitat/Behavior: benthic; spawn in November and December usually in shallows; found in schools; found in hypolimnion in summer, and move to shoals in spring.



Zebra mussel

(actual size about $^1/_2$ inch)

(Cut along dotted line)



Spiny water flea

(actual size about $^1/_2$ inch)

Zebra mussel

(Dreissena polymorpha)

Description: thumbnail sized mussel with light and dark bands.

Adult Diet: filter-feeder on small particles and organisms in water.

Habitat/Behavior: adults are benthic and attach to hard surfaces; usually found in clusters; larvae are planktonic (free-swimming, microscopic); not native to Great Lakes — arrived in Great Lakes in ballast water of international cargo vessel(s).

----------**(Cut along dotted line)**----------

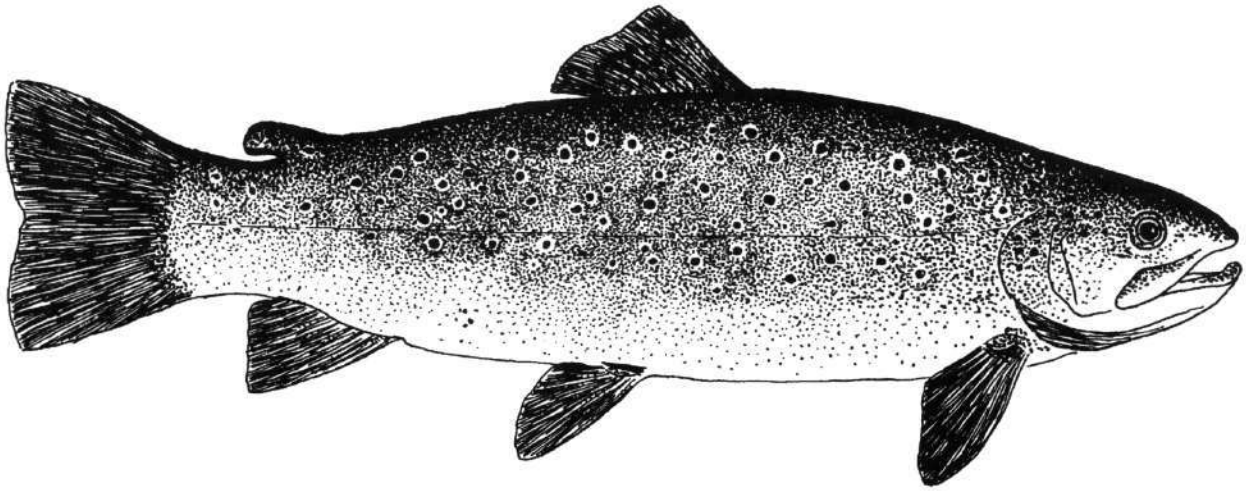
Spiny water flea

(Bythotrephes cederstroemi)

Description: about 1 cm. long; long, spiny tail; large, single eye.

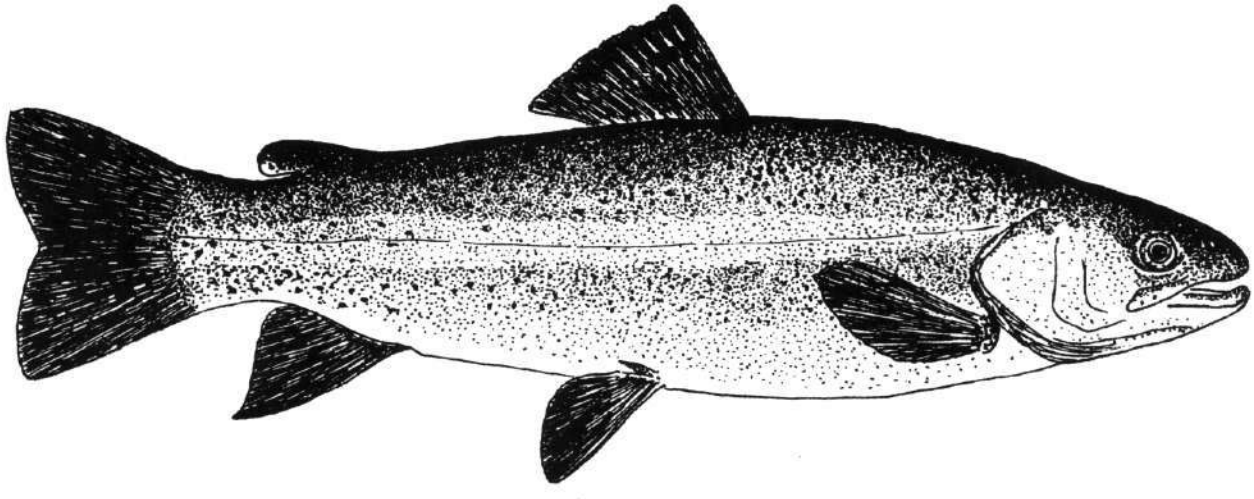
Adult Diet: predatory, pierces and shreds smaller zooplankton including *Daphnia*.

Habitat/Behavior: pelagic zooplankton found in offshore areas; spine appears to serve as defense against predators; migrates to surface at night.



Brown trout

(Cut along dotted line)



Rainbow trout or steelhead

Brown trout

(Salmo trutta)

Description: usually 20-22 in. long but can grow much larger; 4-5 lbs; dark crosses or checks on silvery body, tail with occasional dark spots, 10-12 anal rays.

Adult Diet: smelt, alewife, other forage fishes.

Habitat/Behavior: pelagic (open-water) but also found in benthic and shallow inshore areas; (spawn in rivers, streams); spawn in late fall or early winter when 2-3 years old; do not die after spawning; not native—introduced into Great Lakes region.

----------**(Cut along dotted line)**----------

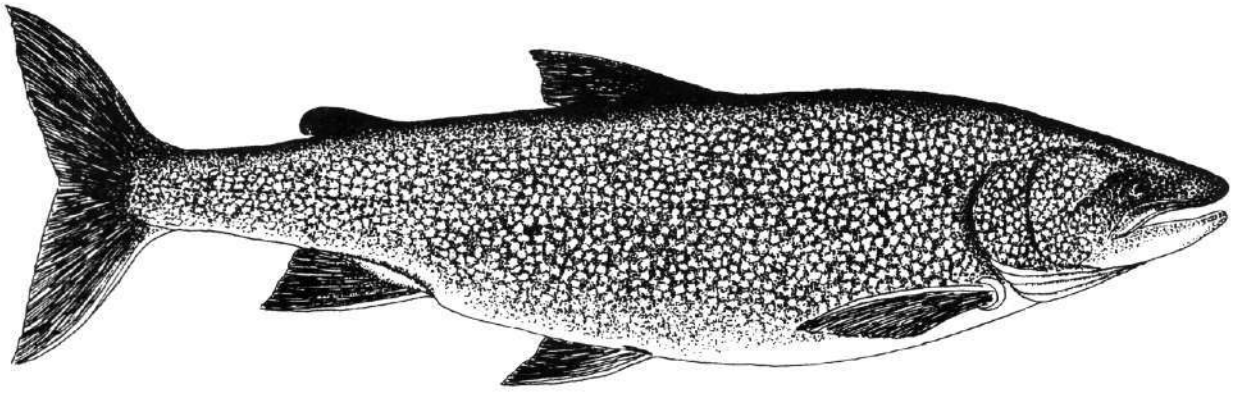
Rainbow trout or steelhead

(Oncorhynchus mykiss)

Description: usually 20-30 in. and 6-10 lbs.; light body with dark spots, side has pinkish band.

Adult Diet: invertebrates, plankton, forage fishes.

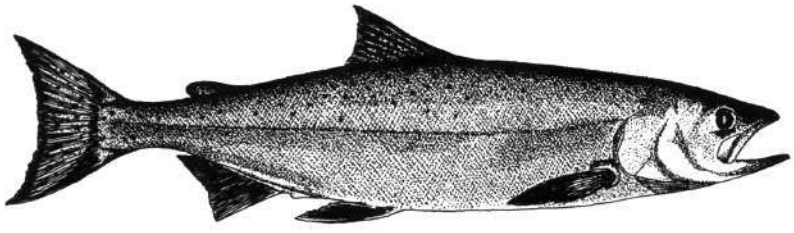
Habitat/Behavior: pelagic (open-water); (spawn in rivers, streams); enter rivers in late October through early May, and spawn from late December through the spring (but mostly in the spring); do not die after spawning; not native to the region—introduced from the Pacific Northwest.



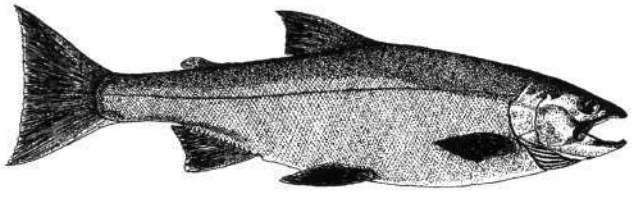
Lake trout

(Cut along dotted line)

PACIFIC SALMON



Chinook salmon



Coho salmon

Lake trout

(Salvelinus namaycush)

Description: often about 31 in. and 10 lbs.; scattered light spots on dark body; forked tail.

Adult Diet: forage fishes such as chubs (ciscoes), lake herring, sticklebacks, alewife, smelt, sculpins.

Habitat/Behavior: mainly benthic, but may be found at various depths (pelagic and inshore); spawn on rocky reefs during November and December; a subspecies called siskowet (or "fat trout") is found in deepwater areas of Lake Superior.

----------**(Cut along dotted line)**----------

PACIFIC SALMON

Chinook salmon

(Oncorhynchus tshawytsha)

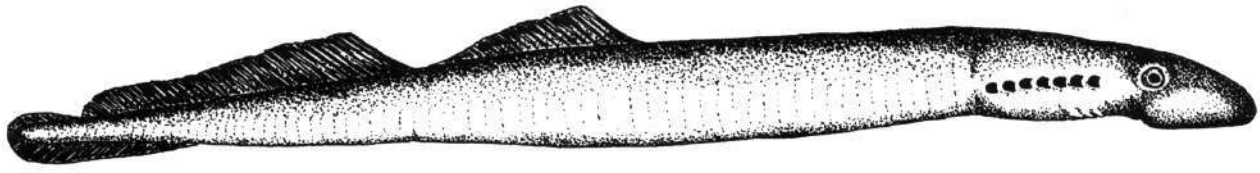
Coho salmon

(O. kisutch)

Description: Chinook salmon – adults about 36 in., 18 lbs.; black mouth and inner gums, anal fin with 15-17 rays, black spots all over tail.
Coho salmon – can reach about 27 in., 6.5 lbs.; gray gums, anal fin with 13-15 rays, black spots on back and upper half of tail.

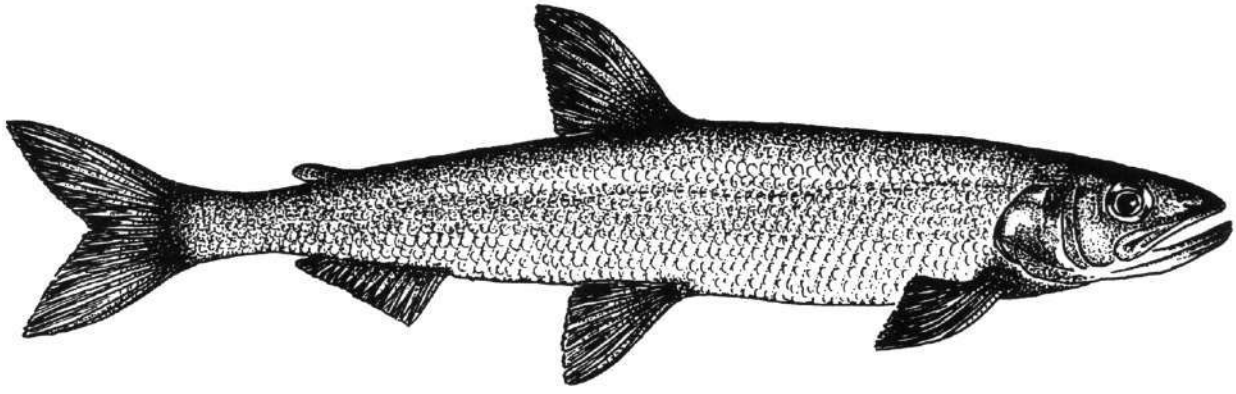
Adult Diet: alewife, smelt, other forage fishes.

Habitat/Behavior: pelagic (open water); anadromous (spawn in rivers, streams); spawn in fall when 2-5 years old; adults die after spawning; 6-month-old chinook and 18-month-old coho migrate from rivers to Great Lakes.



Sea lamprey

(Cut along dotted line)



Rainbow smelt

Sea lamprey

(Petromyzon marinus)

Description: grow up to 34 in.; lacks jaws; has circular mouth with rasping teeth; no paired fins.

Adult Diet: fluids and tissues of large fish, particularly salmon and trout which have small scales.

Habitat/Behavior: pelagic and benthic; spawn in rivers and streams in spring; larval lamprey (called ammocoetes) spend several years buried in sediments feeding on small organisms filtered from the water; migrate to open waters of Great Lakes for adult years; not native to Great Lakes — made its way into upper Great Lakes after the Welland Canal (bypassing Niagara Falls) was opened.

----------**(Cut along dotted line)**----------

Rainbow smelt

(Osmerus mordax)

Description: 7-8 in. and under 1/4–1 lb.; long silvery body, with rainbow-like iridescent color on sides; adipose fin.

Adult Diet: planktivore (plankton-eating).

Habitat/Behavior: mainly pelagic; anadromous (spawn in streams, rivers); spawn in spring.

SUNLIGHT

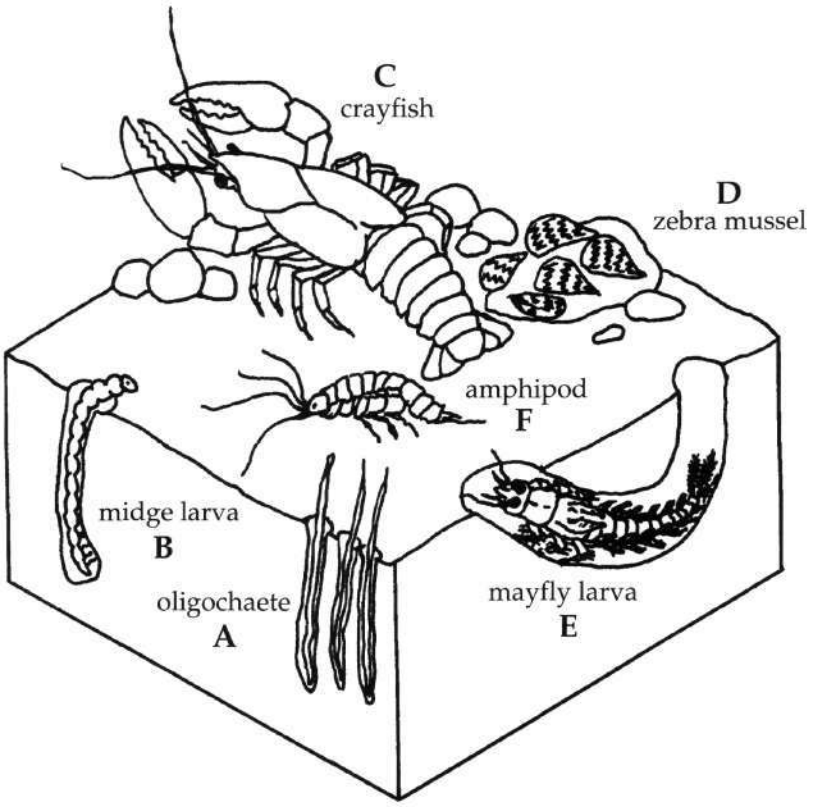
----------(Cut along dotted line)----------

HUMANS

----------(Cut along dotted line)----------

NUTRIENTS

Benthic Life in the Great Lakes



These organisms are scavengers and detritivores. Not drawn to scale; scales range from 1/2 life size to 10 times life size.

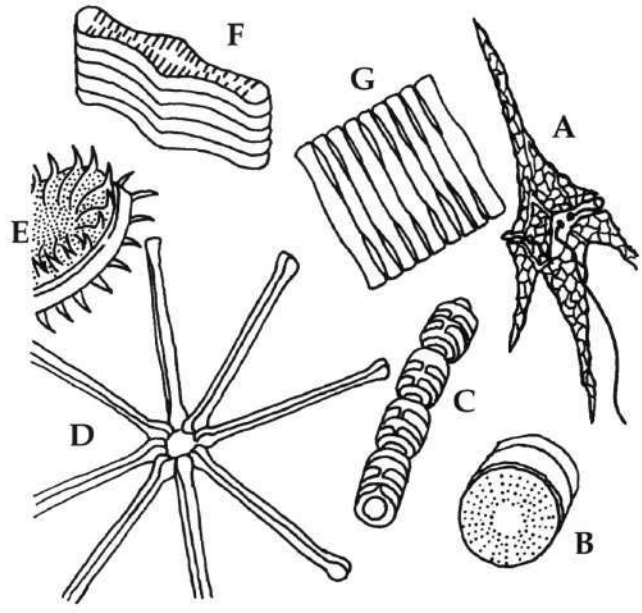
Benthic Life in the Great Lakes

Description: microscopic to small animals which live on the lake bottom. Includes animals from the following groups:

- Oligochaetes (aquatic worms, leeches) — member of segmented worm group; most under 5 cm.
- Crustaceans:
  - Decapods (crayfish) — cylinder shaped body with heavy shell and 5 pairs of walking legs; claws.
  - Amphipods (including *Diaporeia* spp.) — sometimes called freshwater shrimp; no shell, gills at base of legs, slightly compressed (flattened side–to–side).
- Aquatic insects:
  - Chironomids (midge larvae) — long, cylinder–shaped; some have anal gills.
  - *Hexagenia* (mayfly larvae) — long, slender body with feather–like gills along sides of abdomen; 3 tails at posterior end and a pair of tusks at mouth.

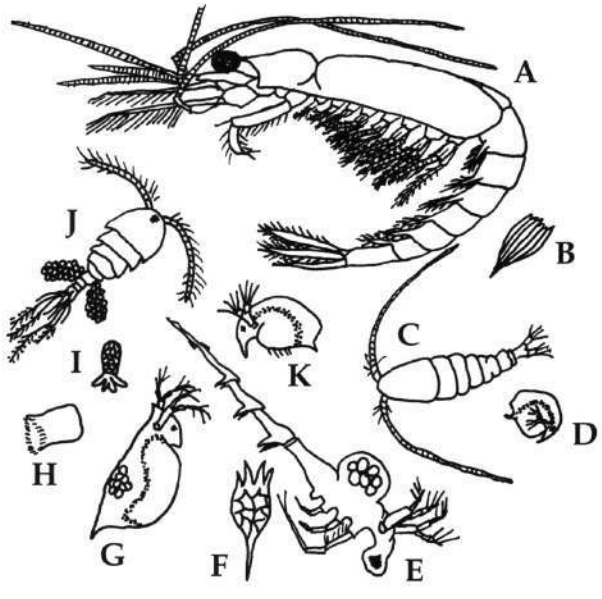
Adult Diet: scavengers/omnivores — decaying plant and animal debris (detritus), bacteria, algae; some feed on crustaceans or insect larvae; crayfish and midge larvae mainly herbivorous, but also detritivores.

Habitat/behavior: benthic; many benthic organisms build burrows or seek cover under rocks or debris. Oligochaetes build tubes and bury themselves head first, leaving the tail end with gills up in the water. Midge larvae may construct small tubes of algae, silt or sand. Mayfly larvae of the genus *Hexagenia* burrow into soft sediments in areas high in oxygen. Many protozoans are sessile and attach to a substrate, while others have pseudopods ("false feet"), cilia or a flagellum which allows them to move. *Diporeia* is the predominant benthic animal in some areas of the Great Lakes; it migrates into the pelagic zone at night (similar to opposum shrimp), but during the day it is close to or buried into the sediments in hypolimnion areas high in oxygen. *Diporeia* breed from December through April and release their young from a brood pouch in the spring.



Phytoplankton

(Cut along dotted line)



Zooplankton

PHYTOPLANKTON

(diatoms, green algae, blue-green bacteria, protists)

Description: microscopic to visible free-swimming plants; found to depths where light can penetrate water.

(Note: Not drawn to scale; scales range from 10,000 to 20,000 times life size.)

---------- **(Cut along dotted line)** ----------

ZOOPLANKTON

Description: microscopic to visible animals which are free-swimming; includes a variety of types of animals.
(Note: Not drawn to scale; scales range from 5 to 1,000 times life size.)

Crustaceans:

Water fleas (cladocerans) – body has hard shell; branched swimming antennae; large eye.

Copepods (e.g., *Cyclops*) – cylinder shaped body; long, segmented swimming antennae.

Opposum shrimp (mysids) – 10 pair of jointed legs; looks like miniature crayfish; stalked eyes.

Rotifers: rotating hairlike cilia at front of body.

Protozoans: single-celled animals such as amoebas, paramecium.

Adult Diet: mostly omnivorous, eating algae, detritus, rotifers, protozoa, other crustaceans; predators which grasp their prey include *Cyclops* and *Leptodora* (a type of water flea). Opposum shrimp, daphnia (a water flea), and rotifers sweep food to their mouths and strain it from the water.

Habitat/Behavior: mostly pelagic, found throughout Great Lakes. Make vertical migrations daily which vary with light levels, season, and age and sex of the individual animal. Most migrate up as darkness sets in and return to deep at dawn. Some species do reverse migration or twilight (at dusk and dawn) migration. Opposum shrimp also make these migrations, but may be considered more benthic than other zooplankton since they are more often found near the bottom during the day and are found in the hypolimnion during the summer. Opposum shrimp reproduce in fall, winter and early spring, then carry their eggs and young in a brood pouch for up to 3 months; young leave the pouch when about 3-4 mm long. Opposum shrimp are an important food source for trout, whitefish and chubs (ciscoes).

Taxonomy of Benthic Life in the Great Lakes

Taxonomic Level	A	B	C
Kingdom	Eukaryote*	Eukaryote*	Eukaryote*
Phylum	Annelida	Arthropoda	Arthropoda
Class	Oligochaeta	Insecta	Crustacea
Order	Lumbriculida	Diptera	Decapoda
Family	Lumbriculidae	Chironomidae	Cambaridae
Genus & species	*Lumbriculus sp.*	*Chironomus sp.*	*Orconectes sp.*
Common name	oligochaete	midge larva	crayfish

Taxonomic Level	D	E	F
Kingdom	Eukaryote*	Eukaryote*	Eukaryote*
Phylum	Mollusca	Arthropoda	Arthropoda
Class	Bivalvia	Insecta	Crustacea
Order	Veneroida	Ephemeroptera	Amphipoda
Family	Dreissenidae	Ephemeridae	Haustoriidae
Genus & species	*Dreissena polymorpha*	*Hexagenia sp.*	*Diporeia sp.*
Common name	zebra mussel	mayfly larva	amphipod, "freshwater shrimp"

* Whittaker's 5 kingdom system classified these organisms as Animalia. Under Woese's 3 kingdom system (1981), they are classified as Eukaryotes.

Taxonomy of Phytoplankton

Taxonomic level	A	A	B	C
Kingdom	Eukaryote*	Eukaryote*	Eukaryote*	Eukaryote*
Division	Phylum Protozoa	Pyrrophycophyta	Bacillariophyta	Bacillariophyta
Class	Mastigophora	Subphylum Sarcomastigophora	Coscinodiscophyceae	Coscinodiscophyceae
Order	Dinoflagellida	Dinoflagellida	Thalassiosirales	Melosirales
Family	Perininiidae	Peridiniidae	Stephanodiscaceae	Melosiraceae
Genus & species	*Ceratium sp.*	*Ceratium sp.*	*Cyclotella sp.*	*Melosira sp.*
Common name	dinoflagellate	dinoflagellate	diatom	diatom

Taxonomic level	D	E	F	G
Kingdom	Eukaryote*	Eukaryote*	Eukaryote*	Eukaryote*
Phylum	Bacillariophyta	Bacillariophyta	Bacillariophyta	Bacillariophyta
Class	Fragilariophycidae	Coscinodiscophyceae	Fragilariophycidae	Fragilariophycidae
Order	Fragilariales	Thalassiosirales	Tabellariales	Fragilariales
Family	Fragilariaceae	Stephanodiscaceae	Tabellariaceae	Fragilariaceae
Genus & species	*Asterionella sp.*	*Stephanodiscus sp.*	*Tabellaria sp.*	*Fragilaria sp.*
Common name	diatom	diatom	diatom	diatom

* Whittaker's 5 kingdom system classified the dinoflagellates as Protista, and the diatoms as Plantae. Under Woese's 3 kingdom system (1981), they are classified as Eukaryotes.

Taxonomy of Zooplankton

Taxonomic Level	A	B	C	D
Kingdom	Eukaryote	Eukaryote*	Eukaryote*	Eukaryote*
Phylum	Arthropoda	Rotifera	Arthropoda	Arthropoda
Class	Crustacea	Monogononta	Crustacea	Crustacea
Order	Mysidacea	Ploima	Copepoda, Suborder Calanoida	Cladocera
Family	Mysidae	Brachionidae	Diaptomidae	Chydoridae
Genus & species	*Mysis oculata relicta*	*Notholca sp*	*Diaptomus sp.*	*Chydorus sp.*
Common name	opossum shrimp	rotifer	copepod	cladoceran

Taxonomic Level	E	F	G	H
Kingdom	Eukaryote*	Eukaryote*	Eukaryote*	Eukaryote*
Phylum	Arthropoda	Rotifera	Arthropoda	Rotifera
Class	Crustacea	Monogononta	Crustacea	Monogononta
Order	Cladocera	Ploima	Cladocera	Ploima
Family	Cercopagidae	Brachionidae	Daphnidae	Asplanchnida
Genus & species	*Bythrotrephes cederstroemi*	*Keratella sp.*	*Daphnia sp.*	*Asplanchna sp.*
Common name	spiny water flea, Bc	rotifer	daphnia	rotifer

Taxonomic Level	I	J	K
Kingdom	Eukaryote*	Eukaryote*	Eukaryote*
Phylum	Protozoa	Arthropoda	Arthropoda
Class	Subphylum – Sarcomastigophora	Crustacea	Crustacea
Order	Testacidia	Copepoda Suborder Cyclopoida	Cladocera
Family	Difflugidae	Cyclopidae	Bosminidae
Genus & species	*Difflugia sp.*	*Mesocyclops sp.*	*Bosmina sp.*
Common name	protozoan – water flea	copepod	cladoceran – water flea

* Whittaker's 5 kingdom system classified these organisms as Animalia. Under Woese's 3 kingdom system (1981), they are classified as Eukaryotes.

Additional Overheads/Handout Masters

References for Additional Overheads/Handout Masters:

Department of Fisheries & Oceans. (Canada) 1989. 1985 Survey of Sport Fishing in Canada: Selected Results Prepared for the Great Lakes Fishery Commission. Economic and Commercial Analysis Report No. 17. Surveys Unit, Economic Analysis and Statistics Division, Economic and Commercial Analysis Directorate, Dept. of Fisheries and Oceans, Ottawa, Ontario. K1A OE6.

Hartman, W. L. 1988. Historical Changes in the Major Fish Resources of the Great Lakes. Pp. 103–131 in Toxic Contaminants and Ecosystem Health, (M. S. Evans, ed.), John Wiley & Sons, Inc., New York.

Hesselberg, R. J., J. P. Hickey, D. A. Nortrup, and W. A. Willford. Contaminant Residues in the Bloater *(Coregonus hoyi)* of Lake Michigan, 1969–1986. J. Great Lakes Res. 16(1): 121–129.

Mills, E. L., J. H. Leach, J. T. Carlton and C. L. Secor. 1993. Exotic Species in the Great Lakes: A History of Biotic Crises and Anthropogenic Introductions. J. Great Lakes Res. 19(1):1–54.

Talhelm, D. R. 1988. Economics of Great Lakes Fisheries: A 1985 Assessment. Great Lakes Fishery Commission, Tech. Rep. No. 54, Ann Arbor, MI.

U.S. Dept. of Interior, Fish & Wildlife Service and U.S. Dept. of Commerce. 1993. 1991 National Survey of Fishing, Hunting and Wildlife Associated Recreation. U.S. Government Printing Office, Washington, DC.

Underhill, J. C. 1986. The Fish Fauna of the Laurentian Great Lakes, the St. Lawrence Lowlands, Newfoundland and Labrador. Pp. 105–136 The Zoogeography of North American Freshwater Fishes (Hocutt, C. H. and E. O. Wiley, eds.), John Wiley & Sons, NY.

Aquatic Life in the Great Lakes

Number of Fish Species Found in the Great Lakes

Basin	# of fish species in lake	# of fish species in tributaries
Erie	99	124
Ontario	95	118
Huron	87	109
Michigan	78	130
Superior	45	71

Source: Underhill, 1986.

Year of First Record for Exotic Species in the Great Lakes

LAKE	SEA LAMPREY	ALEWIFE	SMELT
Ontario	1830s	1873	1929
Erie	1921	1931	1932
Huron	1932	1933	1925
Michigan	1936	1949	1923
Superior	1946	1954	1930

Source: Hartman 1988; Mills et al, 1993.

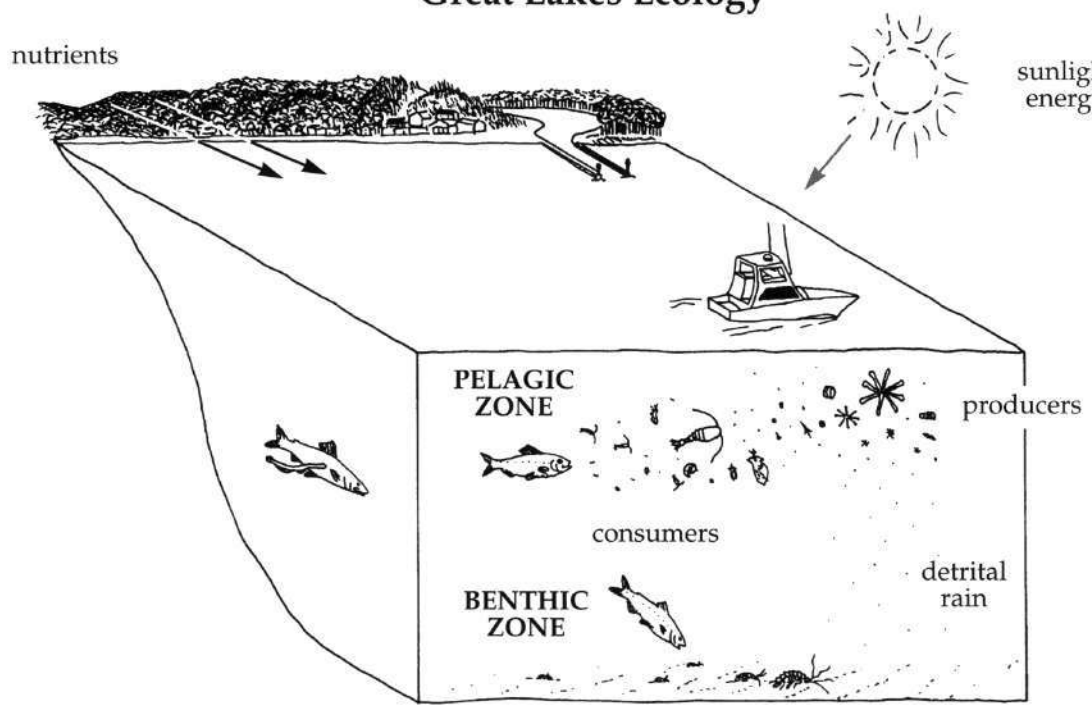
Recent Invaders of the Great Lakes

LAKE	WHITE PERCH	RUFFE	SPINY WATER FLEA**	ZEBRA MUSSEL***
Ontario	1950*	–	1985	1989
Erie	1953*	–	1985	1988
Huron	1980*	–	1984	1990
Michigan	1990	–	1986	1989
Superior	–	1986	1987	1989

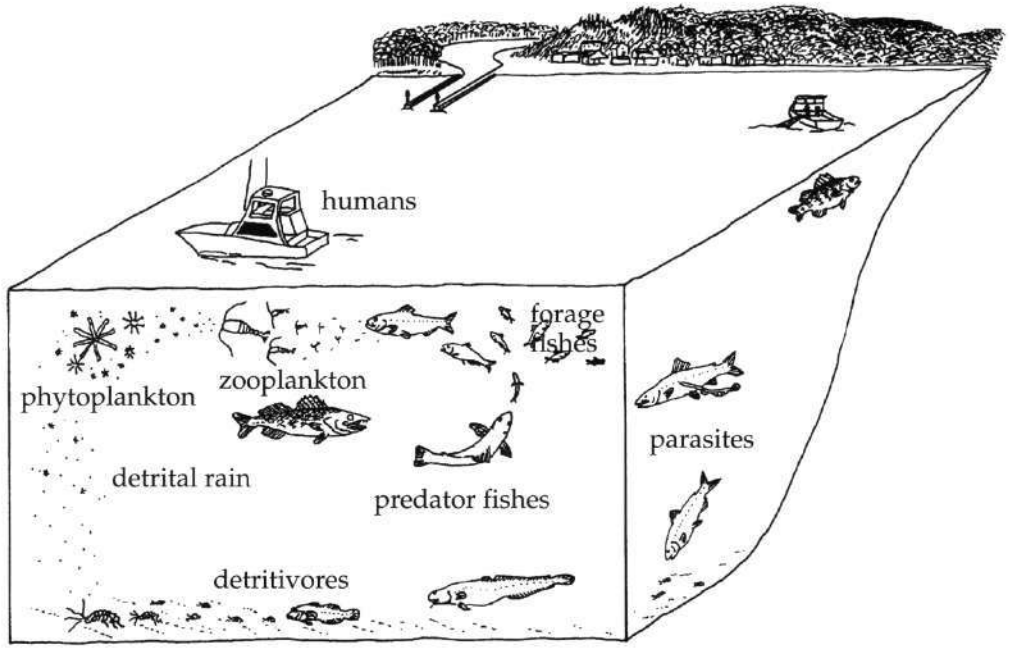
Source: *Hartman, 1988.
**Michigan Sea Grant College Program, 1991.
***U.S. Fish and Wildlife Service, 1992. Nonindigenous Aquatic Species Data Base. U.S. Dept. of Interior, National Fisheries Research Center, Gainesville, FL.

Great Lakes Ecology and Food Web

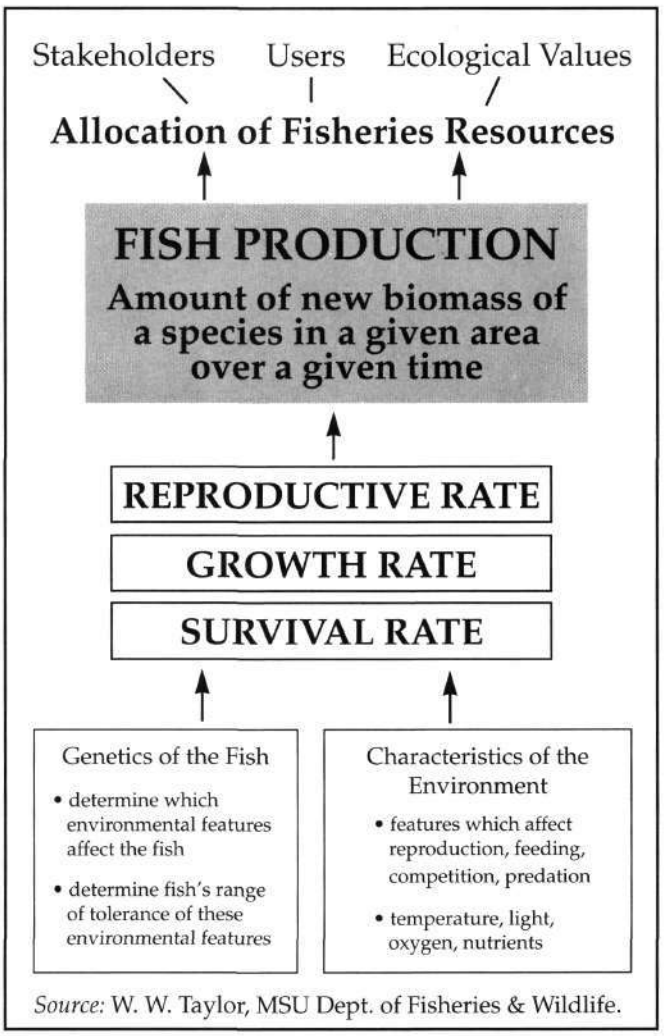
Great Lakes Ecology



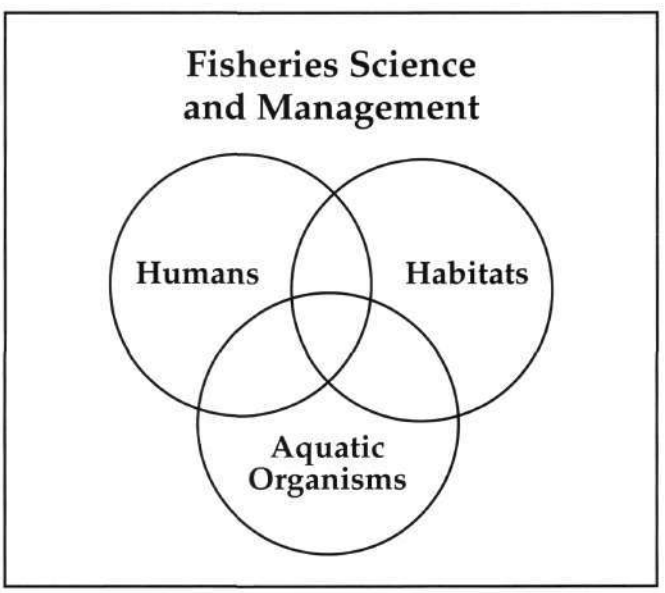
Great Lakes Food Web



Fish Production and Fisheries Science and Management

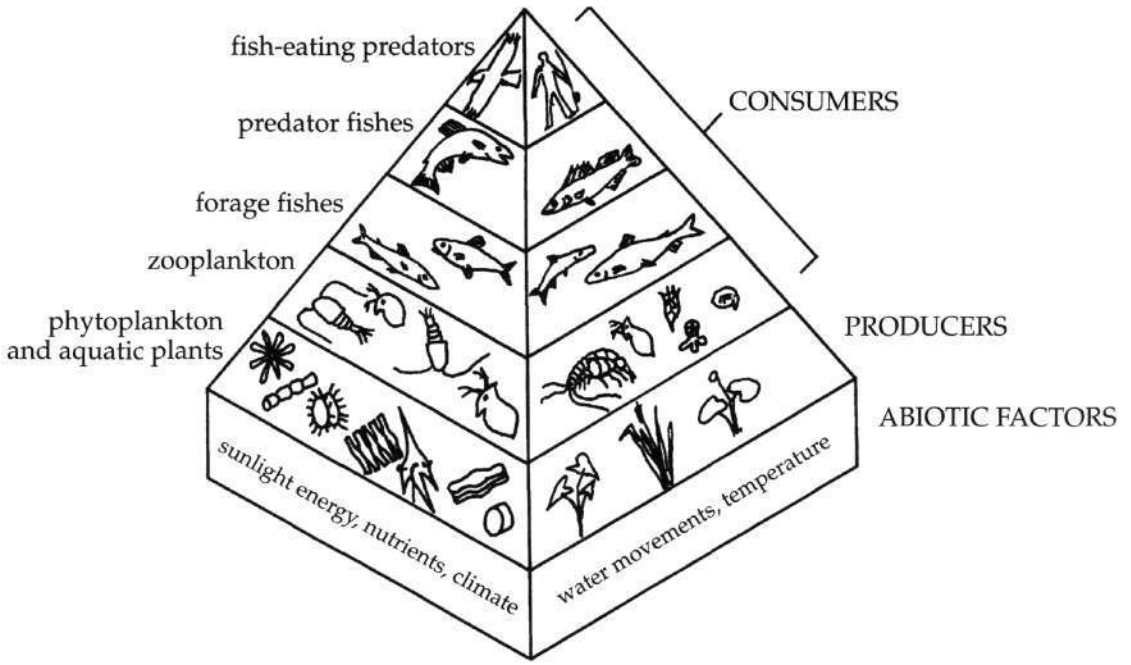


Source: W. W. Taylor, MSU Dept. of Fisheries & Wildlife.

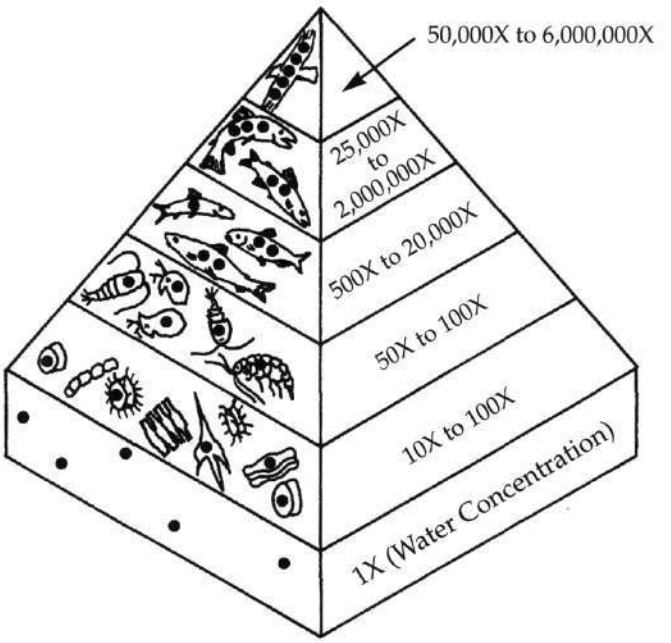


Pyramid of Biomass and Biomagnification in the Great Lakes

Pyramid of Biomass



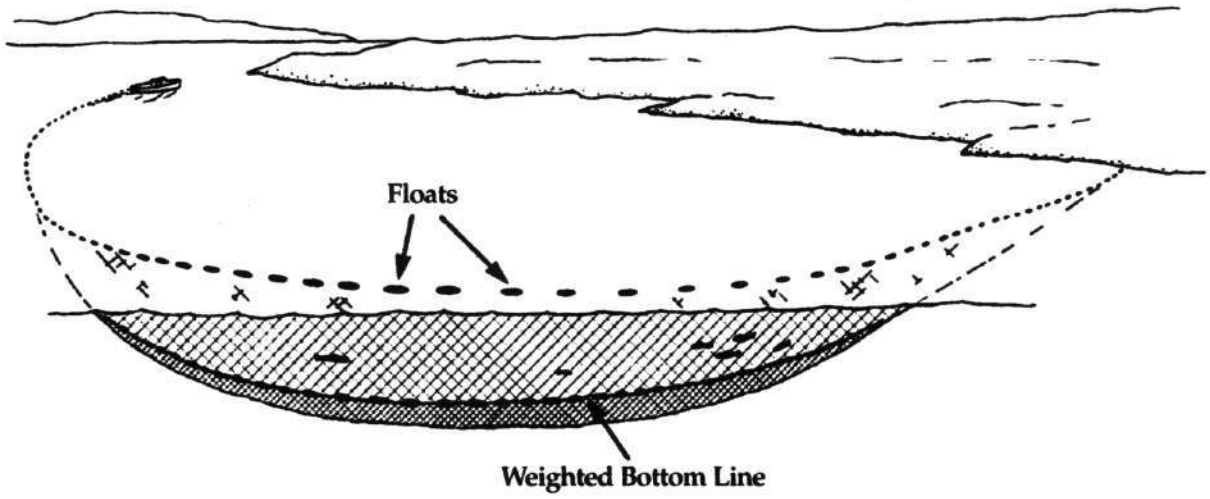
Biomagnification in the Great Lakes



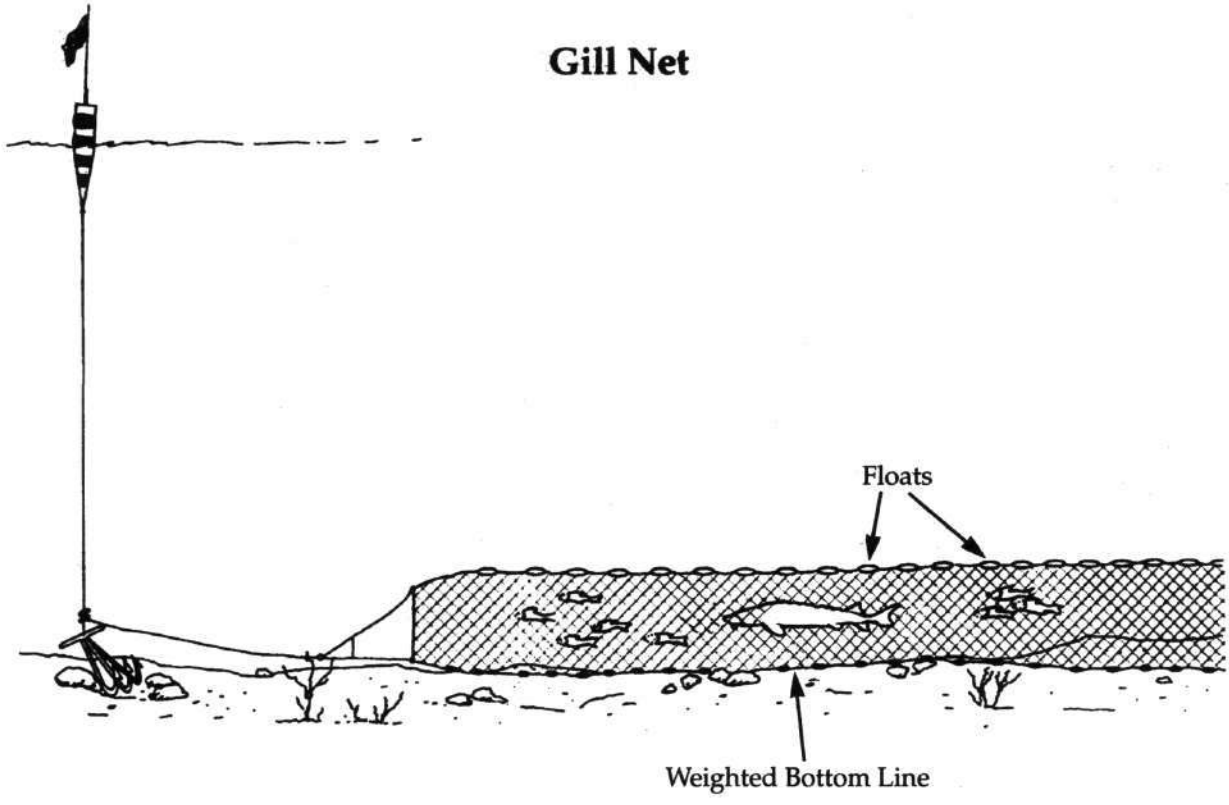
Dots represent concentration of **contaminants** in organism. Concentrations are expressed as multiples of the water concentration at the right of the figure.

Historic and Commercial Fishing Nets in the Great Lakes

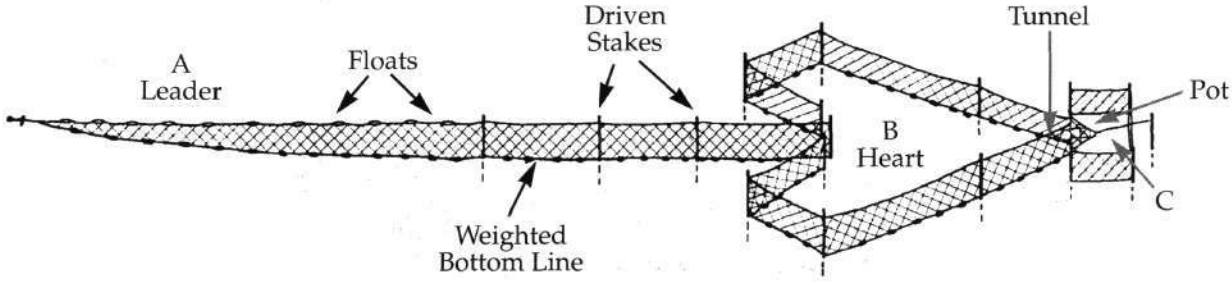
Beach Seine Net



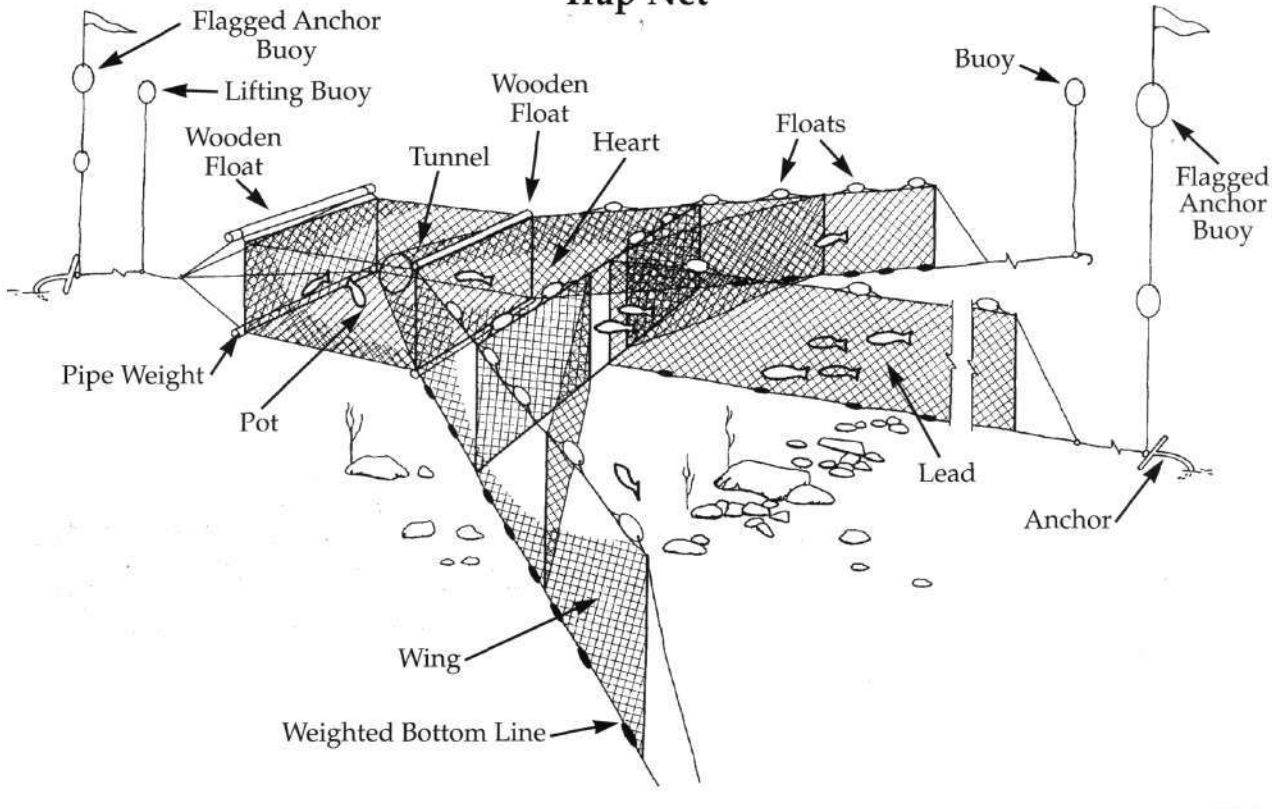
Gill Net



Pound Net



Trap Net



Commercial Fisheries in the Great Lakes

Estimated Worker-Years Attributable to the Great Lakes Food Fishery in 1985

OCCUPATIONS	WORKER-YEARS IN THE U.S.	WORKER-YEARS IN CANADA	TOTAL WORKER-YEARS IN THE GREAT LAKES FOOD FISHERY
Fishing	300	500	800
Processing & Wholesaling	1,900	3,300	5,200
Secondary	1,100	1,900	3,000
TOTALS	**3,300**	**5,700**	**9,000**

Source: Talhelm, 1988.

1991 Catch and Landed Value of Fisheries in the Great Lakes

LAKE	U.S. WATERS		CANADIAN WATERS		ALL GREAT LAKES WATERS
	Total catch (lb.)	Total value (U.S. dollars)	Total catch (lb.)	Total value (Canadian dollars)	Total catch (lb.)
Ontario	232,551	184,630	1,212,728	1,036,489	1,445,279
Erie	5,793,590	3,009,708	40,620,666	28,198,935	46,414,256
Huron	4,747,267	3,413,640	6,378,861	6,992,415	11,126,128
Michigan	17,813,663	13,667,898	—	—	17,813,663
Superior	2,877,240	2,187,020	1,648,681	851,004	4,525,921
TOTALS	**31,464,311**	**22,462,896**	**49,860,936**	**37,078,843**	**81,325,247***

*Total dollar value for catch from all Great Lakes waters is not summed due to fluctuations in U.S. - Canada exchange rates.
Sources: U.S. Fish & Wildlife Service; Ontario Ministry of Natural Resources.

1991 Commercial Catch of Various Species of Fish in U.S. and Canadian Waters of the Great Lakes

SPECIES	U.S. WATERS		CANADIAN WATERS		ALL GREAT LAKES WATERS
	Total catch (lb.)	Total value (U.S. dollars)	Total catch (lb.)	Total value (Canadian dollars)	Total catch (lb.)
Lake whitefish	10,147,729	9,044,929	4,936,706	5,059,193	15,084,435
Yellow perch	3,389,500	6,641,415	5,408,194	11,509,884	8,797,694
Chubs	3,913,231	1,965,686	1,221,500	1,014,307	5,134,731
Lake trout	312,186	156,872	306,454	252,994	618,640
Channel catfish	1,052,934	473,107	118,606	48,181	1,715,540
Lake herring	613,908	212,340	531,888	164,162	1,145,796
Walleye	22,409	24,106	6,482,851	9,604,319	6,505,260
Rainbow smelt	3,519,862	1,689,772	20,238,505	4,126,535	23,758,367
Carp	1,500,508	125,181	116,018	39,324	1,616,526
American eel	—	—	214,248	292,811	—
Chinook salmon	429,827	199,184	—	—	—
White bass	445,808	375,322	1,968,420	1,896,770	2,414,228
White perch	1,015,298	373,707	7,018,105	3,167,713	8,033,403

Sources: U.S. Fish & Wildlife Service; Ontario Ministry of Natural Resources.

Sportfishing in the Great Lakes: Where It Occurs

Number of U.S. Anglers Fishing and Days Spent Angling on Each of the Great Lakes and Connecting Waters in 1991

LOCATION	# U.S. ANGLERS	# DAYS SPENT BY U.S. ANGLERS
Lake Ontario	298,000	2,394,000
Lake Erie	905,000	7.082,000
Lake Huron	230,000	2,113,000
Lake Michigan	864,000	5,090,000
Lake Superior	114,000	883,000
Lake St. Clair	118,000	1,658,000
St. Lawrence River	31,000	218,000
Connecting waters*	260,000	3,021,000
Tributaries**	148,000	1,616,000
TOTALS	2,552,000	25,225,000

(Detail will not add to total due to multiple responses.)

*Connecting waters include St. Clair River, St. Marys River system, Detroit River, Niagara River.

**Includes fishing on tributaries for smelt, salmon and steelhead.

Source: U.S. Dept. of Interior, Fish & Wildlife Service; and U.S. Dept. of Commerce, 1993.

Number of Canadian Anglers Fishing and Days Spent Angling on Each of the Great Lakes and Connecting Waters in 1985

LOCATION	# CANADIAN ANGLERS	# DAYS SPENT BY CANADIAN ANGLERS
Lake Ontario	298,812	3,745,579
Lake Erie	171,683	1,949,822
Lake Huron	443,118	5,183,058
Lake Superior	90,091	967,057
Lake St. Clair	57,625	952,209
St. Lawrence River	82,787	1,220,0114
Connecting waters*	43,247	607,361
TOTALS	997,656	14,625,100

(Detail will not add to total due to multiple responses.)

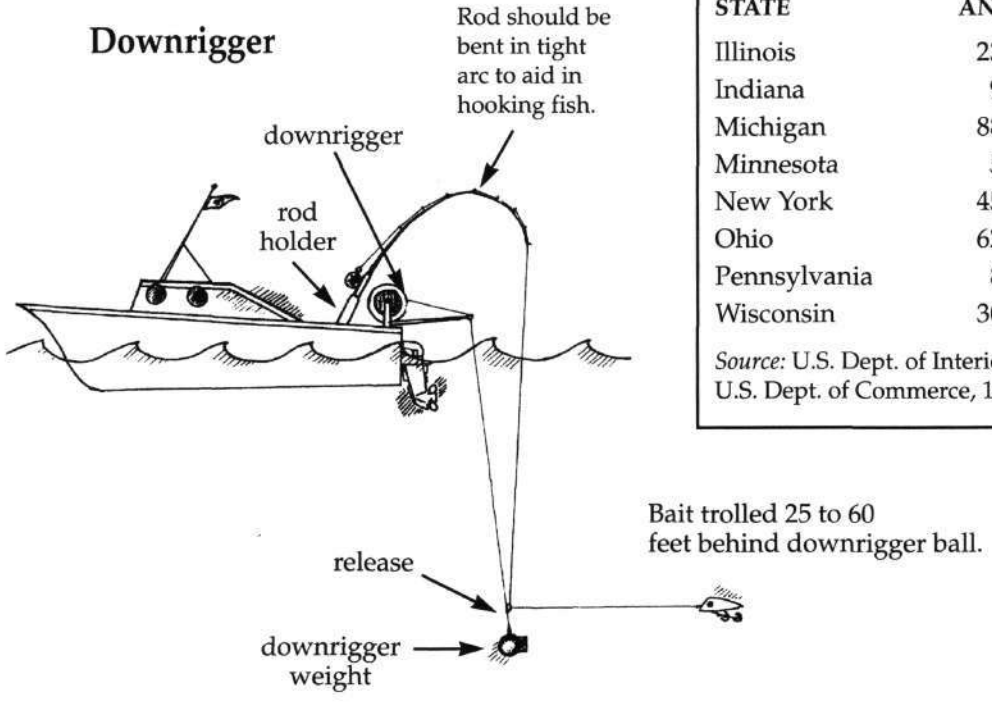
*Connecting waters include St. Clair River, St. Marys River system, Detroit River, Niagara River.

Source: Dept. of Fisheries and Oceans, Canada, 1989.

Number of Anglers and Days Spent Angling by U.S. Anglers on Great Lakes and Connecting Waters by State in 1991

STATE	# U.S. ANGLERS	# DAYS SPENT BY U.S. ANGLERS
Illinois	238,000	1,382.000
Indiana	97,000	573,000
Michigan	886,000	11,060,000
Minnesota	52,000	303,000
New York	458,000	4,426,000
Ohio	629,000	4,602,000
Pennsylvania	85,000	629,000
Wisconsin	301,000	2,353,000

Source: U.S. Dept. of Interior, Fish & Wildlife Service; and U.S. Dept. of Commerce, 1993.



Sportfishing in the Great Lakes: What Species Anglers Prefer

Popularity of Fish Species for U.S. Anglers on the Great Lakes and Connecting Waters in 1991

FISHES	# U.S. ANGLERS SEEKING FISHES	# DAYS SPENT BY U.S. ANGLERS
Walleye and sauger	1,028,000	9,489,000
Yellow perch	983,000	8,170,000
Salmon	721,000	4,622,000
Largemouth and smallmouth bass	526,000	4,369,000
Lake trout	482,000	2,980,000
Steelhead	289,000	2,444,000
Other trout	276,000	2,280,000
Northern pike, pickerel, muskie	213,000	2,318,000

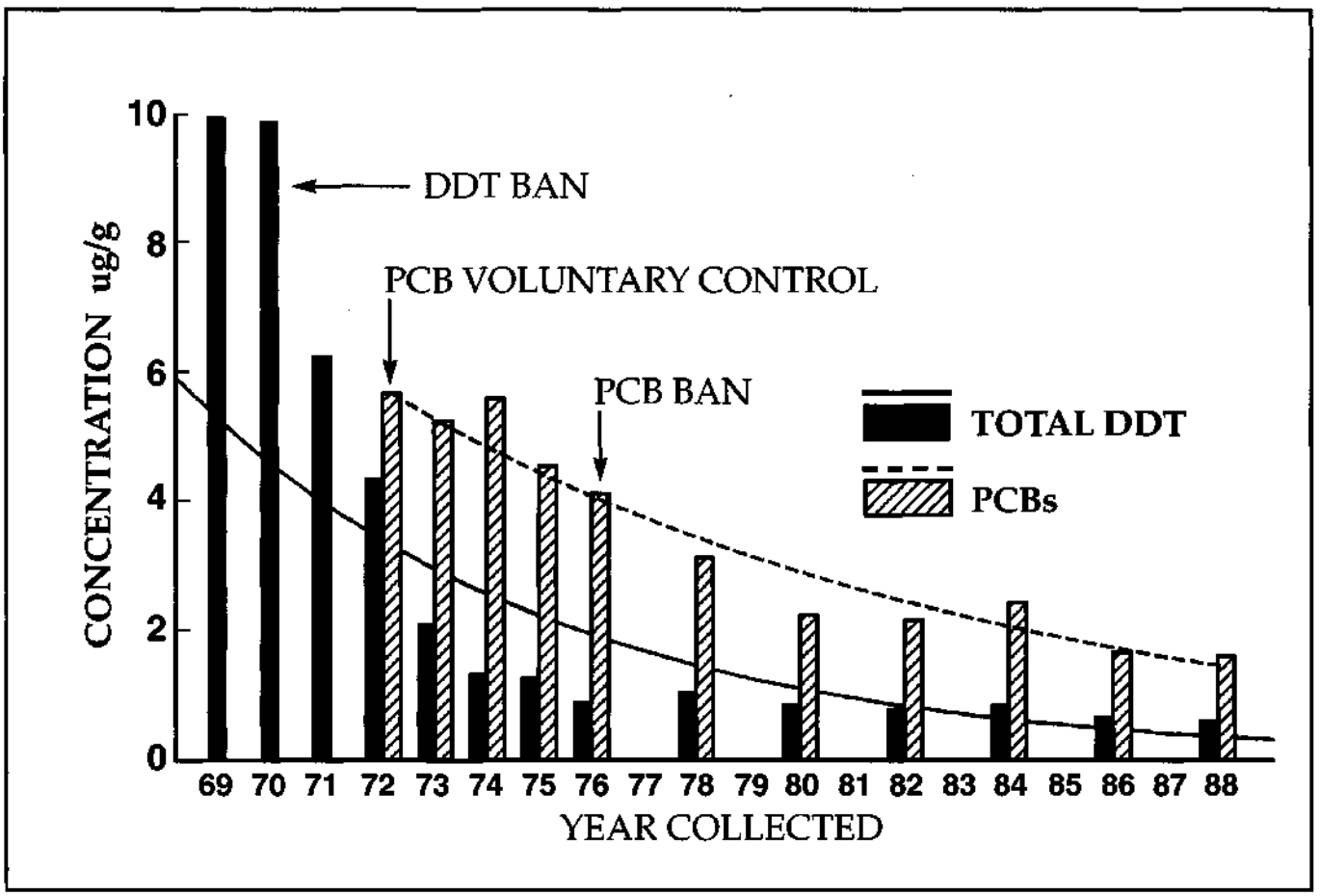
Source: U.S. Dept. of Interior, Fish & Wildlife Service; and U.S. Dept. of Commerce, 1993.

Popularity of Fish Species by Numbers of Fishes Caught by Canadian Anglers on the Great Lakes and Connecting Waters in 1985

FISHES	NUMBER CAUGHT BY CANADIAN ANGLERS
Perch	18,128,013
Smelt	13,458,485
Panfishes	6,169,686
Smallmouth bass	5,912,005
Walleye	5,470,093

Source: Dept. of Fisheries and Oceans, Canada, 1989.

Contaminant Trends in Lake Michigan Bloaters



Source: R. Hesselberg, National Biological Survey, Ann Arbor, MI.

Curriculum Materials Related to Great Lakes Fisheries or Aquatic Sciences

BE SURE TO CHECK THE PUBLICATION "The Life of the Lakes: A Guide to the Great Lakes Fishery" for other useful resource materials. This publication also lists addresses of state, provincial, federal and international agencies, non–profit organizations, state Sea Grant programs, and other institutions. Write to these organizations for more information about Great Lakes fisheries. Other state organizations that educators may wish to contact include: 4–H programs, state science teachers' organizations, and state environmental education organizations.

Andrews, E. 1992. Educating Young People About Water: A Guide to Goals and Resources. Univ. of Wisconsin–Madison, Environmental Resources Center, 216 Agriculture Hall, 1450 Linden Dr., Madison, WI 53706. (A very comprehensive bibliography of a wealth of aquatic education materials.)

Appreciating Your Great Lakes. Illinois/Indiana Sea Grant Communications, 65 Mumford Hall, 1301 W. Gregory Dr., Urbana, IL 61801.

Directory of Great Lakes Educational Material. International Joint Commission, PO Box 32869, Detroit, MI 48232–2869.

Entine, L. and E. Fisher (eds.). 1985. Our Great Lakes Connection: A Curriculum Guide for Grades K–8. Univ. of Wisconsin, Madison, WI.

Final Report of the Great Lakes Educators Advisory Council to the International Joint Commission. 1993. IJC, 100 Oullette Avenue, 8th Floor, Windsor, ON N9A 6T3 or PO Box 32869, Detroit, MI 48232. (Summary of existing programs and recommendations for future efforts.)

F.I.S.H. — Fishermen Involved in Saving Habitat: The Coalition for the Conservation of Aquatic Habitat, Pacific States Marine Fisheries Commission, Habitat Education Program, 45 SE 82nd Dr., Suite 100, Gladstone, OR 97027–2522. Teachers may also contact the F.I.S.H. Habitat Education Program of the Atlantic States Marine Fisheries Commission, 1776 Massachusetts Ave., Suite 600, Washington, DC 20036. (Materials focus on marine, not freshwater, fisheries.)

Fish Ways. Ontario Ministry of Natural Resources, 90 Sheppard Ave., 6th Floor, North York, ON M2N 3A1.

4–H Great Lakes Fishes Fact Sheets (2 page bulletins on various Great Lake fishes). Michigan State University Extension, Bulletin Office, 10B Agriculture Hall, MSU, East Lansing, MI 48824.

Future Fisherman Foundation, 1250 Grove Ave., Suite 300, Barrington, IL 60010. Several resources:

- Fishing Fun For Kids Booklet
- Aquatic Resources Education Curriculum
- Sport Fishing and Aquatic Resources Handbook
- Hooked on Fishing Not on Drugs (video, print materials, posters, awards etc.).

Great Lakes Education Speakers Bureau Directory. Great Lakes Commission, 400 S. Fourth St., Ann Arbor, MI 48103–4816.

The Great Lakes Lighthouse Keepers Association Educational Resource Guide. 1993. GLLKA, PO Box 580, Allen Park, MI 48101.

The Great Lakes in My World: An Activities Workbook for Grades K–8. Lake Michigan Federation, 59 E. VanBuren, Suite 2215, Chicago, IL 60605.

Living in Water. The National Aquarium, Pier 3, 501 E. Pratt St., Baltimore, MD 21202.

National Fishing Week Steering Committee, 2944 Patrick Henry Dr., Suite 15, Falls Church, VA 22044. Several resources including packets for organizing educational clinics.

National Science Teachers Association. 1990. Great Lakes JASON Curriculum. NSTA Publications, 1840 Wilson Blvd., Arlington, VA 22201–3000.

Nowak, P., L. Lin and W. Stapp. 1983. Investigating the Great Lakes Environment: Unit 2, Great Lakes Fishing in Transition (MICHU–SG–83–400), and Investigating the Great Lakes Environment Unit 1, The Sea Lamprey Story (Out–of–print; MICHU–SG–80–400). Michigan Sea Grant College Program, Ann Arbor, MI.

Ohio Sea Grant College Program, 1541 Research Center Bldg, 1314 Kinnear Rd., Columbus, OH 43212–1194. Several resources:

> Oceanic Education Activities for Great Lakes Schools (OEAGLS) (a series including many materials such as *PCBs in Fish: A Problem?, Yellow Perch in Lake Erie, To Harvest a Walleye, A Day in the Life of a Fish, Build a Fish to Scale)* and *Supplemental Curriculum for Holling Clancy Holling's Paddle–To–The–Sea.*

Pathway to Fishing. (Guide for 12–station walk–through seminar about fish and fishing.) Document #024– 010–00697–8, available from: Superintendent of Documents, Washington, DC 20402.

Trout Unlimited, 800 Follin Lane, SE, Suite 250, Vienna, VA 22180–4959. Several resources:

> More than A Fishing Club (video)
>
> Youth Education Handbook
>
> Book of Basic Trout Fishing

U.S. Environmental Protection Agency. 1990. Great Minds? Great Lakes! (EPA Document No. 905/M/90/004). U.S. EPA, Great Lakes National Program Office, 230 S. Dearborn St., Chicago, IL 60604.

Young, K. and M. D. Duda. 1993. Sport Fishing, Boating and Aquatic Resource Outreach Program Inventory. Responsive Management, 245 E. Water St., Harrisonburg, VA 22801.

References for Legends and Stories About the Great Lakes

Bruchac, J. 1985. Iroquois Stories: Heroes and Heroines, Monsters and Magic. The Crossing Press, Freedom, CA 95019.

Holling, H. C. 1969. Paddle–To–The–Sea. Houghton Mifflin Co., Boston, MA.

Otto, S. 1990. Walk In Peace: Legends and Stories of the Michigan Indians. Michigan Indian Press, Grand Rapids Inter–Tribal Council, Grand Rapids, MI.

Schoolcraft, H. R. 1985. The Hiawatha Legends. Avery Color Studios, AuTrain, MI 49806.

Sivertson, H. 1992. Once Upon an Isle: The Story of Fishing Families on Isle Royale. Wisconsin Folk Museum, Mount Horeb, WI.

Videos About Fisheries

(Contact sources for information about price and ordering or borrowing videos.)

Fishermen of Isle Royale. 1976. 20 min. Order from: Isle Royale Natural History Association, Houghton, MI.

Great Lakes Invader: The Sea Lamprey Battle Continues. 1993. 25 min. Order from: Great Lakes Fishery Commission, 2100 Commonwealth Blvd., Ann Arbor, MI 48105.

The Killing Tide. 48 min. (CNN documentary on fisheries issues in North America.) Order from: AFS Publications, PO Box 1056, Evans City, PA 16033.

No Safe Harbor. 19 min. (How habitat affects fishes; marine fisheries examples.) Order from: F.I.S.H. Habitat Education Program, Pacific States Marine Fisheries Commission, 45 SE 82nd Dr., Suite 100, Gladstone, OR 97027–2522.

The Trouble with Toxics. 30 min. Michigan Sea Grant Extension, 334 Natural Resources Bldg., MSU, E. Lansing, MI 48824.

Zebra Mussels. 1993. 30 min. Order from: NY Sea Grant Institute, 117 Nassau Hall, SUNY at Stony Brook, Stony Brook, NY 11794–5001.

Several videos are available from:

> Chippewa–Ottawa Treaty Fishery Management Authority, Albert (Big Abe) LeBlanc Building, 186 E. Three Mile Rd., Sault Ste. Marie, MI 49783.
>
> Great Lakes Indian Fish and Wildlife Commission, PO Box 9, Odanah, WI 54861.

Other Educational Opportunities

Note: Most of these organizations conduct workshops for teachers, youth leaders, other educators, or citizens.

The Schoolship Program
Inland Seas Education Association
PO Box 4223
Traverse City, MI 49685–4223

Trips aboard schooners for grades 6–10; youths examine Great Lakes fishes, plankton, sediments and heritage activities.

R/V D. J. Angus
Water Resources Institute
Grand Valley State University
Allendale, MI 49401

Aquatic science excursions aboard the research vessel for K–12 and citizen groups.

John G. Shedd Aquarium
1200 South Lake Shore Dr.
Chicago, IL 60605

Variety of displays, program offerings and publications/resource materials.

R/V Lake Guardian
Program Manager
102 9th St.
Bay City, MI 48708

EPA research vessel which provides educational programs, as well.

R/V Laurentian
Center for Great Lakes and Aquatic Sciences
The University of Michigan
2200 Bonisteel Boulevard
Ann Arbor, MI 48109

Cruises and teacher training programs on Great Lakes aquatic sciences.

NIMBI – (Now I Must Become Involved)
RR #7
Dunnville, ON N1A 2W6

Water quality testing, other Great Lakes learning activities aboard 40–foot research tug.

Great Lakes Education Program
Macomb County – Michigan State University Extension
Michigan Sea Grant Extension
21885 Dunham Rd.
Clinton Township, MI 48036

Water quality testing and vessel education experience for local elementary classrooms.

F. T. Stone Laboratory
Put–in–Bay, OH 45345
or write to:
Stone Lab
The Ohio State University
1314 Kinnear Rd.
Columbus, OH 43212–1194

Educational workshops on Lake Erie's ecology.

M.V. Macassa Bay
E. K. Tour Boat Service Ltd.
3A Hillyard St.
Hamilton, ON L8L 6A9

Great Lakes water resources tours aboard a 93–foot ship.

Michigan 4–H Youth Programs
Great Lakes Leaders Lab, and 4–H Great Lakes and Natural Resources Camp
6H Berkey Hall
Michigan State University
East Lansing, MI 48824

In cooperation with the MSU Department of Fisheries & Wildlife and Michigan Sea Grant Extension; teen leadership camp for 13–15 year olds and leader/teacher training weekend.

Lake Superior Center
353 Harbor Dr.
Duluth, MN 55802

Educational workshops on Lake Superior for teachers.

Project WET, Aquatic Project WILD, and Aquatic Resource Education Contacts in the Great Lakes Region

Aquatic Project WILD Coordinators

Note: Aquatic Project WILD is a K–12 curriculum available to educators by attending a Project WILD workshop. Contact the individuals below to obtain more information about this program in your area.

Kathleen M. Andrews
Kids for Conservation
Department of Conservation
524 S. 2nd St., Rm 515
Springfield, IL 62701–1787

Ann Picor
Illinois Board of Education
100 N. First St.
Springfield, IL 62777

Warren Gartner
Division of Fish and Wildlife
Department of Natural Resources
6013 Lakeside Blvd.
Indianapolis, IN 46278–1996

Frank Knight
Department of Environmental Conservation
50 Wolf Rd., Rm. 504
Albany, NY 12233

Jon Williams
Ohio Department of Education
65 S. Front St., Rm 1005
Columbus, OH 43266–0308

Paul Schiff
Ohio Division of Wildlife
1840 Belcher Dr.
Fountain Square, G–1
Columbus, OH 43224

Carl Richardson
Pennsylvania Fish Commission
PO Box 1673
Harrisburg, PA 17105–1673

Valeri Humphrey
Department of Natural Resources
Box 7921
Madison, WI 53707

Dale Elshoff
Tollgate Education Center
28115 Meadowbrook Rd.
Novi, MI 48377–1328

Karen VanNorman
Minnesota Nongame Wildlife Section
500 Lafayette Rd.
St. Paul, MN 55155

Christine Wannop
Ontario Ministry of Natural Resources
Resource Stewardship and
Development Branch
External Transfer and Education Section
90 Shepard Ave. East, 6th Floor
North York, ON M2N 3A1

National Project WILD Office
5430 Grosvenor Lane
Bethesda, MD 20814

Project WET Program

Project WET is a new curriculum modelled after the successful Project WILD model. It focuses on water resources topics. For more information, contact the national office at:

National Project WET: Water Education
for Teachers
Montana State University
Culbertson Hall
Bozeman, MT 59715-9908

Aquatic Resource Education Contacts and Programs

Larry Dunham
Division of Fisheries
Illinois Department of Conservation
600 North Grand Ave. W
Springfield, IL 62706

or

Kids for Conservation
Illinois Department of Conservation
524 South Second St.
Springfield, IL 62701–1787

or

Mike Jones
Chicago Urban Fishing Project
9511 Harrison St.
DesPlaines, IL 60016

Urban fishing programs, fishing clinics, resource materials.

Carole Lee
Aquatic Education Program
Bureau of Fisheries
Wisconsin Department of Natural Resources
Box 7921
Madison, WI 53707

Carl Richardson, Coordinator
KARE – Keystone Aquatic Resource Education
Pennsylvania Fish Commission
PO Box 67000
Harrisburg, PA 17106–7000

Teacher workshops, fishing skills, PLAY – Pennsylvania League of Angling Youth (newsletter, materials), publications.

Verdie Abel
Aquatic Education Specialist
Division of Wildlife
Ohio Department of Natural Resources
1840 Belcher Drive
Columbus, OH 43223–1329

Angler workshops, school programs, museum exhibits, state fair program, publications (including Sport Fishing and Aquatic Resources Handbook).

Bruce Matthews
Department of Natural Resources
Fernow Hall
Cornell University
Ithaca, NY 14853

Sportfishing and Aquatic Resource Education Program — offered in conjunction with NY 4–H programs, master anglers as volunteer instructors of youth clubs, workshops, materials, school programs. (Publications available from: Cornell Univ. Resource Ctr., 7 BTP, Ithaca NY 14850.)

Warren Gartner
Department of Natural Resources
6013 Lakeside Blvd.
Indianapolis, IN 46278–1996

Teacher training, fishing clinics, materials.

Linda Erickson–Eastwood
MinnAqua Program Director
Minnesota Department of Natural Resources
Fisheries Section
500 Lafayette Road, Box 12
St. Paul, MN 55155

Teacher workshops, youth materials, urban fishing clinics, offered in conjunction with 4–H youth programs.

Ned Fogle
Michigan Department of Natural Resources
Fisheries Division
PO Box 30028
Lansing, MI 48909

Angling clinics, urban youth fishing programs, materials.

Christine Wannop
Fish Ways
Education Policy Officer
Resource Stewardship and Development Branch
External Transfer and Education Section
Ontario Ministry of Natural Resources
90 Sheppard Ave., 6th Floor
North York, ON M2N 3A1

Detailed fisheries biology and management curriculum.

Environmental Education Organizations in the Great Lakes Region (as of 4/94)

Glen Hester, President
Council of Outdoor Educators of Ontario
20 Linn Circle, RR #3
Caledon East, ON L0N 1E0

John Beaver, President
EE Association of IL
47 Horrabin Hall
Western Illinois University
Macomb, IL 61455

Darci Zolman, President
EE Association of IN, Inc.
Kosciusko County S. & W.C.D.
217 Bell Dr., Suite 1
Warsaw, IN 46580

Don Place, Executive Director
MI Alliance for Environmental
and Outdoor Education
5615 Chickadee Lane
Clarkston, MI 48346

Liz Jones
MN Association for EE
3815 E. 80th St.
Bloomington, MN 55425

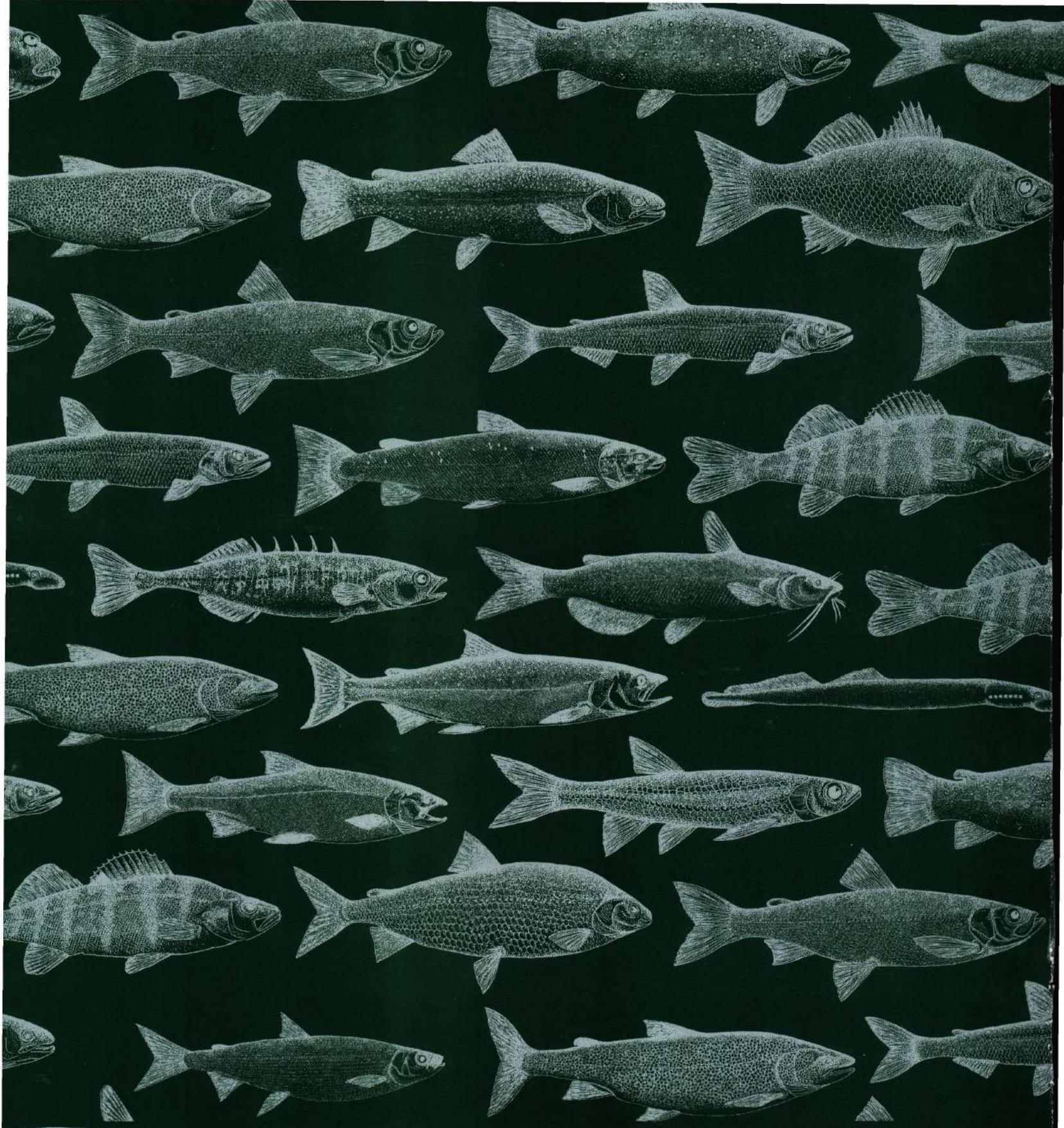
Ed Zero
NY State Outdoor Education Association
134 Cove Rd.
Oyster Bay, NY 11771

Tim Taylor
Ohio Conservation and Outdoor
Education Association
397 West Myrtle Ave.
Newark, OH 43055

PA Alliance for EE
601 Orchid Place
Emmaus, PA 18049

Meta Reigel, Administrative Assistant
WI Assoc. for EE, Inc.
7290 County MM
Amherst Junction, WI 54407

North American Association for EE
PO Box 400
Troy, OH 45373



MICHIGAN STATE UNIVERSITY EXTENSION

Produced by Outreach Communications and printed on recycled paper using vegetable-based inks.

New 9:94-2.5M-TCM-SP - Price $5.00 Extension Bulletin E-2441; MICHU-SG-93-401