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ABSTRACT

This activity book is part of a series designed to take a concept or idea from the existing school curriculum and develop it in the context of the Great Lakes using teaching approaches and materials appropriate for students in middle and high school. The theme of this book is life in the Great Lakes. Students learn about shorebird adaptations, invader species, food webs, and biomass pyramids. Activities are divided into several subjects: (1) Organisms in the Lakes; (2) Ecological Relationships; and (3) Estuary Values and Changes. The activities are characterized by subject matter compatibility with existing curriculum topics. Several kinds of connections have been designed to assist teachers in finding the place where the new materials fit and also the justification for fitting them. The connections include a Framework of Seven Understandings developed by science teachers, science educators, and scientists to represent fundamental desired results of science education. Each activity in this book addresses a number of these Understandings and two or more Earth subsystems. Connections are also made to the National Science Education Standards and the Benchmarks for Science Literacy. (PVD)

LIFE IN THE GREAT LAKES

ES-EAGLS

Earth Systems — Education Activities for Great Lakes Schools

The Ohio Sea Grant College Program is one of 29 state programs that works to increase understanding and wise use of the nation's ocean and Great Lakes resources. Projects are conducted in partnership with government, academia, industry, and the general public. Sea Grant fulfills its mission by promoting education excellence, responsive research and training, and broad, prompt dissemination of knowledge and technical information.

Earth Systems - Education Activities for Great Lakes Schools (ES-EAGLS)

This series of publications was produced as a result of Ohio Sea Grant Education Program's project "Cooperative Curriculum Enhancement and Teacher Education for the Great Lakes" funded by Ohio Sea Grant under grant NA46RG0482, project E/CMD-3, with support from The Ohio State University and cooperating schools.

ES-EAGLS are designed to take a concept or idea from the existing school curriculum and develop it in a Great Lakes context appropriate for students in middle and high school.

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Rosanne W. Fortner

Series Editors

Land & Water Interactions in the Great Lakes EP-082
Amy L. Sheaffer

Great Lakes Climate & Water Movement EP-083
Heidi Miller and Amy L. Sheaffer

Great Lakes Shipping EP-084
Rosanne W. Fortner

Life in the Great Lakes EP-085
Amy L. Sheaffer

Great Lakes Environmental Issues EP-086
Amy L. Sheaffer

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http://www-ohiosg.osc.edu/
OhioSeagrant

ES - EAGLS

Earth Systems - Education Activities for Great Lakes Schools

Results of studies of student knowledge about the oceans and Great Lakes environments indicate a need for greater awareness and a greater understanding of the impact they have upon our lives. Earth Systems - Education Activities for Great Lakes Schools (ES-EAGLS) are designed to take a concept or idea from the existing school curriculum and develop it in a Great Lakes context, using teaching approaches and materials appropriate for students in middle and high school.

The activities are characterized by subject matter compatibility with existing curriculum topics; short activity time lasting one to three classes; minimal preparation time; minimal equipment needs; standard page size for easy duplication; suggested extension activities for further information or creative expression; teachability demonstrated by use in middle school classrooms; and content accuracy assured by critical reviewers.

Included with the activities are some suggestions about possible ways to use the activities in cooperative learning situations and how lessons can be structured according to the learning cycle.

This is one of a series of subject area activity books being published. The subject of this book is life in the Great Lakes. Other subject areas available are Great Lakes shipping, climate and water movement, land and water interactions, and Great Lakes environmental issues. For a more detailed listing of the *Life in the Great Lakes* activities, see the matrix on page 7. Most of the activities in this book were modified from Oceanic Education Activities for Great Lakes Schools (OEAGLS), developed by the Ohio Sea Grant Education Program and revised from 1985 to 1991. All ES-EAGLS are listed inside the back cover.

Life in the Great Lakes

INTRODUCTION

ACTIVITIES

Organisms in the Lakes

Ecological Relationships

Estuary Values and Changes

APPENDIX

Using *ES-EAGLS Life in the Great Lakes*

An accompanying matrix (page 7) matches activities to the Earth Systems Understandings (ESU), and the Earth subsystems directly addressed (hydrosphere, lithosphere, cryosphere, biosphere, atmosphere). It demonstrates the range of instructional opportunities available for the classroom.

The principles that guided development of the activities should also direct their classroom use:
- Potential for collaborative learning and group decision making.
- Use of historical and descriptive as well as experimental data.
- Integration of science disciplines in a social context.

It is recommended that the format for the activities be retained when they are used in the classroom. Some short activities are designed for introduction to topics or for awareness. Longer activities focus attention for extended work and are designed to build understanding, synthesis, application, and evaluation skills. The extent and focus of the activities will help teachers decide which are useful in cooperative groups and which are best for use by the class as a whole.

1. Each activity is a question to be explored. Far too many classroom activities are done for the sake of activity alone. If an important and relevant question is the guide for learning, there is greater focus and a readily apparent reason for doing the activity. Be sure to call students' attention to the question driving the exploration, and encourage creative approaches to problem solving.

2. Most activities are addressed to the student for direct use. Additional notes and answers for teacher use are found in narrow columns on each page so they can be concealed if the page is to be given to students.

3. Activities do not stand alone. They should be linked, before and after, to other curriculum topics and information resources such as the Internet. The best questions are those that lead to more questions!

COOPERATIVE LEARNING POSSIBILITIES

There are many ways to organize the activities with cooperative learning strategies, and all of them are the "right way." You are encouraged to modify strategies to make the activities work in your setting. Some possible strategies follow.

GROUPS

Divide the class into three or four groups, with each group responsible for certain tasks that will contribute to class learning. Assign each group member a job or task appropriate to the lesson. He or she is then responsible to the group for doing this job. Jobs can be combined, and they should be rotated between group members periodically. Some possible job descriptions are:

Facilitator	Develops a plan with the group so that the group will finish within the time limit.
Recorder	Records plan, answers, and conclusions as appropriate.
Reader	Reads instructions and background material to group.
Artist	Sketches diagrams, posters, and charts as appropriate.
Checker	Checks to make sure the group is following instructions and the plan.
Speaker	Shares group progress report with class.
Materials Expert	Gets lab materials and makes sure things are cleaned up and returned.

JIGSAW

Divide the class into groups of four students each. These are the base groups. Then divide the class differently into four expert groups. One person from each base group will be in each of the four expert groups. (You will need to adjust the numbers of groups depending on your class size.) Each student should be in two groups. Instead of having every student doing all activities, assign each expert group a different activity or task on which it becomes the expert. Then have students meet in their base group and share what was done in the expert group and what was learned. Or have the expert groups do their activities and then rotate the base groups through the activities with the "expert" members leading the base groups through the activity.

STUDENT TEAMS ACHIEVEMENT DIVISIONS

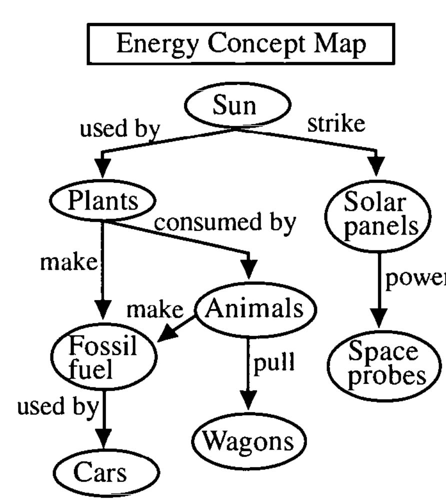
After some type of class presentation such as a lecture, video, or textbook reading, students are divided into teams. Students on the teams work together to make sure that all members of the team understand the material of the presentation. The students then take a quiz individually. Students have a minimum desired score, and the team works to get a high team improvement score (points above the minimum desired score). For more information about this strategy, read *Using Team Learning* by Robert Slavin (Baltimore: The Johns Hopkins Team Learning Project, 1986).

CO-OP CO-OP

This strategy is very student-directed. Students are in teams based on shared interest. The teams subdivide their topics, and each student is responsible to research his or her own subtopic. Students then share what they have learned about the subtopic with their whole team. The teams prepare a presentation for the entire class, and they are encouraged to include the class in the presentation in some way. *Cooperative Learning: Resources for Teachers* by Spencer Kagan (Riverside, CA: University of California, 1985) provides more information about this strategy.

ASSESSMENT STRATEGY: CONCEPT MAPPING

Concept mapping is one way of having students show visually their understanding of concepts and the concepts' relationships to each other. This can be done as a pre-assessment or a post-assessment or both to see the change in a student's understanding. A brief strategy for use of concept mapping would be to brainstorm a list of terms that students know about a topic. Add terms that you want to make sure are included. Have students start with the topic at the top or center of a sheet of paper, and then using arrows and labels, students place the brainstormed terms on the map, showing how they are related. See the example of a student's preliminary energy concept map.



There are many other ways of assessing student achievement, including performance assessment, portfolios, and grading rubrics. To learn more about these strategies you might read:

Aronson, J. 1978. *The Jigsaw Classroom.* Beverly Hills: Sage.

Hassard, Jack. 1990. Cooperating Classroom. *Science Scope.* March, p. 36-45.

Johnson, D.W., R.T. Johnson and E.J. Holubec. 1986. *Circles of Learning: Cooperation in the Classroom.* Edina, MN: Interaction Book Company.

Mayer, V.J. and R.W. Fortner, Eds. 1995. *Science Is a Study of Earth — A Resource Guide for Science Curriculum Restructure.* Columbus, OH: Earth Systems Education Program, The Ohio State University.

Special Supplement on Assessment. March, 1992. *Science Scope.* This issue contains articles on performance assessment, portfolios, group assessment, concept mapping, and rubrics.

Example Cooperative Lessons

Note: Complete information on materials and methods can be found in the activities listed.

Example: Life in a Great Lake

Engagement
As a class brainstorm all of the living things in a Great Lake. Write ideas on the blackboard or poster with one organism listed as suggested by each student.

Exploration
Jigsaw: Divide the class into three expert groups for completing one of each of the following activities.

Activity: "What factors affect the size of a natural population? (A Great Lakes fish example)"
1. Identify group leader. Obtain materials.
2. Play the Perch Life Cycle game. When done, discuss the questions under part G of the Procedure.
3. Discuss each of the activity's objectives.
4. Meet as a group to decide what information from this activity will be shared with your base groups.

Activity: "Who can harvest a walleye?"
1. Identify your group leader. Obtain materials.
2. Play the Walleye game.
3. When the group has completed the game, divide into subgroups. One group completes the activity "What does a biomass pyramid tell us?" and the other group completes Procedure 1 of the activity "What is a food web?"
4. The two groups share their information.
5. Discuss the content related to each of the objectives of the activities.
6. Meet as a group to decide what information from this activity will be shared with your base groups.

Activity: "What do scientists know about invader species of the Great Lakes?"

1. Identify your group leader. Obtain materials.
2. Do the activity using colored cards. Generalize the information about invader species to share with your base groups.
3. Visit the Internet site for the panel on aquatic nuisance species (http://www.glc.org/projects/ans/anspanel.html) and find out what new "aquatic exotics" have entered the Great Lakes in the past two years.
4. Review the zebra mussel updates at the Web site http://patton.nfrcg.gov:80/zebra.mussel and be prepared to share current information with your base groups. Web sites sometimes change. Do a word search if necessary to find sites and related information.

Elaboration

As a class, do the following to complete the jigsaw:

1. Combine groups together into new (base) groups of six or more members (at least two from each expert group). Students should discuss the activities with one another and share what they learned in expert groups.
2. Assign a role from the activity "How can a natural fish population be managed?" to each of your new group members. After members have read their role descriptions, conduct a discussion of the two proposals made by the Division of Wildlife.

Evaluation

1. Assign a Lake Ecology Portfolio Element: In the activities of this session, students have encountered a large variety of organisms on several trophic levels. Using at least 15 different organisms, they are to construct a food web illustrating relationships among them. If they use an organism in its larval form, they must be sure to note that. Otherwise an adult will be assumed. Remember that arrows in a food web go FROM the food TO the eater (e.g., mayfly -> barn swallow).

   When the web is completed, each student chooses one organism and discusses how the history of its species tells us about the environmental history of one or more of the Great Lakes.

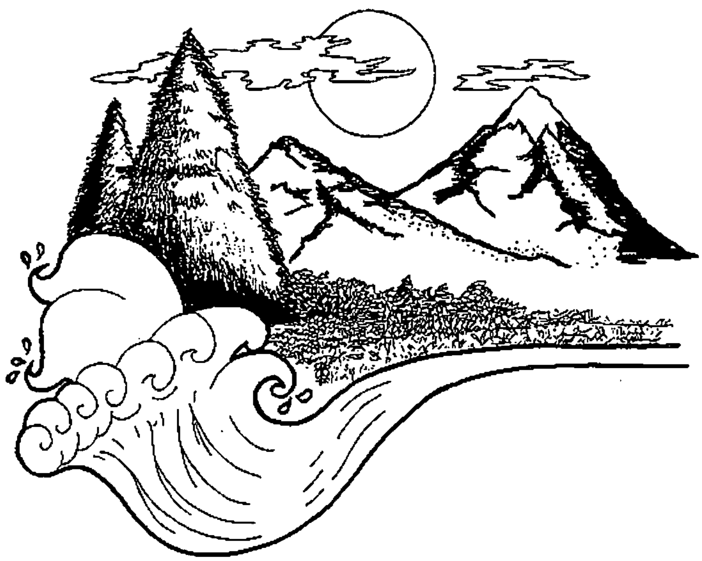
2. Develop a process rubric for use in scoring student performance in the expert group activities and in the application and report-out sessions of base groups. A separate rubric can be used to assess the quality of reports and other communication efforts. A sample rubric is given in the appendix of this volume.

Making Connections

There is always a danger in producing curriculum materials designed for infusion. How can we facilitate getting new material into the existing flow of classroom subject matter? In this project, we have designed several kinds of connections to assist teachers in finding not only the place where the new materials fit, but also the justification for fitting them and the ancillary resources that can contribute to their effectiveness. The connections we see are demonstrated here and in the charts on the following pages.

Earth Systems Education

http://www.ag.ohio-state.edu/~earthsys

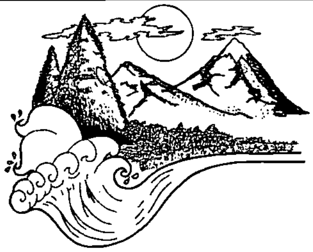


Earth Systems Education is a program of curriculum restructure in which teachers take responsibility for critical evaluation of their science curriculum, including content, classroom processes, learner outcomes, and assessment, and strive to make changes that create a curriculum more responsive to human needs and future quality of life. Earth systems education is based on integration of traditional science disciplines for a more comprehensive understanding of the interactions of Earth subsystems: the hydrosphere, lithosphere, atmosphere, biosphere, and cryosphere.

Efforts are guided by a Framework of Seven Understandings (p. 7 and 117) developed by science teachers, science educators, and scientists to represent fundamental desired results of all of science education. Each activity in this set addresses a number of the Understandings and two or more Earth subsystems, and includes suggestions for extending learning.

The process of curriculum change is assisted by scientists and science educators through development of materials such as these. Additional materials available for Earth Systems Education include a resource guide for science curriculum restructure using Earth as a focus. The guide, titled *Science is a Study of Earth,* includes research background, teacher experiences, and samples of activities useful at elementary, middle, and high school levels. Another volume of activities is designed to help secondary science teachers address the complex issues of global change. *Activities for the Changing Earth System (ACES)* includes 20 interdisciplinary activities. These publications are available from the Earth Systems Education Program, c/o OSU School of Natural Resources, 2021 Coffey Road, Columbus, OH 43210.

Ohio Sea Grant has also produced regional information and activities about global change. *Great Lakes Instructional Materials for the Changing Earth System (GLIMCES)* includes classroom activities for secondary science, based on *Global Change in the Great Lakes Scenarios.* These can be ordered ($9.00 for both) from Ohio Sea Grant, 1314 Kinnear Road, Columbus, OH 43212-1194.



	LIFE IN THE GREAT LAKES	Earth Systems Understandings							Earth Subsystems				
		Beauty & Value	Stewardship	Scientific Process	Interactions	Change Through Time	Earth as Subsystem	Careers & Hobbies	Hydrosphere	Lithosphere	Cryosphere	Atmosphere	Biosphere
pg. #	Activities:	1	2	3	4	5	6	7	1	2	3	4	5
15	How does a dichotomous key work?			X									X
19	What are the characteristics of some Great Lakes fish?			X									X
33	How do fish get their names?	X		X									X
35	How are shorebirds adapted for feeding?	X	X	X	X								X
41	What do scientists know about invader species of the Great Lakes?	X	X	X	X	X	X	X	X				X
55	Who can harvest a walleye?	X	X		X	X	X		X				X
67	What does a biomass pyramid tell us?				X								X
71	What is a food web?	X			X				X	X			X
75	What factors affect the size of a natural population? (A Great Lakes fish example)		X	X	X	X			X	X		X	X
87	How can a natural fish population be managed?	X	X	X	X			X					X
97	What is the ecological role of an estuary?	X	X	X	X			X	X	X			X
105	How does the estuary serve as a nursery?	X		X	X	X			X				X

FRAMEWORK FOR EARTH SYSTEMS EDUCATION*

Understanding #1. Earth is unique, a planet of rare beauty and great value.

Understanding #2. Human activities, collective and individual, conscious and inadvertent, affect Earth systems.

Understanding #3. The development of scientific thinking and technology increases our ability to understand and utilize Earth and space.

Understanding #4. The Earth system is composed of the interacting subsystems of water, rock, ice, air, and life.

Understanding #5. Earth is more than 4 billion years old, and its subsystems are continually evolving.

Understanding #6. Earth is a small subsystem of a Solar system within the vast and ancient universe.

Understanding #7. There are many people with careers and interests that involve study of Earth's origin, processes, and evolution.

* complete Framework on page 117

Content standards, Grades 5-8

Science as inquiry
* Abilities related to scientific inquiry
* Understanding about scientific inquiry

Physical science
Properties and changes of properties in matter
Motions and forces
* Transfer of energy

Life science
* Populations and ecosystems
* Diversity and adaptations of organisms

Earth and space science
Structure of the Earth system
Earth's history

Science and technology
* Understanding about science and technology

Science in personal and social perspectives
* Populations, resources, and environments
* Natural hazards
* Risks and benefits
* Science and technology in society

History and nature of science
* Science as a human endeavor
* Nature of science

Unifying concepts and processes
* Order and organization
* Evidence, models, and explanation
* Change, constancy, and measurement
* Evolution and equilibrium
* Form and function

National Science Education Standards

The activities in *Earth Systems - Education Activities for Great Lakes Schools* have connections to other national developments in science education. Numerous efforts have been underway in the 1990s to restructure science education in response to growing concerns that the historic "layer cake" (discipline-ordered) approach to science lacks relevance to students, prepares them poorly in life skills that demand science literacy, leaves U.S. students lagging on standardized international tests of science knowledge, and ignores or perhaps even perpetuates naive conceptions in science. The primary efforts to change these patterns have emerged from and been supported by national organizations in science and education.

The National Science Education Standards represent the National Academy of Science's attempt to develop guidelines for science curriculum restructure and systemic change in K-12 education. The National Standards include science content standards that express need for integration of disciplines, fewer topics in greater depth, and articulation across grade levels. They do more by providing guidelines for restructuring the teaching of science, the environment for science in schools, and assessment of science learning. The Standards emerged in 1995 as the most comprehensive and perhaps most esteemed of the restructure guidelines.

The following list demonstrates the connections of *Earth Systems - Education Activities for Great Lakes Schools* to many of the National Science Education Standards. Standards preceded by an asterisk (*) are specifically addressed in this activity set.

BENCHMARKS FOR SCIENCE LITERACY

Project 2061 is supported by the American Association for the Advancement of Science (AAAS). Through its book *Science for All Americans*, this project identified science concepts that every high school graduate in the United States should know. Major contributions of this effort include the idea that "less is more," or that a curriculum dealing with fewer concepts in greater detail is preferred over the traditional vocabulary-laden mini-college courses common in U.S. secondary schools. Follow-up work through selected school districts produced several models for implementing the curriculum changes implied by 2061, and has resulted in a set of Benchmarks for designing the course sequences and gauging the progress of students in science through their school careers.

Many of the Benchmarks are addressed through activities in this volume. They are too numerous to list here in their entirety, but the following Benchmarks are among those applicable to the activities.

Examples for grades 6-8 include:

- Animals and plants have a great variety of body plans and internal structures that contribute to their being able to make or find food and reproduce.
- Similarities among organisms are found in internal anatomical features which can be used to infer the degree of relatedness among organisms. In classifying organisms, biologists consider details of internal and external structures to be more important than behavior or general appearance.
- In all environments – freshwater, marine, forest, desert, grassland, mountain, and others – organisms with similar needs may compete with one another for resources, including food, space, water, air, and shelter. In any particular environment, the growth and survival of organisms depend on the physical conditions.
- Individual organisms with certain traits are more likely than others to survive and have offspring. Changes in environmental conditions can affect the survival of individual organisms and entire species.

For grades 9-12 this material addresses:

- Ecosystems can be reasonably stable over hundreds or thousands of years. As any population of organisms grows, it is held in check by one or more environmental factors: depletion of food or nesting sites, increased loss to increased numbers of predators, or parasites. If a disaster such as flood or fire occurs, the damaged ecosystem is likely to recover in stages that eventually result in a system similar to the original one.
- Human beings are part of the earth's ecosystems. Human activities can, deliberately or inadvertently, alter the equilibrium in ecosystems.
- The chemical elements that make up the molecules of living things pass through food webs and are combined and recombined in different ways. At each link in a food web, some energy is stored in newly made structures but much is dissipated into the environment as heat. Continual input of energy from sunlight keeps the process going.

Content standards, Grades 9-12

Science as inquiry
* Abilities related to scientific inquiry
* Understanding about scientific inquiry

Physical science
Chemical reactions
Forces and motions
* Conservation of energy
* Interactions of energy and matter

Life science
* Biological evolution
* The interdependence of organisms

Earth and space science
* Energy in the Earth system
Origin and evolution of the Earth system

Science and technology
* Understanding about science and technology

Science in personal and social perspectives
* Natural resources
* Environmental quality
* Natural and human-induced hazards
* Science and technology in local, national, and global challenges

History and nature of science
* Science as a human endeavor
* Nature of scientific knowledge
* Historical perspectives

Unifying concepts and processes
* Order and organization
* Evidence, models, and explanation
* Change, constancy, and measurement
* Evolution and equilibrium
* Form and function

Other Connections

NOAA Global Change Education Program, U.S. Department of Commerce,
1100 Wayne Ave., Rm. 1210, Silver Spring, MD 20910-5603
(301)427-2089. http://www.noaa.gov/

Great Lakes Environmental Research Laboratory (GLERL) conducts environmental research with an emphasis on the Great Lakes, including toxins in the Great Lakes, natural hazards, ecosystem interactions, hydrology, and effects related to global climate change. GLERL is part of the National Oceanic and Atmospheric Administration (NOAA).
2205 Commonwealth Blvd., Ann Arbor, MI 48105
(313)741-2244. http://www.glerl.noaa.gov/

Canadian Atmospheric Environment Service
Environment Canada, 4905 Dufferin Street, Downsview, Ontario, Canada M3H 5T4

International Joint Commission (IJC) is an appointed commission of representatives from U.S. and Canada who act as advisors of management activities of the Great Lakes and rivers along the border between countries. The IJC incorporates public input and efforts of research, environmental, government and business interests in their ongoing efforts. Main office: 100 Ouellette Avenue, Windsor, ON N9A 6T3.
(519)256-7821; Detroit Office: P.O. Box 32869, Detroit, MI 48232.
(313)226-2170. http://www.great-lakes.net:2200/partners/IJC/ijchome.html

Great Lakes Commission is an interstate commission of the eight Great Lakes states established in 1955 to "promote the orderly, integrated and comprehensive development, use and conservation of the water resources of the Great Lakes Basin."
The Argus II Building, 400 Fourth St., Ann Arbor, MI 48103
(313)665-9135. http://www.glc.org/

Great Lakes Information Management Resource (GLIMR) is an index of Environment Canada's Great Lakes programs, publications, and databases.
http://www.cciw.ca/glimr/intro.html

Great Lakes Information Network (GLIN) is a great place to start exploring the Great Lakes on the Internet.
http://www.great-lakes.net/

National Sea Grant College Program – Great Lakes Network
http://www.mdsg.umd.edu/NSGO/index.html (One web site links all Sea Grant programs.)
Illinois/Indiana Sea Grant Program, 1206 S. Fourth St., 104 Huff Hall, Champaign, IL 61820. (217)333-1824
Michigan Sea Grant College Program, 2200 Bonisteel Blvd., Ann Arbor, MI 48109. (313)763-1437
Minnesota Sea Grant College Program, 1518 Cleveland Ave., N., Rm 302, St. Paul, MN 55108. (612)625-2765
New York Sea Grant Institute, State Univ. of NY, Nassau Hall, Stony Brook, NY 11794-5000. (516)632-6905
Ohio Sea Grant College Program, 1314 Kinnear Rd., Columbus, OH 43212-1194. (614)292-8949
Wisconsin Sea Grant, 1800 University Ave., Madison, WI 53705-4094. (608)262-0644

INTERNET SITES OF GENERAL INTEREST

National Climatic Data Center, http://www.ncdc.noaa.gov
U.S. Army Corps of Engineers, Detroit District, http://sparky.nce.usace.army.mil
Ohio Sea Grant, http://www-ohiosg.osc.edu/OhioSeagrant
National Biological Service, http://www.im.nbs.gov/im.html
The North American Breeding Bird Surveym, http://www.im.nbs.gov/bbs/bbs.html
U.S. Fish and Wildlife - Region 3, http://www.fws.gov/~r3pao/r3home.html
U.S. Fish and Wildlife - Wildlife Species, http://www.fws.gov/
The Tree of Life, including evolutionary relationships, http://phylogeny.arizona.edu/tree/phylogeny.html
Eisenhower National Clearinghouse, teacher resources for mathematics and science, http://www.enc.org
U.S. E.P.A. wetlands information, http://www.epa.gov/owow/ogwow/wetline.html
NOAA, National Estuarine Research Reserves, http://wave.nos.noaa.gov/ocrm/nerr/welcome.html
Threatened and Endangered Species in the Great Lake States, http://www.nceet.snre.umich.edu/EndSpp/greatlakeSp.html

PUBLICATIONS AND OTHER MATERIALS

Fortner, R.W., Project Director; A. Lewandowski and Richard Meyer, Editors, 1996. *Great Lakes Solution Seeker* (CD-ROM). Columbus: Ohio Sea Grant Education Program, Ohio State University.

Fortner, Rosanne W., Project Director, Heidi Miller and Amy Sheaffer, Editors. 1995. *Great Lakes Instructional Material for the Changing Earth System.* Columbus, OH: Ohio Sea Grant Education Program, The Ohio State University. This set of activities explores the potential impacts of global climate change on various sectors of the Great Lakes. Concepts are organized for cooperative learning strategies.

Fortner, R.W. and V.J. Mayer. 1993. *The Great Lake Erie. A Reference Text for Educators and Communicators.* Columbus: Ohio Sea Grant. This is the source of information used in most of the activities. Chapters are written by experts in Great Lakes topics, and readings from the book can serve as the content base for additional instruction.

Mayer, V.J. and R.W. Fortner, 1995. *Science Is a Study of Earth: A Resource Guide for Science Curriculum Restructure.* Columbus, OH: Earth Systems Education Program, The Ohio State University. Ideas on effective ways to improve science teaching and learning, assess progress, do cooperative learning, conduct workshops, etc. Sample activities for grades K-HS.

The Great Lakes. An environmental atlas and resource book. 1995. Jointly produced by the Government of Canada and U.S. EPA, 3rd edition. Copies are available from the Great Lakes National Program Office, U.S. EPA, 77 W. Jackson Blvd., Chicago, IL 60604.

The Great Lakes Forecasting System, Department of Civil Engineering, The Ohio State University, with support from GLERL, NOAA. This online system makes predictions of physical variables of the Great Lakes and gives maps of existing conditions on Lake Erie, updated every six hours.
World Wide Web address – http://superior.eng.ohio-state.edu/

Trautman, Milton B. 1981. *The Fishes of Ohio.* Revised Edition. Columbus: Ohio State University Press in collaboration with Ohio Sea Grant College Program, Center for Lake Erie Area Research.

OTHER RESOURCES

Brown, Shirley, David Crosby, and Dan Jax. *Earth systems science activities.* 1995. Columbus, OH: Bexley Middle School. Activities for grades 6-12 using an Earth Systems Education Framework approach. Funding provided by Ohio Environmental Protection Agency (Ohio EPA) and Ohio Environmental Education Fund (OEEF). Available from Bexley Middle School (publisher), 300 S. Kassingham Road Bexley, OH 43209, Phone: (614)237-4277; Fax: (614)231-8448

International Station Meteorological Climate Summary Ver 2.0 (CD-ROM, DOS). Federal Climate Complex, Asheville, NC.

U.S. E.P.A. Wetlands Hotline: 1-800-832-7828. Publication list and other resources are available.

WOW! The Wonders of Wetlands, produced through a partnership between Environmental Concern, Inc. and The Watercourse. 1995. St. Michaels, MD: Environmental Concern, Inc.; Bozeman, MT: The Watercourse. Hands-on learning activities about wetlands for grades K-12. Available from:
The Watercourse
201 Culbertson Hall Montana State University
Bozeman, MT 59717-57
Phone: (406)994-5392; Fax: (406)994-1919
Also available from Environmental Concern Inc., P.O. Box P, St. Michaels, MD 21663-0480.
Price – $15.95 in 1996

Arts and Literature of the Great Lakes

Many scientists report that their interest in science was at least in part related to their feelings of wonder at the Earth's beauty. As is stated in Earth Systems Understanding #1, "The beauty and value of Earth are expressed by and for people of all cultures through literature and the arts." The developers of ES-EAGLS encourage teachers to use art, music, and literature in teaching. Not only does this address diverse learning styles and stimulate creativity, it also helps students find meaning behind what may otherwise appear to be topics irrelevant to their lives.

Much support is available for teachers to include the arts in teaching science. Listed below are some of the resources the authors have found most valuable. Your school's librarian and music teacher may know of other resources that relate to your specific region or Great Lake. Consult local units of the Great Lakes Historical Society, and merchants in resort areas of the lakes as well.

SELECTED MUSIC RESOURCES

Lee Murdock's Great Lakes folk songs are popular in auditorium programs, private performances, and on cassettes. *Cold Winds* and *Freshwater Highway* are our favorite albums. Depot Recordings, P.O. Box 11, Kaneville, IL 60144 Phone: (708)557-2742.

Paddle-to-the-Sea. 1990. Narrated, composed, and performed by Liona Boyd. Winnipeg, Canada: Oak Street Music Inc. Based on the book *Paddle-to-the-Sea* by Holling C. Holling. The original book can be an additional reference for Great Lakes activities, and a supplemental guide is available from Ohio Sea Grant, The Ohio State University.

Pat Dailey is a country rock singer from Bay Village, Ohio. His albums are a mix of bar-room humor and serious songs of the Great Lakes. We use his "Great Lakes Song" and others from the *Freshwater* and *Shore Lines* collections most often. Albums are available from Olympia Records, P.O. Box 40063, Bay Village, OH 44140.

Privateer is a Celtic folk duo from the Chicago area that sings traditional Great Lakes songs and original material related to the lakes. Sextant Music, 6342 W. Belmont, Chicago, Il 60634 Phone: (312)775-1257.

Banana Slug String Band has excellent songs about the Earth system for younger students. Contact them at BSSB, P.O. Box 2262, Santa Cruz, CA 95063.

The Sierra Club Survival Songbook, collected and edited by Jim Morse and Nancy Mathews, introduction by Pete Seeger, illustrated by Jos. A. Smith. San Francisco: Sierra Club, 1971.

SELECTED ART AND POETRY RESOURCES

Earth Songs by Myra Cohn Livingston, Poet and Leonard Everett Fisher, Painter. 1986. New York: Holiday House, Inc.

Hangdog Reef. Poems Sailing the Great Lakes. This is the only volume we have found that is specific to Great Lakes topics. Please let us know if you find others!

In a Grain of Sand, by Andreas Feininger. 1986. San Francisco: Sierra Club Books. Several photographs portray the beauty of natural processes.

How does a dichotomous key work?

Scientists use "keys" to identify things and put them into groups on the basis of how they are alike. This activity will introduce you to a dichotomous (die-caht'-uh-mus) key. A dichotomous key is a key in which things are divided into two groups each time a characteristic is considered. The prefix "di" means two, and the whole word "dichotomous" refers to something with two parts or branches.

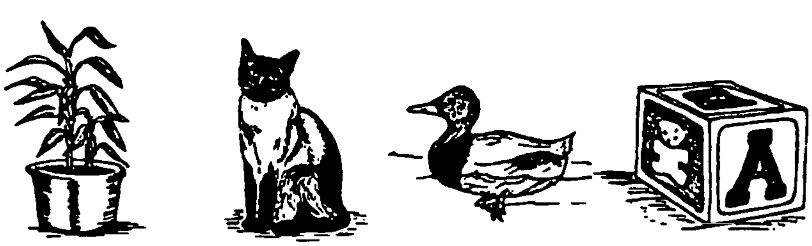
OBJECTIVE

When you have completed this activity, you should be able to construct and use a simple dichotomous key.

PROCEDURE

Look at the example of a dichotomous key (Figure 1). At the top are pictures of four items to be classified. The maker of the key looked at the items and decided that they were different in a number of ways. These differences are listed as pairs of characteristics on the left side of the key. The right side of the key identifies the item or tells you what step to go to next if an item has a certain characteristic.

Figure 1. Example of a Dichotomous Key.



Key

Characteristic		Next step or identification
1A.	Living	2
1B.	Nonliving	Block
2A.	Has a brain	3
2B.	No brain	Plant
3A.	Body covered with fur	Cat
3B.	No fur	Duck

Source

OEAGLS EP-019A, "Getting to know your local fish" by Suzanne M. Hartley and Rosanne Fortner.

Earth Systems Understanding

This activity adresses ESU 3, a key is a tool used by scientists.

Materials

For every group of 3-4 students:
- Paper clip.
- Pen.
- Pencil.
- Two different coins.
- Rubber band.

Teacher's Note

Please work with the students closely on the procedure to help ensure their understanding. The activity on "What are the characteristics of some Great Lakes fish?" will fail if this one is only marginally understood.

Prerequisite Student Background

None.

An enjoyable film related to this topic is "Classification," from the University of Utah. The 29-minute film shows different ways of classifying familiar objects. It provides an excellent introduction to this investigation. Other films that discuss classification of animals are also available. Ask a biology teacher at your local high school.

Teacher's Notes

1-2. The "keying out" process is a difficult one for many students to grasp. You should go over the procedure for the first activity step by step with your students, then divide them into groups to complete the activity. Follow the procedure carefully, emphasizing that only one characteristic at a time is used to classify items, and two groups are constructed based on that one characteristic. The two groups are subdivided farther and farther until only one item remains in a group. That item is then identified.

3. By looking back through the steps used to key out an item, you can get a list of the item's characteristics. Cat, for example, is living, has a brain, and has a body covered with fur.

Possible Answers

Characteristic	Next step or identification
2A. Made mostly of wood	pencil
2B. Made mostly of plastic	pen
3A. Made of metal	4
3B. Not made of metal	rubber band
4A. Disc shaped	5
4B. Not disc shaped	paper clip
5A. Silver color	dime
5B. Brown color	penny

An example of one possible key is shown here. Many variations are possible. The best way to check a key is to have students give the key and one item to someone else. That person should be able to list the steps followed to reach an identification of the item.

If necessary, key out all four items in the example to assure that students understand. You may also have to lead them through several steps in construction of a key to identify the 6 items listed in the materials section of the Student Guide. It is helpful to have the students physically group the items as they are discussed – one pile for writing implements, one pile for "everything else." Then separate the writing implements by color of mark made, plastic or wood, color of the implement, or other characteristic, and identify each. Step 3 will be a way to divide "everything else" into two groups, and so on.

1. Let's classify the second item as an example. Look at Step 1 of the key and decide if the pictured item is a living or nonliving thing. Since the picture shows a living thing, read across line 1A to the right hand column to find the next step or the identification. You are told to go to Step 2.

2. In Step 2 of the key, from what you know about the thing you are classifying, decide if the thing has a brain or not. Since it does, read across line 2A, which tells you to go to Step 3.

3. In Step 3, decide if the thing has fur or not. Since it does, reading across line 3A brings you to the identification, <u>cat</u>.

4. Now try making a dichotomous key yourself using the six items listed in the MATERIALS section. Look at the items and decide how they are different and alike. Statement one is given as an idea to get started. Fill in other pairs of characteristics on your own paper until you have identified all six items.

<u>Key</u>

Characteristic	Next step or identification
1A. Will make a mark on paper	2
1B. Will not make a mark on paper	3

5. Compare your key with those constructed by other groups. Keys can be different and still be correct! Discuss the kinds of descriptions that can make keys hard to interpret (large-small, fancy-plain, pretty-ugly, etc.), and try to avoid using such inexact terms in your own keys.

Apply what you learned

Assemble a collection of stamps with living things pictured on them. Develop a dichotomous key to the organisms. See also: Mayer, Victor J. and Fortner, Rosanne, 1986. An interdisciplinary database for science investigations: Postage stamps. *School Science and Mathematics* 86 (5): 395-403.

Imagine you have been asked to key over 100 species. Where would you start? How would you know what characteristics were important in distinguishing organisms? The following information should give you some idea of the challenges facing those who try to key a large ecosystem, such as the Great Lakes, as they seek to manage the living resources found there.

Background Reading

"When the first Europeans arrived in the basin nearly 400 years ago, it was a lush, thickly vegetated area. Vast timber stands consisting of oaks, maples and other hardwoods dominated the southern areas. . . The forest and grasslands supported a wide variety of life, such as moose in the wetlands and coniferous woods, and deer in the grasslands and brush forests of the south. The many waterways and wetlands were home to beaver and muskrat which, with the fox, wolf and other fur-bearing species, inhabited the mature forest lands. . . It is estimated that there were as many as 180 species of fish indigenous to the Great Lakes. Those inhabiting the nearshore areas included smallmouth and largemouth bass, muskellunge, northern pike and channel catfish. In the open water were lake herring, blue pike, lake whitefish, walleye, sauger, freshwater drum, lake trout and white bass. Because of the differences in the characteristics of the lakes, the species composition varied for each of the Great Lakes. Warm, shallow Lake Erie was the most productive, while deep Superior was the least productive.

Changes in the species composition of the Great Lakes basin in the last 200 years have been the result of human activities. Many native fish species have been lost by overfishing, habitat destruction or the arrival of exotic or non-indigenous species, such as the lamprey and the alewife. Pollution, especially in the form of nutrient loading and toxic contaminants, has placed additional stresses on fish populations. Other human-made stresses have altered reproductive conditions and habitats, causing some varieties to migrate or perish. Still other effects on lake life result from damming, canal building, altering or polluting tributaries to the lakes in which spawning takes place and where distinct ecosystems once thrived and contributed to the larger basin ecosystem."

(From *The Great Lakes, An Environmental Atlas and Resource Book.* 1995. Jointly produced by the Government of Canada and U.S. EPA, 3rd edition.)

The history of the fishery in Lake Erie is a case in point. "The fish fauna of Lake Erie and its tributaries consists of 139 species and subspecies. This is more freshwater species than in virtually any other state in the United States, and more than in all of New England. It is a great 'mixed bag' of fishes. How did this one lake and its drainage come to be populated with this fauna? Primitive Lake Erie once drained through the Maumee River into the Wabash of Indiana and out into the Mississippi. At another time, waters flowed northwest through the Teays River from the Carolinas into Lake Erie, allowing the invasion of fishes from Kentucky, West Virginia and the east coast. The connection across Michigan allowed species to invade from the upper Mississippi and western Canada. The glacier, in its retreat, left glacial species behind. And the Great Flood through New York allowed species to enter from upstate New York and other New England areas.

Other species were purposefully introduced from areas across the sea: carp and brown trout from Europe and the goldfish from Asia. Others (smelt and perhaps the grass carp) escaped from experimental ponds. Still more recently, the St. Lawrence Seaway (especially the Welland Canal) has allowed the invasion of the white perch, alewife and the dreaded sea lamprey. A new invader, the pink salmon, has entered through Great Lakes connections from northern Canada. The fauna of Lake Erie is thus a collection of fishes from more than 18 states, Canada, Europe and Asia.

It is difficult to determine the precise composition of Lake Erie's fish fauna prior to the arrival of the European settlers, but all indications are that populations in Lake Erie were dominated by predaceous species (pike, muskellunge, walleye and smallmouth bass) rather than omnivores or planktivores which currently dominate (carp, goldfish, gizzard shad). It is also generally agreed that individuals were much larger then than at present. Numerous anecdotes in the writings of early pioneers and settlers contained remarks about six-foot pike (muskellunge) and 250-pound sturgeon. A man who caught a catfish to feed his family of seven noted that they 'ate of it three times.' That's a very big catfish. But then he wrote that ' . . . we gave the rest to the Indians.'

Over history the fishes have seen many threats, such as severe pollution, dams, commercial and sport fishing, decreased oxygen levels and loss of spawning grounds. Species numbers suffered serious declines, and the Lake Erie ecosystem was in trouble until the latter half of the 1900s. The actions taken by various governmental agencies, growing public awareness, the 'environmental movement,' and quirks in the economy throughout the 1960s, 1970s, and early 1980s have resulted in a most remarkable recovery of the lake and its fish fauna.

The economy also has played an important role in the restoration of the lake. Whereas siltation is one of the most critical problems in the lake, economic pressures have resulted in different farming practices along the shoreline. The high cost of fuel reduced the fall plowing of fields, no-till planting began to occur, and in many instances farms collapsed and soils returned to old field communities. Fewer new housing projects and less road construction in recent years also contributed to less runoff of silt. Nutrient control through sewage treatment and decreased farm runoff have resulted in a reduction of algal blooms. The situation has improved in many areas and in some instances work is still needed to address important issues.

Whether you are a resident of the Great Lakes community or not, whether you are intimately familiar with the fishery of Lake Erie or not, the history of the fishery of the lake stands as a great lesson in the response of a freshwater ecosystem to the multitudes of pressures placed upon it by the demands of society, its people and its use of the land as well as the waters. The state of the fishery in Lake Erie and the other Great Lakes has improved but we cannot take for granted. We have made a beginning, but there is yet much to be done."

(Modified excerpts from White, Andrew M. 1993. "History of Changes in the Lake Erie Fishery." In *The Great Lake Erie*. Edited by Rosanne W. Fortner and Victor J. Mayer, Columbus: Ohio Sea Grant College Program, The Ohio State University.)

What are the characteristics of some Great Lakes fish?

If you know how to construct a dichotomous key, you can make one that classifies real organisms, some fish in the Great Lakes. For this activity you will work in groups of 3 or 4. Your group will construct a key to identify some fish families and learn something about them. Lake Erie has a larger variety of fish life than any of the other Great Lakes. Scientists believe this is because of the southern position of the lake and because it is shallow. Lake Erie has 138 species of fish. These species can be grouped into 27 families. All of the fish in a given family share certain characteristics. In this exercise you will learn how to use these characteristics to identify the 27 families. The fish are also found throughout the other Great Lakes, along with others that prefer colder water.

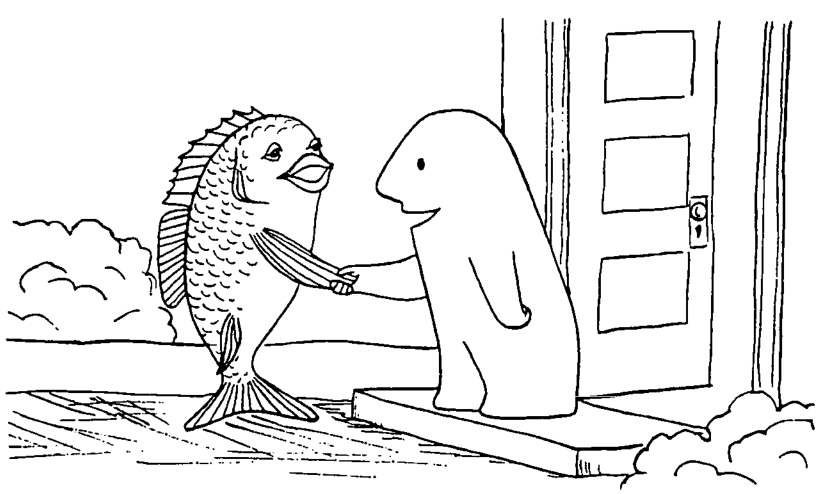
OBJECTIVES

Upon completion of this activity, you should be able to:

- Describe some ways fish differ from each other in appearance.
- Use similar characteristics of fish to group them into categories for classification.
- Comment on the diversity of fish in the Great Lakes.

PROCEDURE

Regardless of whether they live in an ocean, lake, or stream, all fish are alike in some ways. A typical bony fish has scales embedded in its skin. These scales have concentric growth rings that can be counted to determine the age of the fish. A few kinds of fish <u>do</u> <u>not</u> have any scales.



Source

OEAGLS EP-019, "Getting to know your local fish" by Suzanne M. Hartley and Rosanne Fortner.

Earth Systems Understanding

This activity focuses on ESU 3, a key is a tool used by scientists to organize information.

Materials

- Fish pictures and information about fish families.

Teacher's Notes

Go over the fish characteristics with students to make sure they are aware of what differences to look for. Remind them of the glossary, not only for looking up unfamiliar words, but for choosing descriptive words to use in their key.

Following this activity are pages of fish for student teams to key. Both the pictures and the written descriptions can be used to describe differences.

Fish also have gills. The fish's mouth and cheeks act as a pump to push water over the gills. As water passes over the gills, oxygen dissolved in the water is exchanged for carbon dioxide from the fish's blood.

Fish differ from each other in several characteristics. Study the fish characteristics diagram so you can recognize differences when you get your fish pictures from your teacher. Refer to the GLOSSARY to find definitions of terms you do not understand from the pictures.

1. Divide into five groups. Each group will receive pictures and descriptions of a group of fish common to Lake Erie, whose families are also found throughout the Great Lakes. Look at the fish pictures with your group. List the names of the fish you are working with on your answer sheet.

2. How are your fish different from each other? List four general ways (head shape, spines, etc.).

3. Cut your picture sheet into sections so that each piece contains only one fish. With your team, decide how to divide the fish into two groups based on one characteristic. Put the fish pictures into piles according to that characteristic, which will be Statement 1 of your key. On your answer sheet, fill in 1A and B, with the next steps or identification on the right side. [If you have not done the activity "How does a dichotomous key work?," you should refer to it for ideas here.]

4. Next, take the fish in one pile and discuss how they differ from each other. Fill in Statement 2A and B.

5. Continue dividing your fish in this way until each group has only one fish in it. When you reach this point, the right-hand column should be filled in with the fish's name.

Teacher's Notes

Answers to questions 1 and 2 will differ from team to team. The questions are given mainly as advance organizers and to guide you in assessing student performance.

The "Key to Great Lakes Fish" will also differ from team to team. An example is given using Group III.

Possible Key to Group III

Characteristic	Next step or identification
1A. Lateral line	2
1B. No Lateral line	4
2A. Forked tail	Salmon
2B. Rounded tail	3
3A. Long dorsal fin	Bowfin
3B. Short dorsal fin	Pirate Perch
4A. Vertical stripes on sides	Killifish
4B. No stripes	5
5A. Long narrow anal fin	Livebearer
5B. Short anal fin	Mudminnow

6. Check your finished key when all your fish have been classified. You should be able to pick up any fish picture and follow the key to find the name of the fish.

7. Exchange keys and fish pictures with another group. Do not give the list of fish names from the original sheet to the other team. See if they can identify the fish using only your descriptions in your key.

8. Get your original fish pictures and key back when the other team is finished. Read the Fish Family Descriptions your teacher has given you. Tell the class how you grouped your fish and a little about each fish.

9. From the group reports, answer these questions.

   A. What fish is covered with bony plates?

   B. How do sea lampreys damage other fish?

   C. How does a filter-feeding fish eat?

   D. Describe a major characteristic of a bowfin.

   E. List five Great Lakes fish that are valuable as food for humans.

   F. How did the sucker family get its name?

   G. Name two Great Lakes fish that have no scales.

   H. How did the freshwater drum get its name?

   I. Name two kinds of Great Lakes fish that are used as bait for fishing.

10. If time permits, work with the entire class to develop a key that will classify all 27 families of Lake Erie fish.

11. Contact your state's Fisheries office and find out what other families of fish are found in your nearest Great Lake. Add a

Teacher's Notes

The exchange of keys and pictures with another group is a good way to find out if the keys will work. It also exposes students to other possible ways of distinguishing between fish. When the students have constructed their own key and tried out the key made by another team, they should be well aware of what differences to look for. Making a key to all the fish should not be difficult at this point. If you want to try this, we suggest that you have students write the name of each fish on its picture, then tape all the pictures to the blackboard. Have students volunteer to divide the fish into groups to create a key, one step at a time.

If you prefer to use the overhead projector, an included page (31) has pictures of all of the fish. Make a transparency of that page and cut it apart so you can physically group the fish as the key is constructed. One possible way to group all the fish is shown on page 32. A graphic way to show the same classification scheme is also provided on page 32. It may assist students who learn better with visual cues.

Answers

A. Sturgeon are covered with bony plates.
B. Lampreys are parasites that attach to other fish with their sucker mouths and suck out their blood and body fluids.
C. It filters microscopic organisms from the water by collecting the organisms on gill rakers. Then the fish swallows these food organisms.
D. It has a long fin that arches in a bow along its back.
E. Sturgeon, yellow perch, white bass, burbot, salmon, freshwater drum, white perch, walleye, and catfish are valuable as human food.
F. The fish have an extendable sucker mouth for picking or sucking up organisms.
G. Catfish, eel and sturgeon have no scales.
H. It makes a drumming sound.
I. Minnows, shiners, and chubs are used as bait.

page of those fish to this activity.

Great Lakes Fish
(Possible Key)

Characteristic			Next step or identification
1	A.	Snake-shaped	2
1	B.	Shaped like a fish	3
2	A.	Sucker mouth	Lamprey
2	B.	No sucker	Eel
3	A.	Barbels	4
3	B.	No barbels	7
4	A.	Bony plates	Sturgeon
4	B.	No bony plates	5
5	A.	One barbel	Burbot
5	B.	Two or more barbels	6
6	A.	Slim body	Catfish
6	B.	Fat body	Carp
7	A.	Two dorsal fins	8
7	B.	One dorsal fin	17
8	A.	All fin rays connected	9
8	B.	Four to six unconnected spines	Stickleback
9	A.	Second dorsal fin large	10
9	B.	Second dorsal fin small	15
10	A.	Dorsal fins separate	11
10	B.	Dorsal fins joined	12
11	A.	Horizontal stripes	White bass
11	B.	Vertical color bands	Yellow perch
12	A.	Fan-shaped pectoral fin	Sculpin
12	B.	Small triangular pectorals	13
13	A.	Skinny body	Silverside
13	B.	Round body	14
14	A.	Mouth on top	Sunfish16
14	B.	Mouth on bottom	Drum Salmon
15	A	No spines	
15	B.	Spine on side	Troutperch
			Smelt
16	A.	Row of spots	
16	B.	No spots	19
			18
17	A.	Short nose	
17	B.	Long nose	Paddlefish
			Gar
18	A.	Forked tail	
18	B.	Rounded tail	20
			24
19	A.	Forked tail	
19	B.	Rounded tail	21
			Sucker
20	A.	Regular mouth	
20	B.	Sucker mouth	22
			23
21	A.	Wide body	
21	B.	Narrow body	Mooneye
			Gizzard shad
22	A.	Smooth belly	
22	B.	Sawtooth belly	Pike
			Minnows
23	A.	Flat head	
23	B.	Round head	Bowfin
			25
24	A.	Long dorsal fin	
24	B.	Short dorsal fin	26
			Livebearer
25	A.	Short anal fin	
25	B.	Long anal fin	27
			Mudminnow
26	A.	Lateral line (partial)	
26	B.	No lateral line	Pirate perch
			Killifish
27	A.	Two bands at base of tail	
27	B.	Many bands at tail	

REFERENCES

Hubbs, Carl L., and Karl F. Lagler. 1983. *Fishes of the Great Lakes Region.* Ann Arbor: The University of Michigan Press.

Trautman, Milton B. 1981. *The Fishes of Ohio.* Columbus: Ohio State University Press.

There are several Web sites regarding fish species in the Great Lakes. Investigate the following:

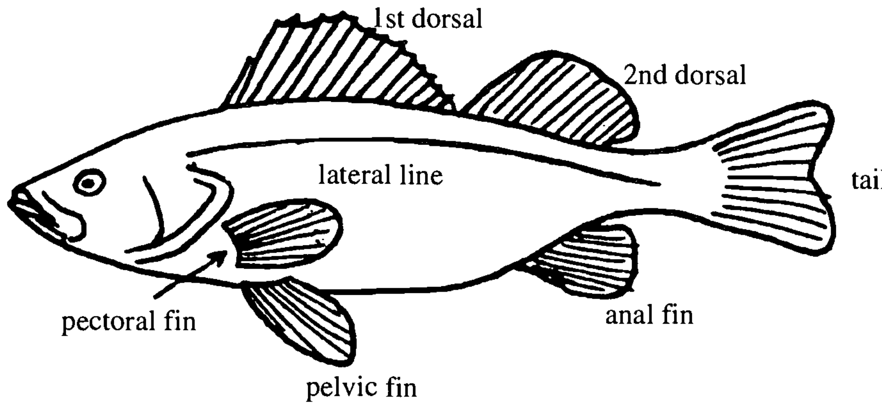
http://h2o.seagrant.wisc.edu/communications/publications/FISH/LakeMichFishIndex.html

http://h2o.seagrant.wisc.edu/communications/publications/FISH/LakeSupFishIndex.html

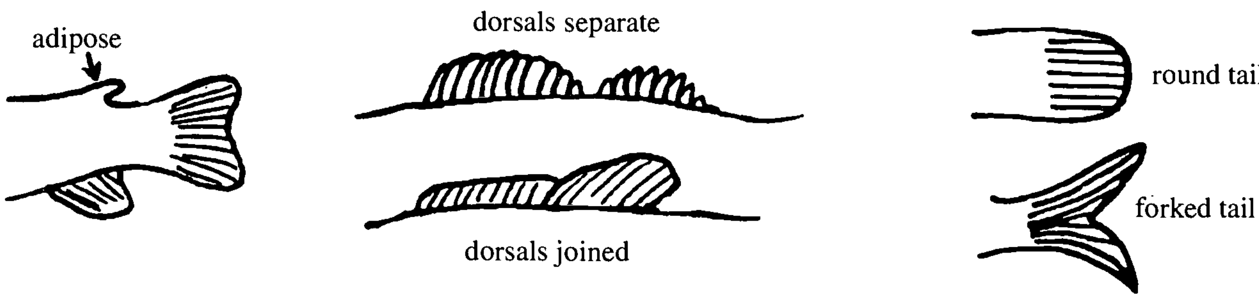
Contact your nearest Sea Grant office for fishery publications. Addresses are on page 10.

Fish Characteristics

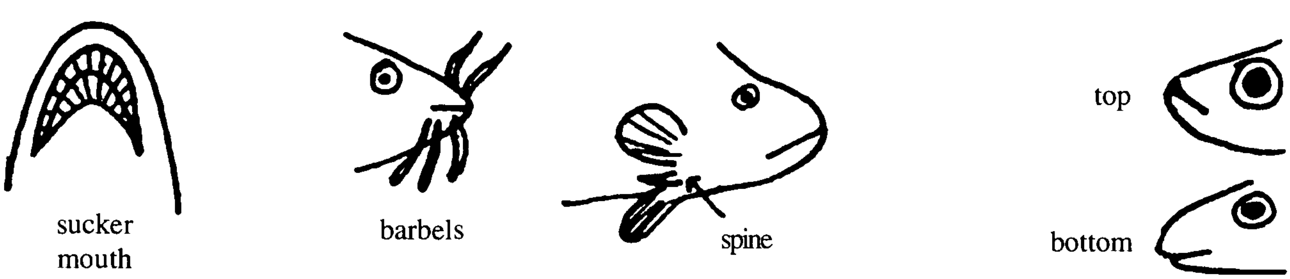
Where the fins are:



Fin types:



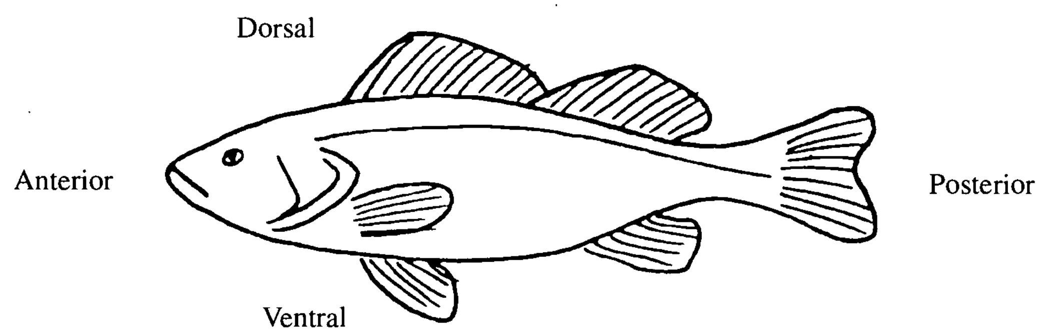
Head features:



Also look for differences in:

- Body shapes
- Lateral line (present or absent)
- Spines (present or absent, and location)
- Spots or stripes
- Head shapes
- Fin shapes

Glossary



Adipose Fin – Fleshy fin behind the dorsal fin.

Anterior – Front.

Barbels (pronounced bar-bulls) – Whiskers that help the fish detect food.

Carnivore – Flesh eating animal.

Commercial Fish – Fish caught for commercial trade.

Concentric – Having a center in common. Example: growth rings on a tree. 

Dorsal – Pertaining to the back or top.

Filter Feeder – Filters microscopic plants and animals from the water for food.

Forage Fish – Fish used as food by larger fish.

Lateral Line – A sensory organ with a row of pores running along each side of the head and body of most fish. It looks like a dotted line.

Omnivore – An animal that eats any sort of food, plant, or animal.

Parasite – An organism living in or on another organism (its host) from which it obtains food.

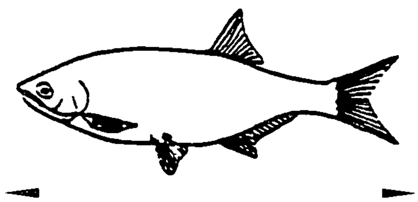
Posterior – Rear.

Scales – Flexible overlapping plates that cover the bodies of some fish. Scales help to protect the fish.

Sport fish – Fish that are caught by individuals for recreation.

Ventral – Pertaining to the underside or belly.

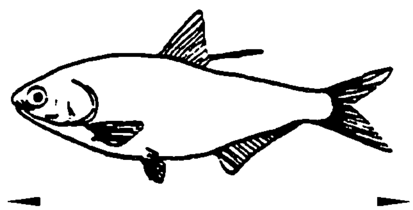
I.



30-38 cm

A. Mooneye Family - Hiodontidae

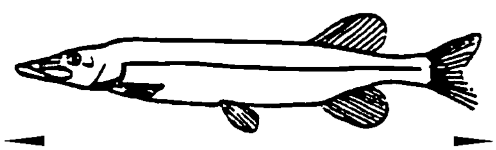
These fish are silver or gold in color. They eat insects, insect larvae, and small minnows. They prefer to feed in swiftly moving water, but live in calm water. Mooneyes are not very good to eat.



31-41 cm

B. Herring Family - Clupeidae

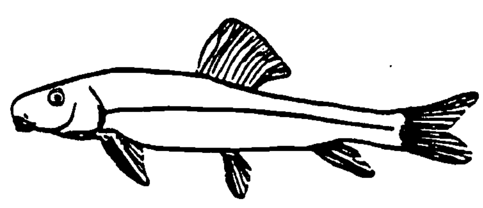
Herrings have a saw-toothed or jagged belly. They feed on plankton. Many larger fish such as walleyes often eat gizzard shad, one member of the herring family. Alewives, another member of this family, have been introduced to the Great Lakes. They have great population explosions followed by rapid die-off. The accompanying picture is of a gizzard shad.



48-94 cm

C. Pike Family - Esocidae

Pike live in lakes, ponds, and streams where the water is warm and full of weeds. They are very fierce and eat anything they can catch. Some pike grow to be 7 feet long and weigh as much as 35 pounds. Pike populations have declined because of destruction of spawning grounds.



30-65 cm

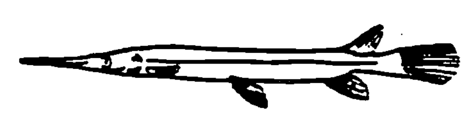
D. Sucker Family - Catostomidae

Suckers live on the bottom of lakes, ponds, and streams. They have special mouths that help them to suck up small animals and plants. Some suckers, like the bigmouth buffalo, grow to be very large. Many fishermen like to catch these big fish, which are good to eat.

51-122 cm

E. Paddlefish - Polydontidae

Paddlefish live in silty rivers and flood plain lakes. Some grow to be 6 feet long and weigh up to 150 pounds. They get their name from their paddle-shaped snouts. Paddlefish eat by swimming with their mouths open. Food washes into their mouths as they swim along. Fish that eat this way are called filter feeders. Paddlefish are endangered because dams along rivers prevent migration and spawning.

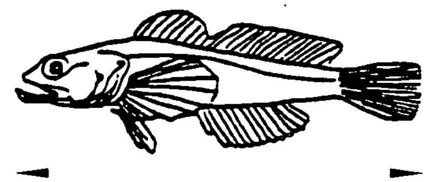


41-91 cm

F. Gar Family - Lepisosteidae
These fish have bony plates covering their bodies. Gars have sharp, strong teeth and eat all kinds of fish, both living and dead. They are so hard to catch that fishermen have gar-rodeos and use wire snares instead of fishing poles to catch the fish. Gars prefer to live in the calm waters of bays rather than in the open lake.

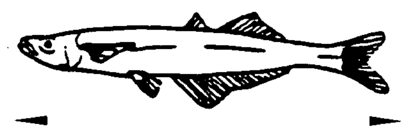
II.

A. Sculpin Family - Cottidae
Sculpins have large spiny heads. They have no scales. Sculpins live on the deep bottom, feeding on small fish.



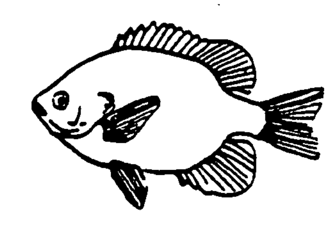
4-10 cm

B. Silverside Family - Atherinidae
Silversides get their name because of their very light color. They feed near the surface of the water and often skip in the air for short distances. The Silverside's numbers are decreasing.



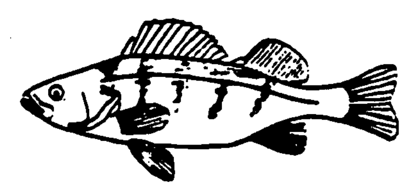
7-10 cm

C. Sunfish Family - Centrarchidae
There are many types of fish in this family. Largemouth bass, smallmouth bass, and bluegills are all sunfish. They eat smaller fish, frogs, and other creatures such as crayfish. Sunfish are protected from commercial fishing.



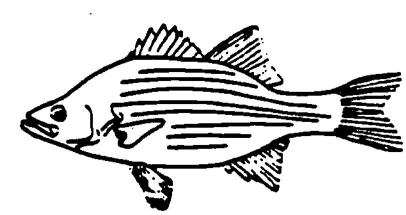
9-15 cm

D. Perch Family - Percidae
This group includes the walleye and the yellow perch, both of which are important in sport fishing. They are also important commercially. Walleye live in cold, clean water. Yellow perch are smaller than walleye and can live in warmer water.



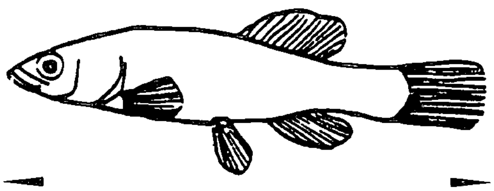
11-30 cm

E. Temperate Basses - Percichthyidae
The white bass and the white perch are the temperate basses found in Lake Erie. These fish live in quiet water over sand and gravel bottoms. Schools, or groups, of white bass are often seen just under the surface of the water. They feed on smaller fish, including their own young.



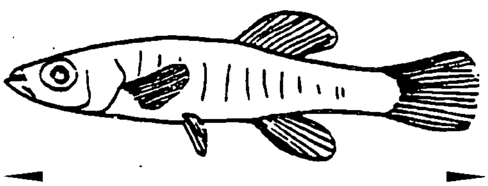
19-41 cm

III.



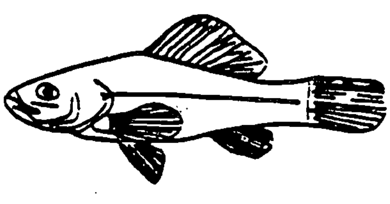
5-10 cm

A. Mudminnow Family - Umbridae
Mudminnows eat many kinds of food, both plants and animals living. Mudminnows will dive into the muddy bottom to escape from danger. Because other fish like to eat mudminnows, anglers often use them as bait.



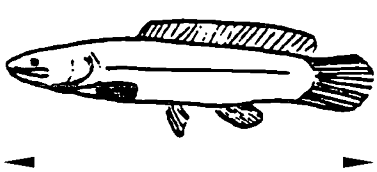
4-7 cm

B. Killifish Family - Cyprinodontidae
Killifish have mouths that open along the upper front of their heads. This helps them feed at the surface of the water. Killifish live in clear, shallow water where there are many plants. Anglers use killifish as live bait because many larger fish eat them.



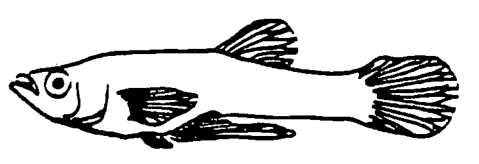
4-11 cm

C. Pirate Perch Family - Aphredoderidae
These are small fish, up to 4 inches long. They eat smaller fish and aquatic insects. They are rarely caught.



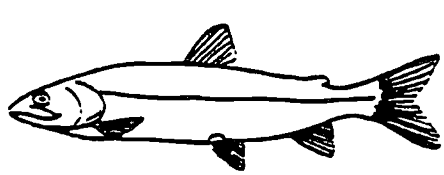
38-63 cm

D. Bowfin Family - Amiidae
Bowfins get their name from the long fin that arches over their backs. They live in quiet water where there are many plants. Bowfins eat fish, frogs, and crayfish.



2-3 cm males 5-6 cm females

E. Livebearers Family - Poeciliidae
Livebearers do not lay eggs. The baby fish are born alive. The "mosquitofish" Gambusia feeds on the mosquito larvae that live near the surface of the water.

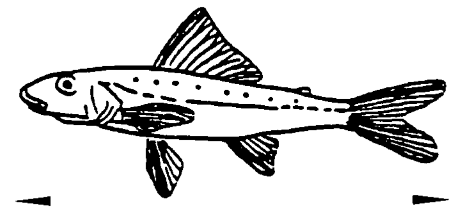


50-110 cm

F. Trout and Salmon Family - Salmonidae
Salmon and trout belong to the same family. These fish have an extra fatty fin called the adipose fin. Fishermen like them because they are large and good to eat. Salmon do not live naturally in Lake Erie. The Department of Natural Resources stocks the lake with salmon for the fishermen to catch.

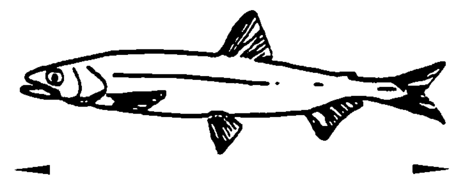
IV.

A. Troutperch Family - Percopsidae
Troutperch have rough scales. They have an adipose fin like the trout and spiny fins like the perch. Many other fish eat the troutperch.



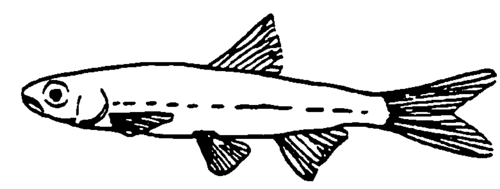
8-13 cm

B. Smelt Family - Omeridae
Smelt are small fish with smooth scales. They may grow to be 9 inches long. Smelt have an adipose fin. They also have teeth on their tongues. They eat smaller fish and other creatures such as crayfish.



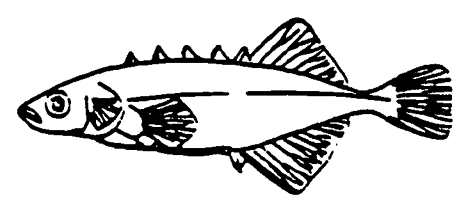
18-25 cm

C. Minnow Family - Cyprinidae
Minnows are important as food for many larger fish. They are also widely used for bait. This family also includes the carp and goldfish. Minnows live in warm, organically rich waters.



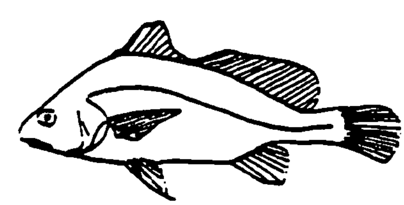
8-18 cm

D. Stickleback Family - Gasterosteidae
Sticklebacks get their name from the stiff spines on their backs. They live in the cold, quiet waters of streams and bogs.



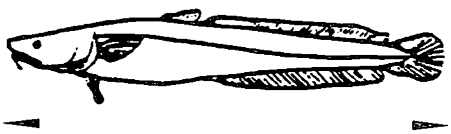
30-76 cm

E. Drum Family - Scianenidae
These fish gets their name from the drumming sound they make. They have a lateral line that extends all the way across their tail fins. Some fishermen call this fish the "sheepshead." Other common names include silver bass, gray bass, and reef bass. They eat crayfish, aquatic insects, and small fish.



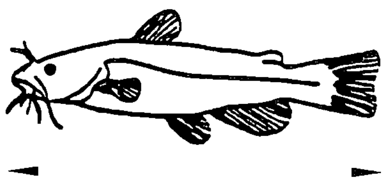
4-6 cm

V.



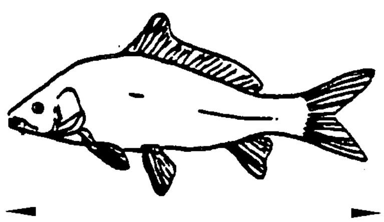
41-81 cm

A. Cod Family - Gadidae
Cod have one long feeler, or barbel, under their chins. The Great Lakes representative of the cod family is the burbot. It is not commercially valuable like its marine cousins.



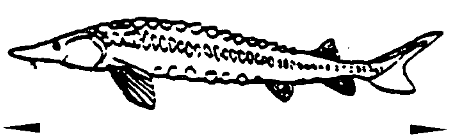
28-76 cm

B. Catfish Family - Ictaluridae
Catfish eat both plants and animals. They have feelers (barbels) near their mouths to help them find food. They have no scales. Bullheads are small catfish. They live in muddy ponds and streams. They can survive even when ponds dry up. The male bullhead watches the nest and guards the young. The flathead catfish can weigh up to 100 pounds. Fishermen like catfish because most of them are good to eat.



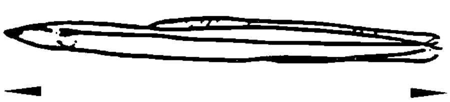
31-76 cm

C. Minnow Family - Cyprinidae
Minnows are important as food for many larger fish. They are also widely used for bait. This family also includes the carp and goldfish. Minnows live in warm, organically rich waters.



51-140 cm

D. Sturgeon Family - Acipenseridae
These fish have bony plates covering their bodies. Sturgeons have special mouths for sucking up food from the bottom of the water. Feelers on their mouths help them to find food. People like to eat caviar made from sturgeon eggs. Sturgeons do not spawn until they reach 20 years of age. Their numbers have decreased sharply since 1916 due to loss of spawning grounds.



76-102 cm

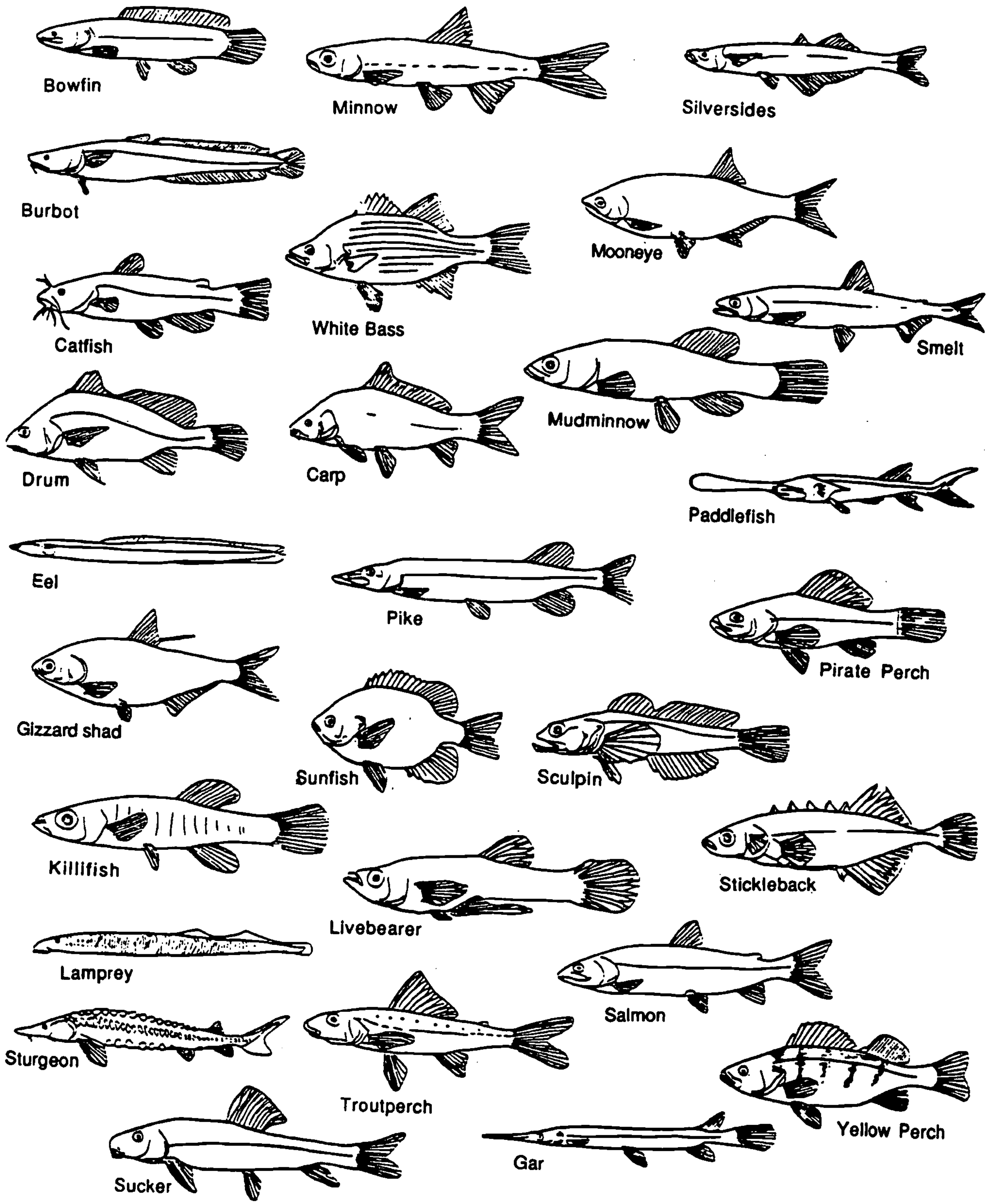
E. Eel Family - Anguillidae
Eels eat both plants and animals. They have true jaws. They are long and thin like snakes and have no scales. Eels feed at night and hunt by sense of smell. They can survive in polluted water.

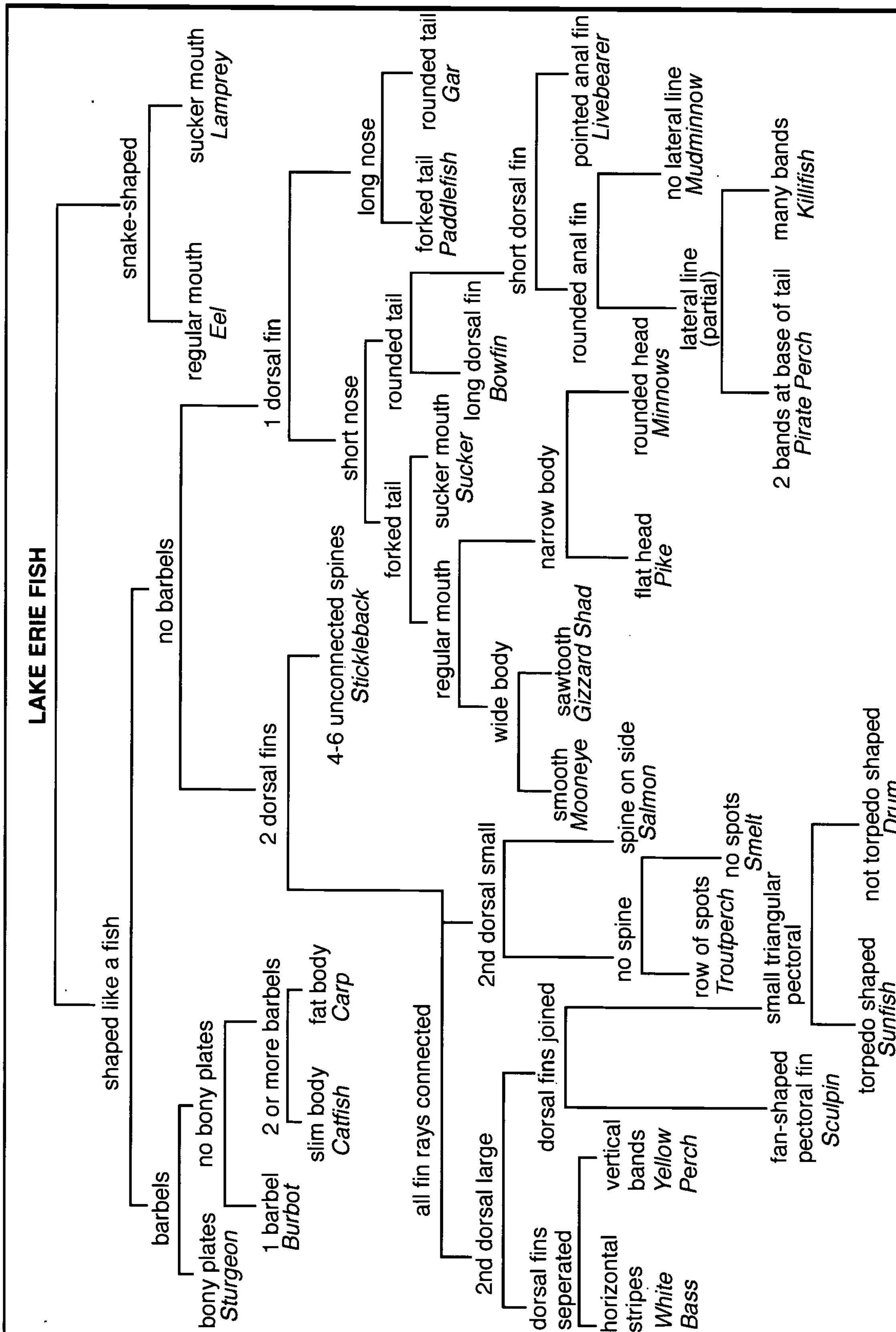
15-63 cm

F. Lamprey Family - Petromyzontidae

Young lampreys live in the mud on the bottom of streams. It takes up to 7 years for the young lampreys to grow up. Lampreys have sucking mouths and sharp teeth. Some adult lampreys are parasites. They use their sucking mouths to attach themselves to other fish and suck their blood. Lampreys have no jaws.

Teacher Page. For use as an overhead transparency.




LAKE ERIE FISH
snake-shaped
regular mouth
Eel
sucker mouth
Lamprey
shaped like a fish
barbels
bony plates
Sturgeon
no bony plates
1 barbel
Burbot
2 or more barbels
slim body
Catfish
fat body
Carp
no barbels
1 dorsal fin
short nose
forked tail
regular mouth
wide body
smooth
Mooneye
sawtooth
Gizzard Shad
narrow body
flat head
Pike
rounded head
Minnows
sucker mouth
Sucker
rounded tail
long dorsal fin
Bowfin
short dorsal fin
rounded anal fin
lateral line (partial)
2 bands at base of tail
Pirate Perch
many bands
Killifish
no lateral line
Mudminnow
pointed anal fin
Livebearer
long nose
forked tail
Paddlefish
rounded tail
Gar
2 dorsal fins
4-6 unconnected spines
Stickleback
all fin rays connected
2nd dorsal small
no spine
row of spots
Troutperch
no spots
Smelt
spine on side
Salmon
2nd dorsal large
dorsal fins seperated
horizontal stripes
White Bass
vertical bands
Yellow Perch
dorsal fins joined
fan-shaped pectoral fin
Sculpin
small triangular pectoral
torpedo shaped
Sunfish
not torpedo shaped
Drum

How do fish get their names?

Some fish in the Great Lakes are named for the way they look (stickleback, bowfin, and others). For others, it is difficult to determine how they got their common names. In this activity, you will make up stories and draw pictures about how a fish might have gotten its name.

OBJECTIVE

Use your sense of humor and creative talents to explore how the common names of animals might originate.

PROCEDURE

You have seen pictures of how some fish in the Great Lakes really look. But suppose you had never seen a fish and only knew its common name. You might guess that the fish's name had something to do with how it looks, how it behaves, or maybe where it lives.

1. Listed here are some common names of Great Lakes fish and ocean animals. Choose one name from either list. What animal did you choose?

Great Lakes Fish	Ocean Animals
1. Freshwater drum	1. Hammerhead shark
2. Madtom	2. Hatchetfish
3. Catfish	3. Swordfish
4. Mudminnow	4. Dogfish
5. Walleye	5. Starfish
6. Pirate-perch	6. Pipefish
7. Sunfish	7. Jellyfish
8. Paddlefish	8. Parrotfish
9. Mooneye	9. Queen triggerfish
10. Bigmouth buffalo	10. Porcupinefish
11. Silverside	11. Sea robin
12. Bullhead	12. Toadfish
13. Mosquitofish	13. Clownfish

2. On your own paper, draw a funny picture about how that animal might look, based on its name. If you chose a fish, your drawing needs to have some basic fish characteristics: pair of eyes, tailfin, mouth, and some normal fin arrangement.

3. Write a short story (one or two paragraphs) about how the animal you chose got its name.

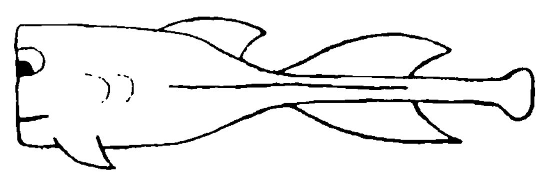
Earth Systems Understandings

This activity focuses on ESU 3, a scientist's tool, and ESU 1, arts related to the Earth System.

Materials

- Paper.
- Pencil.
- Crayons or markers.

This activity is designed to stimulate imagination and creativity. Expect a wide range of answers, and maybe consider preparing a booklet of class results that could serve as an idea bank for future classes.



paddlefish

2. Displaying the art work and sharing clever stories may create further interest in the origin of names.

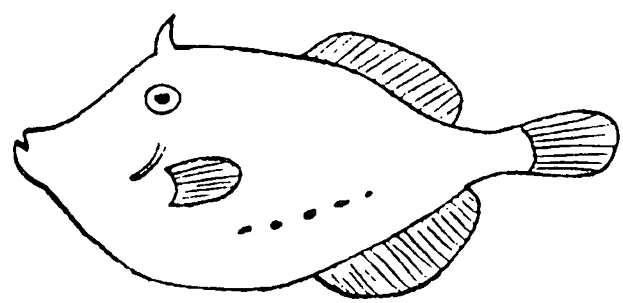
Review Questions

These questions review the skills developed in the previous three activities.

1. How do scientists use a dichotomous key?
2. The Great Lakes have great biodiversity! List three ways that fish are alike (what makes them fish?)
3. Then list five ways in which the families of Great Lakes fish differ from each other.
4. Demonstrate your skill in using a key. Identify this fish using the key provided.

Key

1 A.	Rounded tail	2
B.	Forked tail	Reef Fish
2 A.	Mouth on top	3
B.	Mouth on bottom	Toadfish
3 A.	Wide vertical stripes	Spadefish
B.	No stripes	4
4 A.	Spine on head	Filefish
B.	No spine	Tripletail



Extension

This activity is adapted from a "Fishical Education" exercise developed by teacher Dottie Wendt at Waipahu High School, Waipahu, Hawaii. Ms. Wendt had her students write stories about the origin of some local fish names. She also had them construct a "boxfish" out of found materials from home. You may want to use her idea as an extension of this investigation. It offers the chance for students to explore their own creativity and present information they find through doing research on some fish in their area.

Reference

Trautman, Milton B. 1981. *The Fishes of Ohio*, Revised Edition. Columbus, Ohio: Ohio State University Press in collaboration with Ohio Sea Grant Program, Center for Lake Erie Area Research. ISBN #0-8142-0213-6.

How are shorebirds adapted for feeding?

Over 300 different kinds of birds have been seen in the Great Lakes region. Canada geese, bitterns, coots, rails, terns, and many species of ducks nest in the marshes. The islands are important nesting sites for egrets, herons, gulls, and cormorants. Bald eagles nest in trees along the shoreline. Many more species of birds are found in the forests and fields around the Lakes. This great variety of birds is found in the Lake region because the area includes so many kinds of habitats, the places in which the birds live – marshes, islands, shorelines, forests, and fields. The different habitats provide the nesting sites and feeding places that the birds need to live. Each species of bird is adapted for a certain kind of habitat and for feeding on certain kinds of foods.

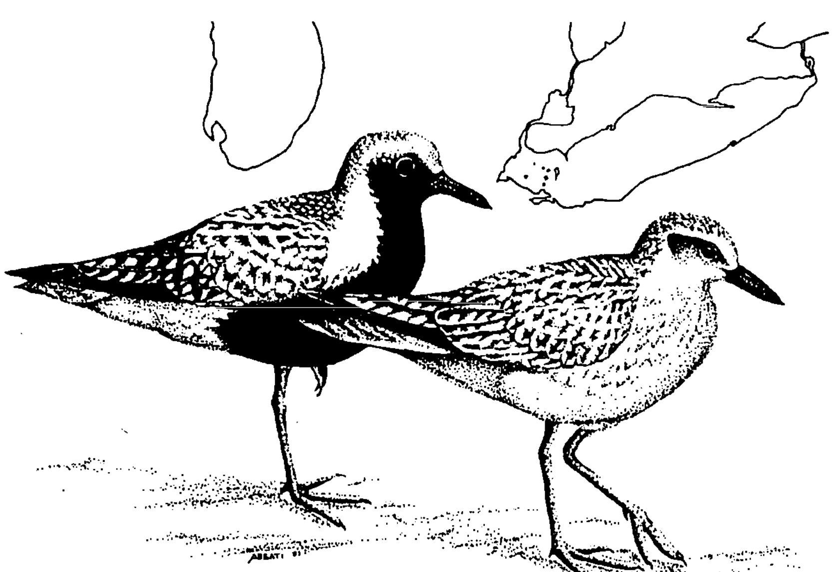
Marshes and mudflats in the Great Lakes support many shorebirds, all seeming to feed in the same area, and yet the different species of birds are rarely competing for food. Where shorebirds are feeding together, their sizes, shapes, food tastes, and behavior help them gather the food items for which they are best adapted. In a marsh or mudflat, many different kinds of birds can feed together because there are many different kinds of food items available. Each type of bird is best suited for eating a certain type of food.

Small birds like sanderlings and dunlin pluck tiny insects from the surface or first inch of mud. Plovers and dowitchers pick up worms and mollusks a little deeper in the mud or sand. Willets and godwits with longer bills pull out small clams, worms, and other animals burrowed still deeper in the mud.

OBJECTIVES

When you have completed this activity you should be able to:

- Describe how bird beaks are adapted for the types of foods they eat.
- Identify how such adaptations determine feeding success and affect survival.



Source

Modified from EP-030, "Eating Like a Bird," by Chris Brothers and Rosanne W. Fortner.

Earth Systems Understandings

The activity addresses ESU 1 as it examines the uniqueness of bird species and ESU 2 as students consider the effects of human activities on bird habitat and food supply. ESU 3 and 4 relate to our study of form and function in organisms.

Materials

(For a class of 30)
- 30 paper cup "stomachs."

Food items:
- 150-200 marbles.
- 300 toothpicks.
- 150-200 metal washers or pennies.

Beak types:
- 10 spoons.
- 10 clip clothespins.
- 20 popsicle sticks or tongue depressors.
- Newsprint paper for a large graph.

Overview

Students use everyday objects to simulate species of shorebirds with beaks of different shapes and sizes. They gather different food items with different beak types and compare feeding success and survival to these adaptations.

Prerequisite Student Background

Students should be able to construct bar graphs. They should be somewhat familiar with the concept of adaptations. You may want to review or introduce the concept before beginning the activity.

Teacher's Notes

Have students sit in a circle on a carpeted floor in an area large enough to avoid bumping and crowding by the hungry birds. Each student should have a paper cup "stomach" in which to collect food and either a spoon, clothespin or set of two popsicle sticks to use as a "beak." There should be an equal number of each type of beak in the group. If there is not, you will need to divide the total number of the food types by the number of birds having that type of beak. Another possibility is to have one or two students assist with data collection. In step E, when all three food items are available at the same time, there should be about the same number of each available.

Allow about 20 to 30 seconds for the birds to "eat."

The bar graph can be done with the whole class at the blackboard or on a piece of newsprint, or each student can draw his or her own graph on graph paper. This game can also be modified and played on desk or table tops with smaller groups of students.

Answers

1. The beak best adapted for each type of food is the one that is able to pick up a lot of that food. For example, spoons may be good for picking up marbles but not toothpicks; clothespins may be good for picking up toothpicks and pennies; popsiclesticks can pick up toothpicks and pennies, but perhaps not as well as clothespins can.

Procedure

A. In this activity, you will play the part of a hungry shorebird. You have a special kind of "beak" for getting "food" to go in your paper cup "stomach." Other birds will be feeding in the same area and may be trying to get the same kind of food. Discuss how each "beak" might be used to pick up food.

B. Your teacher will distribute one of the food types (pennies, marbles, or toothpicks) in the feeding area. When the teacher gives the signal, start picking up food from the floor "mudflat." You must use only your "beak" to pick up the "food" and put it in your "stomach."

C. At the end of round one, count the number of food items in your stomach. On your answer sheet, add up and record for each type of beak the number of food items eaten by all the students having that kind of beak.

D. "Feed" two more times using each of the other two food items. Again, add up and record on your answer sheet the total number of that food item eaten by each type of beak used.

E. Try testing all three food items at the same time. Record on your worksheet the total of each type of food eaten by each type of bird.

F. Draw a bar graph of the results of your experiments. An example is shown with the activity (Figure 1). Discuss the results of your feeding experiments with your class. Answer the questions on your worksheet.

Analysis

1. Which beak type gathered the most marbles? Which gathered the most pennies? Which gathered the most toothpicks? Which types of beaks seem to be best adapted for which types of food?

2. What could a bird do if the only food item available in the mudflat was marbles, but its beak was not well adapted for eating marbles?

3. What might happen to the birds in the marsh if a chemical spill killed all of the marbles but did not affect the toothpicks or pennies?

4. In the last experiment, did each beak type obtain some food when all three food items were available at one time? Was it easier to get more food with only one type available or with all the food items together? How did success at finding food differ from the rounds with only one kind of food?

5. How are your simulated spoon, clothespin, and popsicle stick beaks like those of real birds? Look at photographs or drawings of birds in field guides, books, magazines, or on posters to find out.

Answers

2. The bird might move to another mudflat or marsh where more of the food it is well adapted for eating is available. The bird may switch to other food sources that its beak will allow it to eat. The bird may starve if it cannot find another food source.

3. The spoonbills might be greatly affected since they rely heavily on marbles for food. They might starve or they might try to eat more pennies. If they ate more pennies, they would be competing more with clothespins and popsiclesticks for food. Answers will vary depending on the actual data your students collect.

4. If all three kinds of birds were competing for the same food type, even those birds best adapted for gathering that food may find it hard to get much food, because some of it is being eaten by the other kinds of birds. If more than one type of food is available, each bird can eat the food it is best adapted to catching. Thus it will likely be easier to find food and each bird type will have greater feeding success when all three food types are available. In general, the more kinds of foods available, the greater the number of kinds of birds that can live in the mudflat or marsh.

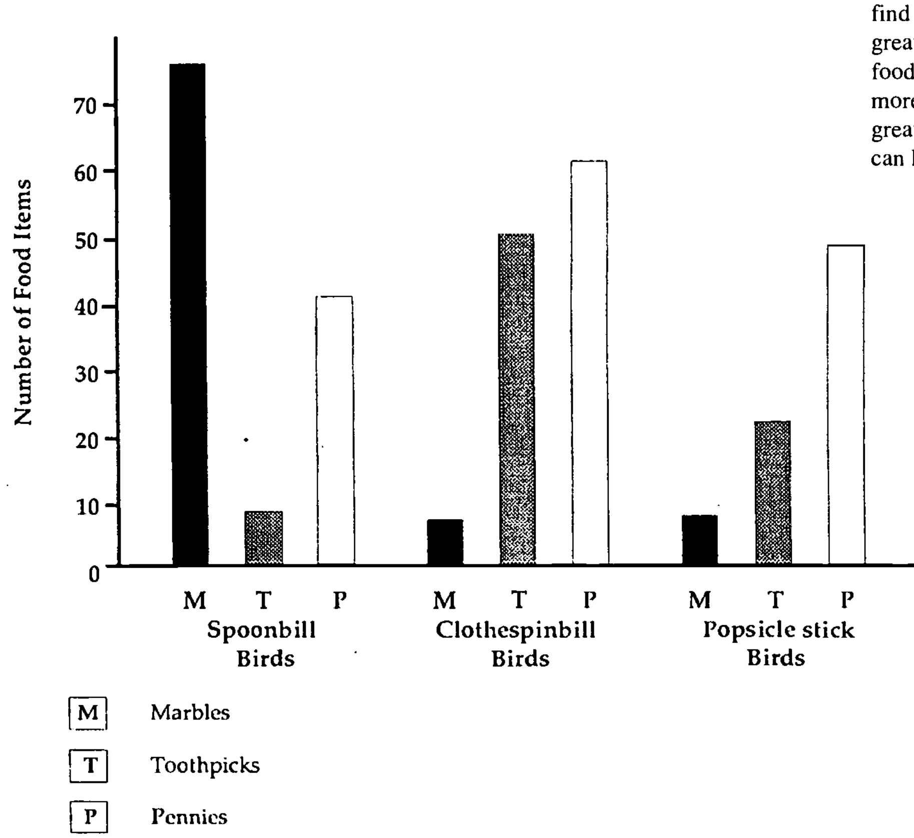


Figure 1. Sample graph of the ability of different types of birds to obtain various foods.

Review Questions

1. An ornithologist (a scientist who studies birds) makes the following observations on the food eaten by scaup, black, and merganser ducks.

	# of Fish Eaten	# of Insects Eaten	# of Plants Eaten
Scaup	2	45	0
Black duck	0	25	40
Merganser	15	5	0

A. Which bird(s) beak is probably best adapted for feeding on fish?
(1) Scaup (2) Black duck (3) Merganser (4) Both 1 and 2

B. If an oil spill killed the insects and fish in the marsh, which bird(s) would be most likely to survive?
(1) Scaup (2) Black duck (3) Merganser (4) Both 1 and 2

2. How do the beaks birds have affect the kinds of foods they can eat?

3. Why would birds have greater feeding success in a marsh where there are many food types available than in a marsh with only a few kinds of foods available?

Answers

1A. (3) – Merganser

1B. (2) – Black duck

2. Each bird's beak is adapted for catching and eating certain kinds of prey or for feeding on certain kinds of plants. While the bird may be able to feed on other organisms as well, it is probably best suited for certain ones.

3. When there are more food types available, each species of bird can feed on the kinds of food for which it is best adapted. It may be easier to find food with more types available, and there may be less competition from other birds trying to feed on the same food. In general, the more kinds of foods available, the greater the number of birds that can live in the marsh.

Extensions

1. How might the surface on which the birds are feeding affect their feeding success? Conduct more feeding experiments using different surfaces; for example, try grass, concrete, sand, or a wood floor.

2. If possible, go birdwatching with your class to watch real shorebirds feeding. If a trip to a marsh or mudflat is not possible, try watching birds feeding at a bird feeder. How are these birds using their beaks as feeding tools?

3. Show drawings or photographs of some real birds, the foods they might eat, and the habitats they might live in. Have students match each bird with the food item it would eat and with its habitat.

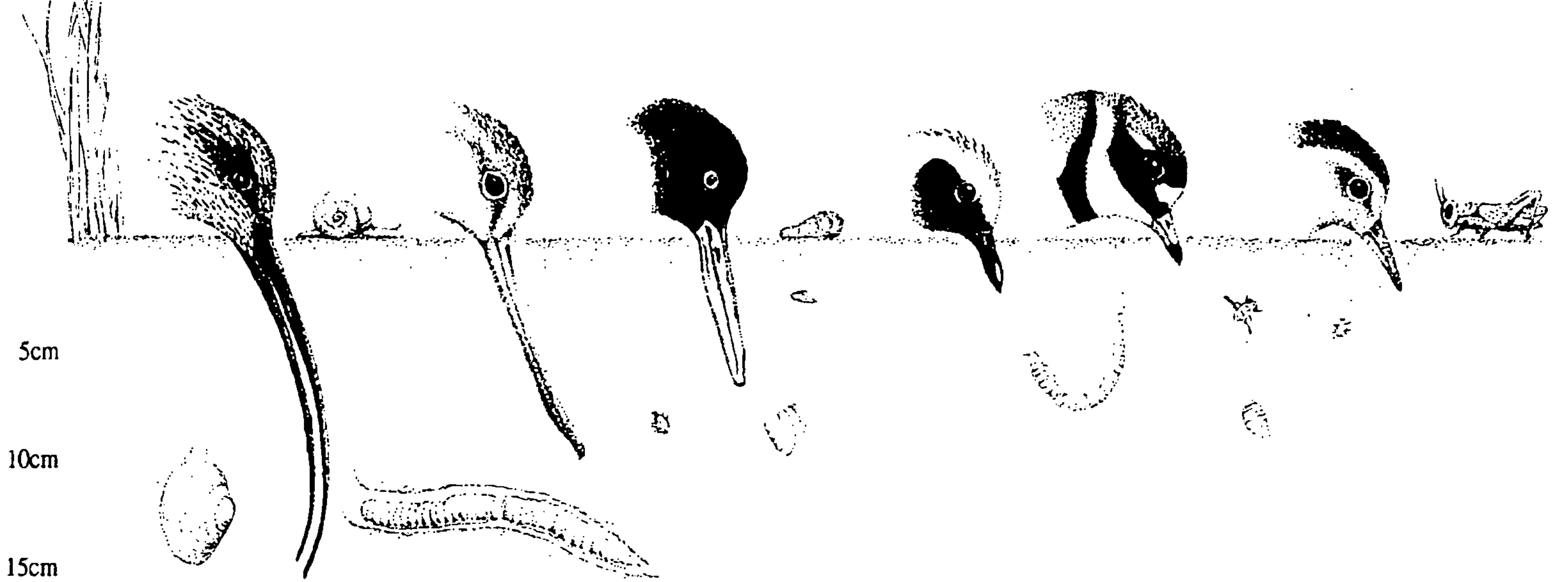
References

Bent, Arthur Cleveland. *Life Histories of North American Shore Birds*. Dover Publications, Inc., New York. 1962.

Platt, Carolyn V. "Shoreline Saga: Migration and Lake Erie." *Timeline*. The Ohio Historical Society. Feb/ March, 1990. 7(1):45.

Thomson, Tom. *Birding in Ohio*. Indiana University Press, Bloomington, IN. 1983.

Each species has a beak especially adapted for the type of food and how the food is gathered.



Long-billed Curlew (*Numenius americanus*)	Marbled Godwit (*Limosa fedoa*)	American Oystercatcher (*Haematopus palliatus*)	Black-bellied plover (*Pluvialis squatards*)	Semipalmated Plover (*Charadrius semipalmatus*)	Least Sandpiper (*Calidris minutilla*)
Body length 50-60cm (20-24in)	**Body length** 42-50cm (16.5-20in)	**Body length** 42.5-50cm (17-20in)	**Body length** 27.5-37cm (11-15in)	**Body length** 15-18cm (6-8in)	**Body length** 12.5-15cm (5-6in)
Food molluscs, worms, and insects.	**Food** grasshoppers, insects and their larvae, molluscs, snails, and crustaceans.	**Food** bivalves, snails, and worms.	**Food** grasshoppers, seeds, and berries.	**Food** worms, insects, crustaceans, and seaweed.	**Food** small crustaceans, worms, insects, and larvae.

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Adapted from Dee Estuary Conservation Group © 1976

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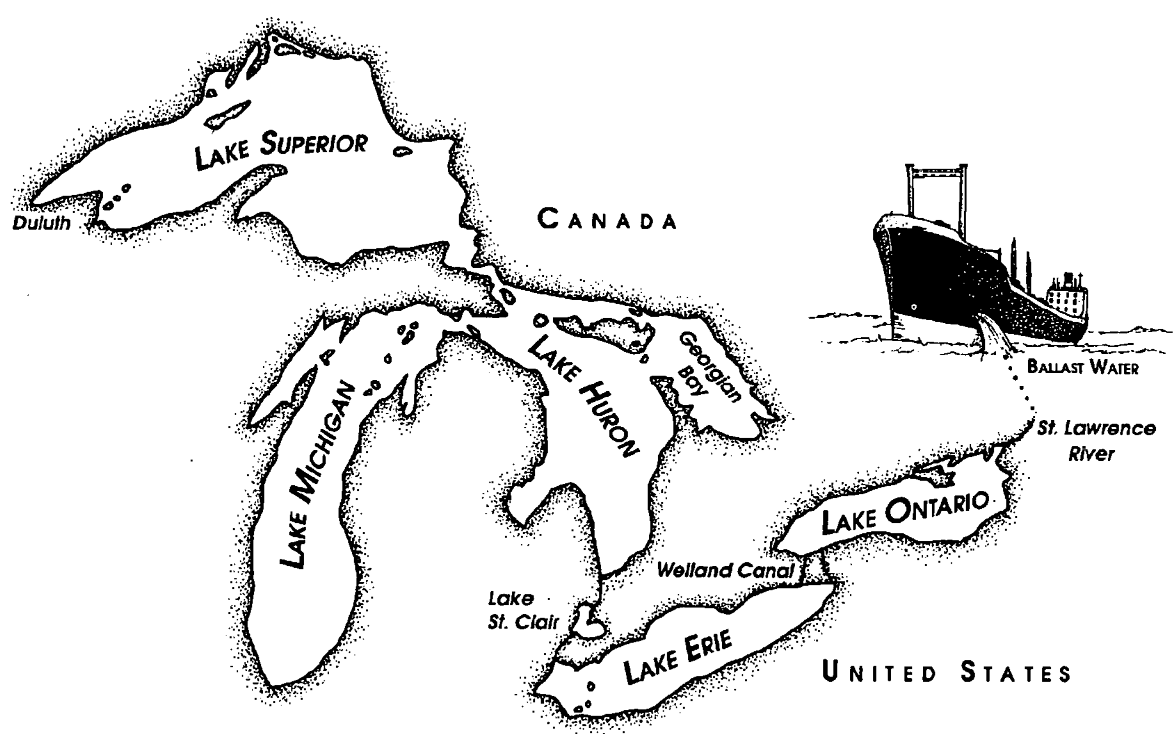
What do scientists know about invader species of the Great Lakes?

Since the early 1800s, over 140 species of aquatic plants, algae, fish, worms, mollusks, and other organisms have invaded the Great Lakes. Likewise, some North American species such as the green sunfish (*Lepomis cyanellus Rafinesque*) have migrated eastward and have become pests in Europe. Biologists worry about these intrusions, because each new species in the Great Lakes alters the region's ecosystem. Any environment has a fixed amount of energy that must be divided among all the species present. When a foreign (exotic) species invades an ecosystem, it often has no enemies. This allows an invader to increase rapidly, displacing native organisms by filling their niches. This change allows the once biodiversified region to lose some of its genetic diversity.

It is estimated that about 15 percent of the 175 species of fish in the Great Lakes are nonnative species that were introduced accidentally or intentionally. Eighty-six invader species are plants, although plants have received less attention as invaders. How these invaders get into the region is variable, but many have been shipped in unintentionally.

When ships are not loaded with cargo, they take on ballast to balance and stabilize them as they travel. The use of water as a ballast material has replaced the use of sand and stones. Ballast tanks are filled with water from the harbor where ships are loaded, and then dumped, along with any aquatic organisms present, when ships reach their destination. It is estimated that in the history of the Great Lakes, 34 percent of the invader species entered in solid ballast and 56 percent through ballast water. As shipping times between continents becomes shorter, the threat of introducing live exotics becomes greater.

The United States and Canada have requested that all ships entering the Great Lakes discharge their water ballast while still in the ocean, replacing it with salt water to reduce the introduction of new exotic species. About 90 percent of the ships currently comply with the request.



Source

Modified from "What do scientists know about Great Lakes invader species and the effects of global change on them?" In *Great Lakes Instructional Material for the Changing Earth System (GLIMCES)* by Rosanne W. Fortner, Heidi Miller, and Amy Sheaffer. Ohio Sea Grant Education Program, The Ohio State University.

Earth System Understandings

This activity focuses on ESU 3, 4, and 5. In addition, Extensions address ESU 1, 2, 6, and 7. Refer to the Framework for ESE for a full description of each understanding.

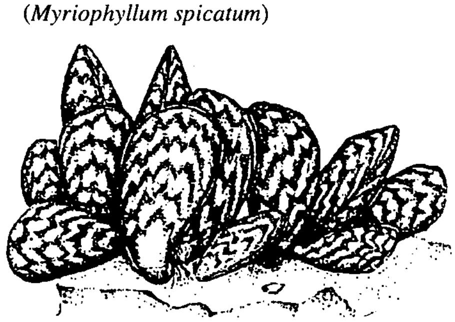
Materials

For each group of 3–4 students:

- Copies of the included information cards. Each of the three card categories (invader picture, introduction, ecosystem impact) should be copied onto a different color card stock paper. [24 cards per group]
- Answer sheet.

Invader Species in this Activity

Zebra Mussel
(*Dreissena polymorpha*)
Sea Lamprey
(*Petromyzon marinus*)
Spiny Water Flea
(*Bythotrephes cederstroemi*)
River Ruffe
(*Gymnocephalus cernuus*)
Alewife
(*Alosa pseudoharengus*)
White Perch
(*Morone americana*)
Purple Loosestrife
(*Lythrum salicaria*)
Eurasian Watermilfoil
(*Myriophyllum spicatum*)



Objectives

At the completion of this activity you should be able to:

- Name and visually recognize some invader (*nonindigenous*) species of the Great Lakes.
- Locate on a world map the origins of the Great Lakes invader species.
- Explain the ways in which invader species are introduced into the Great Lakes.
- Analyze the impacts of invader species on the Great Lakes ecosystem.

Procedure

1. Work in groups of three to four people each, with a complete set of 24 shuffled cards. (If there are eight groups, each group will be able to take a separate invader to report on at the conclusion of the activity.)
2. Beginning with the picture of the invader, match the cards to determine which introduction and ecosystem impact card goes with each invader. For each picture, there should be one matching card of each other color.
3. When group members agree that they have matched the cards to the best of their ability, you may check your answers on the answer sheets.
4. Each group selects an invader to present to the class; construct a poster on the invader, develop a fact sheet, or create a skit to introduce your invader. The impact of the invader on human affairs should be included.
5. Consult the Internet for up-to-date information. Begin with sites for the Great Lakes Panel on Aquatic Nuisance Species, for example http://www.glc.org/projects/ans/anspanel.html, and find others you find interesting. Other examples include:

   http://www.great-lakes.net/envt/exotic/exotic.html – Exotic Species in the Great Lakes region.

   http://www.nfrcg.gov/nas/nas.htm – National Biological Service's, Nonindigenous Aquatic Species (NAS) Information Resource.

   http://patton.nfrcg.gov:80/zebra.mussel – zebra mussel information resources, including U.S. distribution maps by year.

Review Questions

1. Why should people be concerned about nonindigenous species? How do they affect ecosystems?

2. How can the transfer of invader species be controlled or stopped in the Great Lakes or elsewhere in the world? Draft a piece of legislation that your group thinks could be enacted to stop exotic species from invading the Great Lakes.

3. Identify as many Great Lakes jobs as possible that are impacted by invader species. (Some impacts may be positive; that is, new jobs may have been created by the newcomers.)

Extensions

1. Do research on controls that have been tried on various invader species and report on their successes or failures. Brainstorm a creative way to control one of the invaders.

2. Draw a humorous cartoon depicting the problem of invader species. (Example: A zebra mussel looking for a place to attach on an already-overcrowded lake bottom, a white perch nudging out a yellow perch, purple loosestrife choking other plants, etc.)

References

Michigan Sea Grant. Spiny Tailed *Bythotrephes*. Its Life History and Effect on the Great Lakes (booklet). *Upwellings* Vol. 11 (3), Summer 1990 Vol. 14 (1), Winter 1992.

Michigan DNR. *Zebra Mussels in Lake Michigan: What recreational boaters and anglers should know* (brochure). Office of Great Lakes, P.O. Box 30028, Lansing, MI 48909.

Ohio Sea Grant. *The Spiny Waterflea,* Bythotrephes. *A newcomer to the Great Lakes*. Dave Berg. 2 pp. FS-049.

Wisconsin Sea Grant. *The Sea Lamprey: Invaders of the Great Lakes.* Warren Downs. 8 pp. WIS-SG-82-138. 1982.

Minnesota Sea Grant. *Seiche*, Spring 1992 — Eurasian milfoil: Can it be controlled?

Answers to Review Questions

1. Invading species threaten to change present ecosystems, often in unpredictable ways. Because invaders frequently do not have predators, they often have the ability to disrupt the existing ecological balance and dominate an area. Consider the effects of European humans after their introduction to North America. How many other species have humans displaced?

2. Bilge water is critical to the spread of invaders. Have students brainstorm different ways that invaders can be introduced and possible methods for preventing their spread.

3. Increased numbers of researchers are needed to study the potential impact and spread of the invaders. There could be new public water systems and industry jobs to keep pipes clean. Fishers will be affected because the type and quality of catch (fish size and health) will be different. Beach cleaners would be needed to get rid of dead fish, and boat cleaners will be in great demand to protect boats from invaders (potentially by developing and applying special toxic paints that will prevent zebra mussels in particular from adhering to boat hulls). Recreation facilities will most likely also experience some increased business because of the added water clarity that zebra mussels cause by filtering water, but may also lose some business because of decreased fishing opportunities. Park systems and gardeners must be concerned, because invader species will compete with the native vegetation and wildlife.

Invader #1

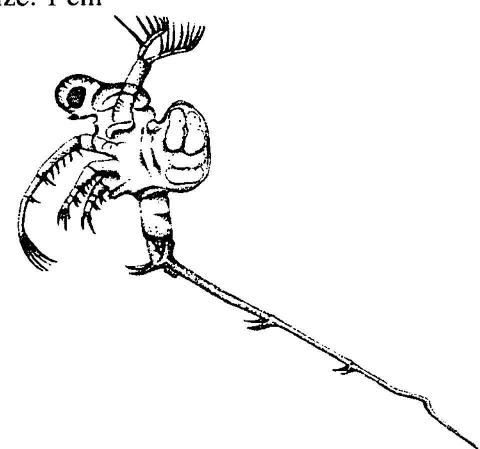
Zebra Mussel (*Dreissena polymorpha*)
Adult size: 1-4 cm long

Invader #2

Sea Lamprey (*Petromyzon marinus*)
Adult size: 3 feet (91 cm)

Invader #3

Spiny Water Flea (*Bythotrephes cederstroemi*)
Adult size: 1 cm



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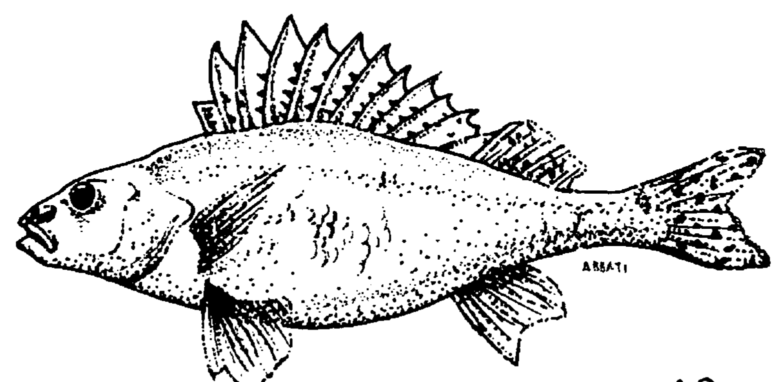
Invader #4

River Ruffe (*Gymnocephalus cernuus*)
Adult Size: usually less then 15 cm long



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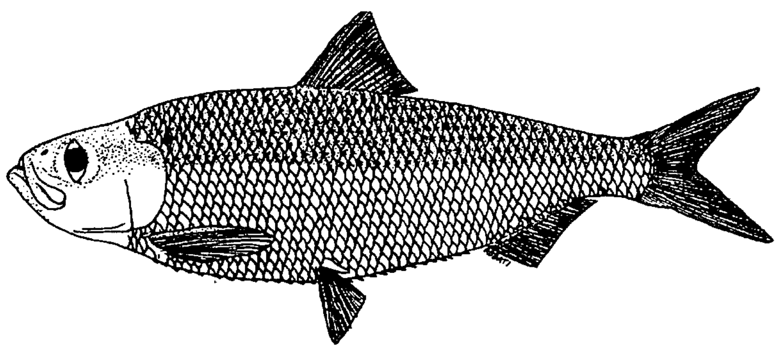
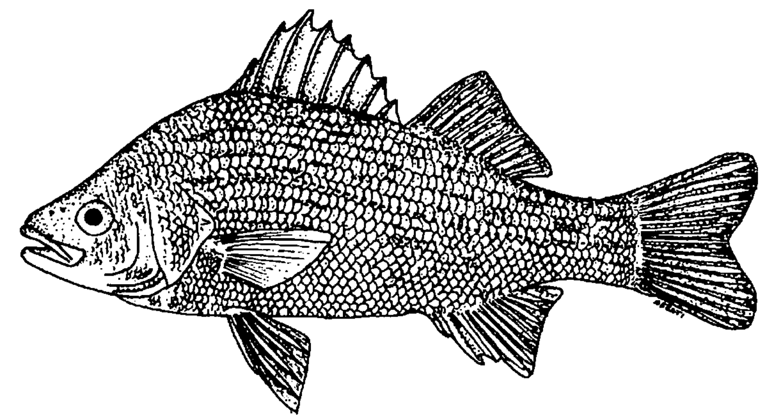
INVADER #5

Alewife (*Alosa pseudoharengus*)
Adult size: 3 cm



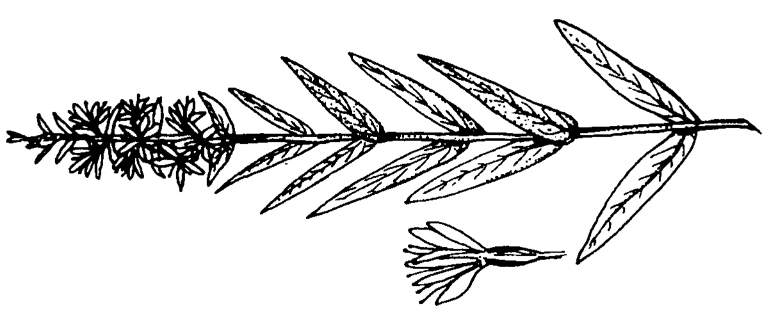
INVADER #6

White Perch (*Morone americana*)
Adult size: 30 cm (20 cm is more common)



INVADER #7

Purple Loosestrife (*Lythrum salicaria*)
Adult height: .5 to 2 meters tall



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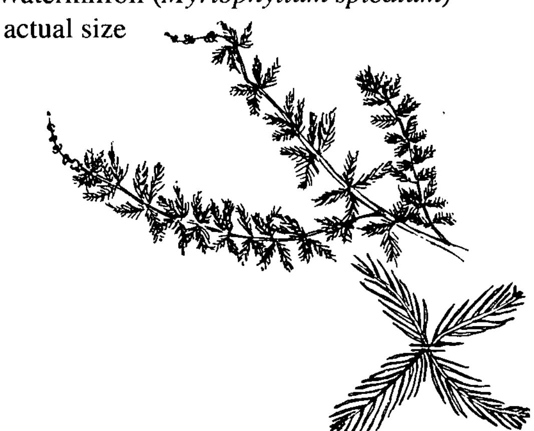
INVADER #8

Eurasian Watermilfoil (*Myriophyllum spicatum*)
Leaflet is actual size



51

INTRODUCTION

Originally it came from the Caspian Sea region of Poland, Bulgaria, and Russia. Canals built during the early 1800s allowed it to spread throughout Europe. By 1830 it had invaded Britain. First introduction into the Great Lakes was about 1985, when one or more transoceanic ships discharged ballast water into Lake St. Clair. Freshwater ballast from a European port likely contained larvae and possible yearlings. Being a temperate, freshwater species, it found the plankton–rich Lake St. Clair suitable as a habitat.

INTRODUCTION

Arriving from the freshwater and brackish water in northern Europe, this invader was discovered in Lake Superior in 1986. It is assumed that it "hitchhiked" in ballast waters from Europe and Asia. In 5 years, its population reached 1.8 million adults, making it the most abundant fish in the Duluth harbor. This bottom feeder can reproduce in its first year and the females may lay 13,000 to 200,000 eggs per season.

INTRODUCTION:

Originally, it came from the Atlantic Ocean, the St. Lawrence, and Hudson Rivers, and their tributaries for spawning, and possibly Lake Ontario. It swam from Lake Ontario into Lake Erie through the Erie and Welland Canals, gaining entry into the upper Great Lakes by attaching to hulls of boats.

52

INTRODUCTION

A native of northern Europe, it made its way into Lake Huron in 1984 and was present in all Great Lakes by 1987. It is believed to have been brought over in fresh water or mud in ballast water of European freighters from Eastern Baltic Ports, as studies show that the Great Lakes species closely resembles the species in the ports of Finland and St. Petersburg (the former Leningrad).

53

INTRODUCTION

This species was intentionally imported from Northern Europe over 100 years ago, because its hardiness and beautiful flowers were popular with landscapers, florists, and gardeners.

INTRODUCTION

It came from Europe, Asia and North Africa and was introduced into North America as an aquarium plant. It has since spread to 37 states and 3 Canadian provinces.

INTRODUCTION

Coming from the salty Atlantic Coast, this invader migrated through water routes, including canals in New York State and the St. Lawrence River. It swam into the upper Great Lakes through the Welland and/or Erie barge canal before 1931.

54

INTRODUCTION

From saltwater areas of the Atlantic Coast, this invader moved up the Hudson River and via various canal systems into Lake Ontario and Lake Erie.

55

Ecosystem Impact

This is a large plankton form that eats the smaller plankton, thereby competing with small fish for their food source and affecting their survival and growth rates. Its spiny tail prevents young fish from swallowing it, thus removing it from the food chain. It is an invader species so new that it may take years to determine its total impact.

Ecosystem Impact

It is called "the beautiful killer," because its dense roots choke waterways as it competes with other vegetation. It spreads quickly, crowding out valuable plants that provide food for migrating waterfowl, and destroys habitat for almost all other forms of wetland life.

Ecosystem Impact

Only about 8 inches long, this perch-like fish has no value as a sport or food fish. It is less temperature-dependent than perch and tolerates more polluted areas. It also can find hidden prey in soft sediments more efficiently than its competitors. This fish is not preferred by predators because of its spiny fins. It displaces sport and food fish, especially yellow perch and walleye, yet is not readily consumed in the food web. This invader made up 90 percent of the fish population in the Scottish lake, Loch Lomond, only 9 years after it was introduced.

56

Ecosystem Impact

Forms thick mats that choke out native aquatic vegetation. It disrupts all forms of water recreation—boating, swimming, and fishing.

57

ECOSYSTEM IMPACT

It destroys valuable fish, especially lake trout, by attaching with its sucker-like mouth to suck out the blood and body tissues. It upsets the ecological balance by removing top predators, allowing for explosion of the populations of smaller fish such as alewives. It had great economic impact on the commercial fishing industry of the Great Lakes during the 1950s.

ECOSYSTEM IMPACT

Suspected to be partially responsible for the decline of Lake Erie's yellow perch because of competition.

ECOSYSTEM IMPACT

It filters the plankton from the water, binding what it doesn't use into pellets that cannot be used by other plankton-feeding organisms. It accumulates on objects such as boat hulls and underwater pipes, clogging valves of both industrial and municipal water intake sources.

58

ECOSYSTEM IMPACT

Large numbers die off in spring and summer because of electrolyte imbalance from living in fresh water. These die-offs clog municipal and industrial intake pipes and foul beaches. In 1967 bulldozers had to remove 50,000 tons of the rotting fish. The sea lamprey enabled this invader to thrive in Lake Erie by killing lake trout and other fish at the top of the aquatic food chain. After the sea lamprey arrived, this invader proliferated. Between 1960 and 1966, for example, they went from representing 8 percent to 80 percent of Lake Michigan's fish by weight. Presently this invader is food for larger game fish.

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Answers to Cards

Invader 1: Zebra mussel (*Dreissena polymorpha*)

Introduction: Originally, it came from the Caspian Sea region of Poland, Bulgaria, and Russia. Canals built during the early 1800s allowed it to spread throughout Europe. By 1830 it had invaded Britain. First introduction into the Great Lakes was about 1985, when one or more transoceanic ships discharged ballast water into Lake St. Clair. Freshwater ballast from a European port likely contained larvae and possible yearlings. Being a temperate, freshwater species, it found the plankton–rich Lake St. Clair and Lake Erie to be suitable habitats.

Ecosystem Impact: It filters the plankton from the water, binding what it doesn't use into pellets that cannot be used by other plankton–feeding organisms. It accumulates on objects such as boat hulls and underwater pipes, clogging valves of both industrial and municipal water intake sources.

Invader 2: Sea Lamprey (*Petromyzon marinus*)

Introduction: Originally it came from the Atlantic Ocean, the St. Lawrence and Hudson Rivers, and their tributaries for spawning, and possibly Lake Ontario. It swam from Lake Ontario into Lake Erie through the Erie and Welland Canals, gaining entry into the upper Great Lakes by attaching to hulls of boats.

Ecosystem Impact: It destroys valuable fish, especially lake trout, by attaching with its sucker–like mouth to suck out blood and body tissues. It upsets the ecological balance by removing top predators, allowing for explosion of populations of smaller fish such as alewives. It had great economic impact on the commercial fishing industry of the Great Lakes during the 1950s.

Invader 3: Spiny Water Flea (*Bythotrephes cederstroemi*)

Introduction: A native of northern Europe, it made its way into Lake Huron in 1984 and was present in all Great Lakes by 1987. It is believed to have been brought over in fresh water or mud in ballast water of European freighters from Eastern Baltic Ports, as studies show that the Great Lakes species closely resembles the species in the ports of Finland and St. Petersburg (the former Leningrad).

Ecosystem Impact: This is a large plankton form that eats the smaller plankton, thereby competing with small fish for their food source and affecting their survival and growth rates. Its spiny tail prevents young fish from swallowing it, thus removing it from the food chain. It is an invader species so new that it may take years to determine its total impact.

Invader 4: River Ruffe (*Gymnocephalus cernuus*)

Introduction: Arriving from the freshwater and brackish water in northern Europe, this invader was discovered in Lake Superior in 1986. It is assumed that it "hitchhiked" in ballast waters from Europe and Asia. In 5 years, its population reached 1.8 million adults, making it the most abundant fish in the Duluth harbor. This bottom feeder can reproduce in its first year, and the females may lay between 13,000 to 200,000 eggs per season.

Ecosystem Impact: Only about 8 inches long, this perch-like fish has little value as a sport or food fish. It is less temperature-dependent than perch and tolerates more polluted areas. It also can find hidden prey in soft sediments more efficiently than its competitors. This fish is not preferred by predators because of its spiny fins. It displaces sport and food fish, especially perch and walleye, yet is not readily consumed in the food web. This invader made up 90 percent of the fish population in the Scottish lake, Loch Lomond, only 9 years after it was introduced.

Invader 5: Alewife (*Alosa pseudoharengus*)

Introduction: Coming from the salty Atlantic Coast, this invader migrated through water routes, including canals in New York state and the St. Lawrence River. It swam into the upper Great Lakes through the Welland and/or Erie barge canal before 1931.

Ecosystem Impact: Large numbers die off in spring and summer because of electrolyte imbalance from living in fresh water. These die-offs clog municipal and industrial intake pipes and foul beaches. In 1967 bulldozers had to remove 50,000 tons of the rotting fish. The sea lamprey enabled this invader to thrive in Lake Erie by killing lake trout and other fish at the top of the aquatic food chain. After the sea lamprey arrived, this invader proliferated. Between 1960 and 1966, for example, they went from representing 8 percent to 80 percent of Lake Michigan's fish by weight. Presently this invader is forage for larger game fish.

Invader 6: White Perch (*Morone americana*)

Introduction: From saltwater areas of the Atlantic coast, this invader moved up the Hudson River and via various canal systems into Lake Ontario and Lake Erie.

Ecosystem Impact: Suspected to be partially responsible for the decline of Lake Erie's yellow perch because of competition.

Invader 7: Purple Loosestrife (*Lythrum salicaria*)

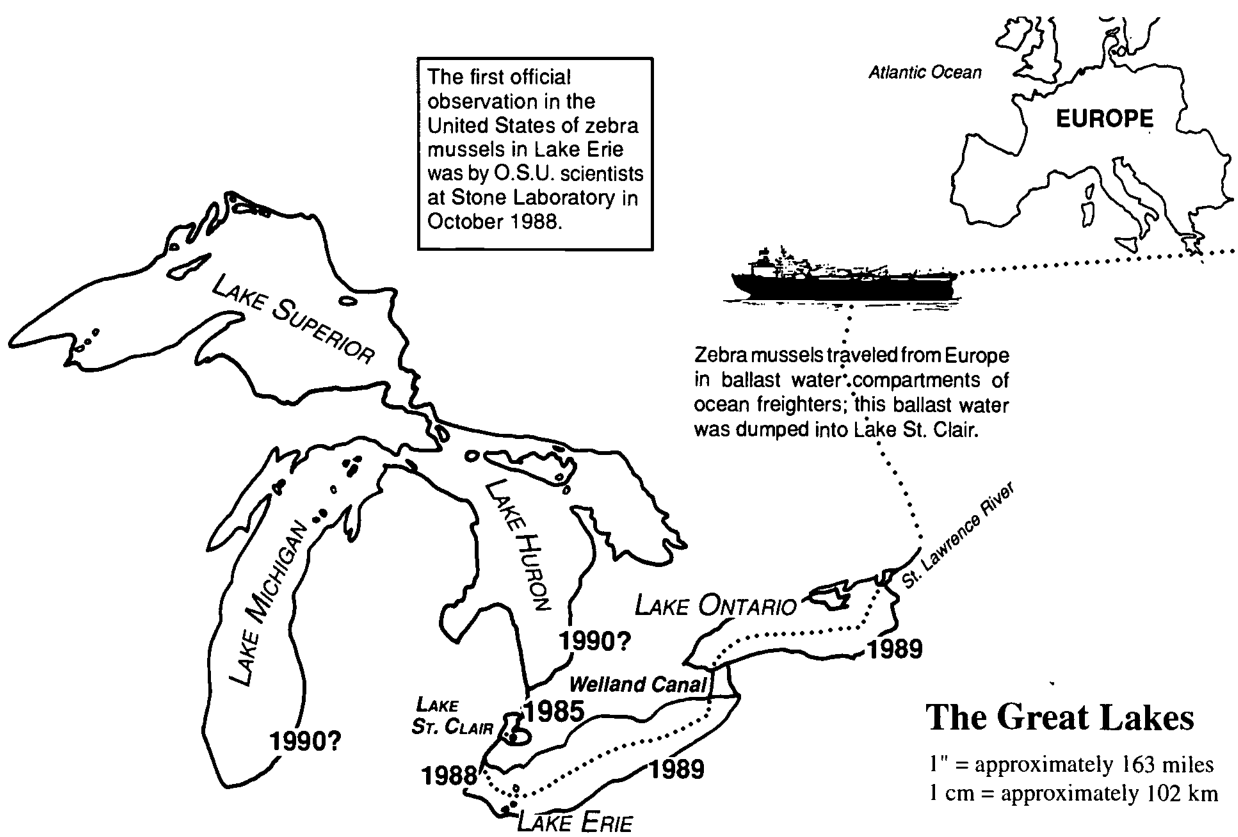
Introduction: This species was intentionally imported from Northern Europe over 100 years ago, because its hardiness and beautiful flowers were popular with landscapers, florists, and gardeners.

Ecosystem Impact: It is called "the beautiful killer," because its dense roots choke waterways as it competes with other vegetation. It spreads quickly, crowding out valuable plants that provide food for migrating waterfowl, and destroys habitat for almost all other forms of wetland life.

Invader 8: Eurasian Watermilfoil (*Myriophyllum spicatum*)

Introduction: It came from Europe, Asia, and North Africa and was introduced into North America as an aquarium plant. It has since spread to 37 states and 3 Canadian provinces.

Ecosystem Impact: Forms thick mats that choke out native aquatic vegetation. It disrupts all forms of water recreation —boating, swimming, and fishing.



The Great Lakes

1" = approximately 163 miles
1 cm = approximately 102 km

Ecological Relationships

Background Reading

Now that you have explored some of the different types of species present in the Great Lakes ecosystem, you can investigate the life of an individual organism in greater depth. Each member of a species depends on the interactions of various components in an ecosystem for its livelihood. What will help is "a better understanding of the life cycles and needs of species important to the lake's commercial and sport fisheries, not only the fishes themselves but also the algae, zooplankton, insects, aquatic birds and other organisms that make up the food web of which fishes are a part."

(From Tramer, Elliot J. 1993. "Effect of Human Activities on the Ecology of Lake Erie." In The Great Lake Erie. *Edited by Rosanne W. Fortner and Victor J. Mayer, Columbus: Ohio Sea Grant College Program, The Ohio State University.)*

The Lake Erie Fishery reflects the challenges posed to an ecosystem and its organisms. The ecosystem of the lake responded to various challenges over time through changing its species composition. By the 1900s, "the combined effect of stream obstruction, draining and diking marshlands, extreme pollution of streams and harbors, loss of rooted aquatic vegetation, heavy siltation, increased flooding, overfishing and the introduction of exotic species had resulted in the reduction of the populations of many native fishes to perhaps 20% of their former abundance. These species were replaced by an increase in the population of others, especially carp, goldfish, bullhead and other less valuable species.

The period from 1900 to 1940 was one of relative stability in the fishery. The low levels of walleye, smallmouth bass, sauger and others now became the 'norm.' The lost populations of lake trout, brook trout, muskellunge and northern pike became the 'fish stories' told by grandfather but not really believed.

Yellow perch now became a valuable food species and was sought after by commercial (fishers) and (anglers) alike. It alone tells the story of shifting preferences due to the loss of higher quality fishes. . . Yellow perch increased, partially as a result of the lack of competition from blue pike and walleye, and production skyrocketed to nearly 28 million pounds." This brief history shows how organisms ebb and flow in response to outside pressures placed on an ecosystem like that in the Great Lakes.

(Modified excerpts from White, Andrew M. 1993. "History of Changes in the Lake Erie Fishery," In The Great Lake Erie. *Edited by Rosanne W. Fortner and Victor J. Mayer, Columbus: Ohio Sea Grant College Program, The Ohio State University.)*

"As an ecosystem the Great Lakes basin is a unit of nature in which living organisms and nonliving things interact adaptively. An ecosystem is fueled by the sun, which provides energy in the form of light and heat. This energy warms the earth, the water and the air, causing winds, currents, evaporation and precipitation. The light energy of the sun is essential for the photosynthesis of green plants in water and on land. Plants grow when essential nutrients such as phosphorus and nitrogen are present with oxygen, inorganic carbon and adequate water.

Plant material is consumed in the water by zooplankton, which graze the waters for algae, and on land by plant-eating animals (herbivores). Next in the chain of energy transfer through the ecosystem are organisms that feed on other animals (carnivores) and those that feed on both animals and plants (omnivores). Together these levels of consumption constitute the food chain, or web, a system of energy transfers through which an ecological community consisting of a complex of species is sustained. The population of each species is determined by a system of checks and balances based on factors such as the availability of food and the presence of predators, including disease organisms.

Every ecosystem also includes numerous processes to break down accumulated biomass (plants, animals, and their wastes) into the constituent materials and nutrients from which they originated. Decomposition involves micro-organisms that are essential to the ecosystem because they recycle matter that can be used again.

Stable ecosystems are sustained by the interactions that cycle nutrients and energy in a balance between available resources and the life that depends on those resources. In ecosystems, including the Great Lakes basin, everything depends on everything else and nothing is ever really wasted."

(From The Great Lakes. An environmental atlas and resource book. *1995. Jointly produced by the Government of Canada and U.S. EPA, 3rd edition.)*

Who can harvest a walleye?

The Great Lakes are an example of a natural community. In this community the small organisms (living things) outnumber the large organisms. The smaller organisms may be eaten by the larger ones. If we count all the organisms of one kind, then count all the things they eat and all the things that eat them, we can draw a pyramid of numbers that will also show who eats what.

In the "Walleye Game" there are four levels to the pyramid. The largest level is that of algae, the tiny water plants that produce food by photosynthesis. The other levels are all consumers that cannot make their own food. Gizzard shad are small fish that eat algae. Because they are plant eaters, scientists call them herbivores. The walleye is a larger fish. There are fewer walleyes than gizzard shad, so the walleye level is smaller. Walleyes eat herbivores, so scientists say that walleyes are first-order carnivores. The organism that eats the first-order carnivore (a person, in this game) is called a second-order carnivore.

OBJECTIVES

When you have completed this investigation you should be able to:

- Apply the meaning of the following terms as they relate to a biomass pyramid: producer, herbivore, first-order carnivore, second-order carnivore.
- Calculate the relative number of kilograms at each level of the biomass pyramid in a given environment.
- Analyze how different conditions in the environment affect the pyramid.

PROCEDURE

This game shows how factors affecting lower parts of the food chain can affect higher levels as well. The pyramid in this game is a biomass type because it is based on the weight of the organisms in kilograms.

Source

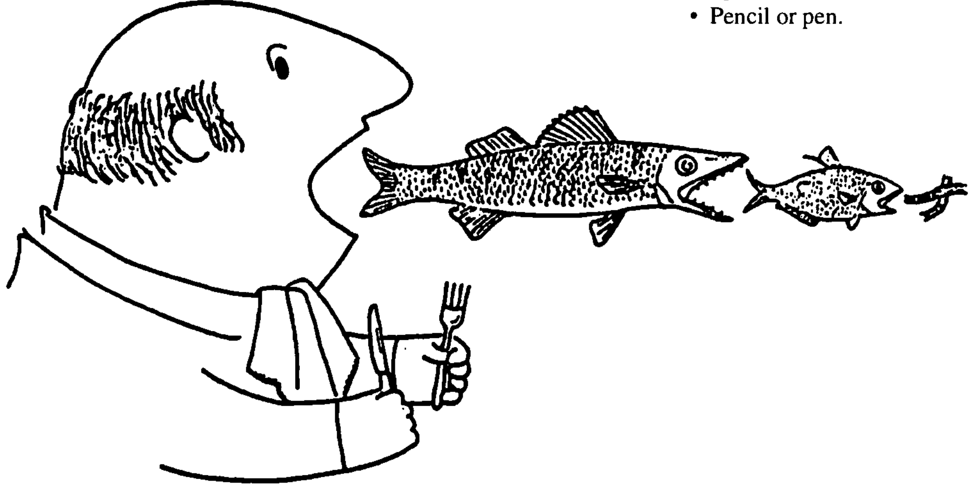
OEAGLS EP-11, *To Harvest a Walleye,* Activity A, by Susan Leach, Gabriele Reil and Rosanne W. Fortner.

Earth Systems Understandings

This activity focuses on ESU 4, interactions within Earth systems, and ESU 2, effects of human activities. ESU 6 is involved as the sun is the source of energy for algae to photosynthesize.

Materials

- Walleye Game Board.
- Productivity Cards.
- Biomass Record.
- Markers (buttons).
- Spinner.
- Pencil or pen.

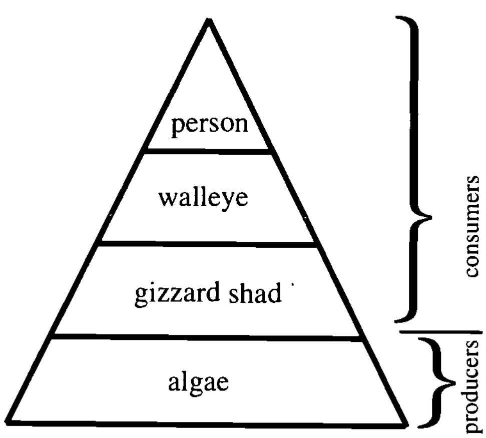


The object of this game is to end at the block labeled "Harvest" with at least one kilogram of fish. You will keep track of kilograms (kg) of organisms on the "Biomass Record." The game is best played by 2-4 individuals.

1. Before playing the game, read through the game board and Productivity Cards to pick out any words that are new to you. Look up the words in the Glossary.

2. Begin at START with 1,000 kg of algae. Record this amount in the "Producers" column of the Biomass record. Spin the spinner to see who moves first. The player with the highest number will move first. Play then goes around the board to the left.

3. Move through each level of the pyramid by moving your marker the number of spaces shown on the spinner. Change your number of kilograms as the board directs. Record the new number of kg on your Biomass Record each time the mass changes.



4. Some sections of the board require you to divide the mass of the organisms by some number. Drop any fractions that you get in your answers.

5. At the end of each level, it is assumed that all organisms are captured by organisms of the next level. You must change columns on the Biomass Record and divide by 10 whenever you pass the algae or fish pictures, even if you don't land on them. (Scientists know that on the average, only 10% of the energy available at one level of a food chain is passed on to the next level.)

6. If at any time you have less than 1 kg left, you must return to block 1 and begin again.

7. The winner of the game is the first player to land at the triangle labeled "Harvest" with at least 1 kg of walleye. You must spin the exact number to land on "Harvest."

8. At the end of the game compare results on your Biomass Record with those of the other players. Compare the kg of biomass that you had at the beginning of each level of the pyramid.

9. List on your worksheet some of the things that happened to your organisms and how they affected your populations as you progressed through the game.

REVIEW QUESTIONS

1. Give an example of the kinds of organisms represented in a food pyramid. What kinds of organisms are on the bottom? Why?

2. Which levels of a pyramid have the least energy available? Why?

See Also

Glossary of the Great Lakes – http://www.d.umn.edu/~seagr/GGL/ to learn about specific terms, organizations, and issues.

GLOSSARY

1. algae bloom: Situation in which algae have multiplied very rapidly.

2. breeding ground: Place where organisms reproduce.

3. carnivore: Animal that eats animals.

4. entrain: To suck fish up into water intake valves from industry. (Such fish are killed by temperature and pressure changes and physical abrasion.)

5. eutrophication: The natural aging process of a lake during which the lake becomes shallower and shallower and warmer and warmer, finally becoming a marshland, and then dry land.

6. food chain: Sequence in that organisms eat and are eaten by other organisms.

7. herbicide: A chemical that kills plants.

8. herbivore: Animal that eats plants.

9. impinge: To suck fish up against industrial intake sieves and hold them there, causing suffocation.

10. landfill: Portion of lake that is diked and filled with gravel, soil, garbage etc., to make more land area.

11. nutrients: Chemicals needed by plants and animals – fertilizers (potassium, phosphorus, nitrogen).

12. organism: Any living thing.

13. producer: Plant that performs photosynthesis and forms the base of the food chain.

14. thermal pollution: Hot water.

Biomass Record Sheet

	PRODUCERS (ALGAE)	HERBIVORES (GIZZARD SHAD)	FIRST ORDER CARNIVORES (WALLEYE)	SECOND ORDER CARNIVORE (PERSON)
PLAYER 1				
PLAYER 2				
PLAYER 3				
PLAYER 4				

REFERENCES

Almost all biology and ecology texts will have some reference to food chains, pyramids, and webs. The texts below may be useful.

Miller, G. Tyler, Jr., *Living in the Environment: principles, connections, and solutions.* 8th Ed. Wadsworth Pub. Co., Belmont, CA, 1994. 701 p., ill.

Ohio Department of Natural Resources, Division of Wildlife, Publication 185, "Gizzard Shad in Ohio," Life History Notes.

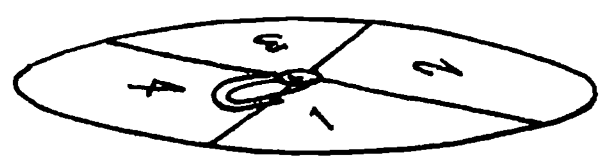
Ohio Department of Natural Resources, Division of Wildlife, Publication 141, "Walleye and Blue Pike in Ohio," Life History Notes.

Reel in a Walleye "online!"

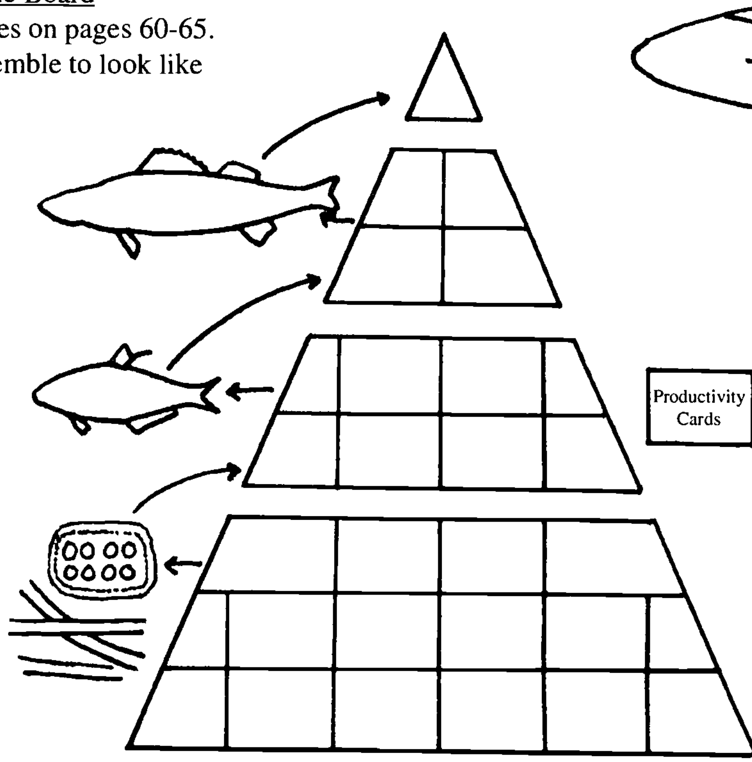
The Internet is also a source of information about fish species. Find out more about walleye by using the address http://h2o.seagrant.wisc.edu/communications/Publications/Fish/walleye.html. Web addresses sometimes change. Do a word search using "walleye" and fish related topics if necessary.

GAME PIECES

<u>Spinner</u> (one per game)
paper clip and paper fastener attached to cardboard circle, or to a plastic lid marked as shown.



<u>Game Board</u>
Pieces on pages 60-65.
Assemble to look like



<u>Productivity Cards</u> (one set per game)
Copy the following two pages on heavy paper. Cut apart and turn upside down on game boards.

Eutrophication speeds up in the shallow parts of lake. Lack of oxygen kills all but 100 kg.	Pollution from a coastal river enters the lake. Lose 100 kg organisms.
ORGANISMS DOUBLE!	Tanker grounds on shoal dumping sulfuric acid. Lose 100 kg.
Oil spill. Lose all organisms. Go back to block 1: begin with 1,000 kg algae.	Sewage treatment plant opens with better cleaning equipment. Lower nutrient levels result because there is less sewage pollution. Lose 50 kg.

An illegal landfill is built near the lake, and wastes seep out into shore areas. Breeding grounds are destroyed. Lose all organisms. Go back to block 1 and begin with 1,000 kg algae.

Grass carp (herbivorous fish from another food chain) are introduced into the lake. They eat 1/2 your algae.

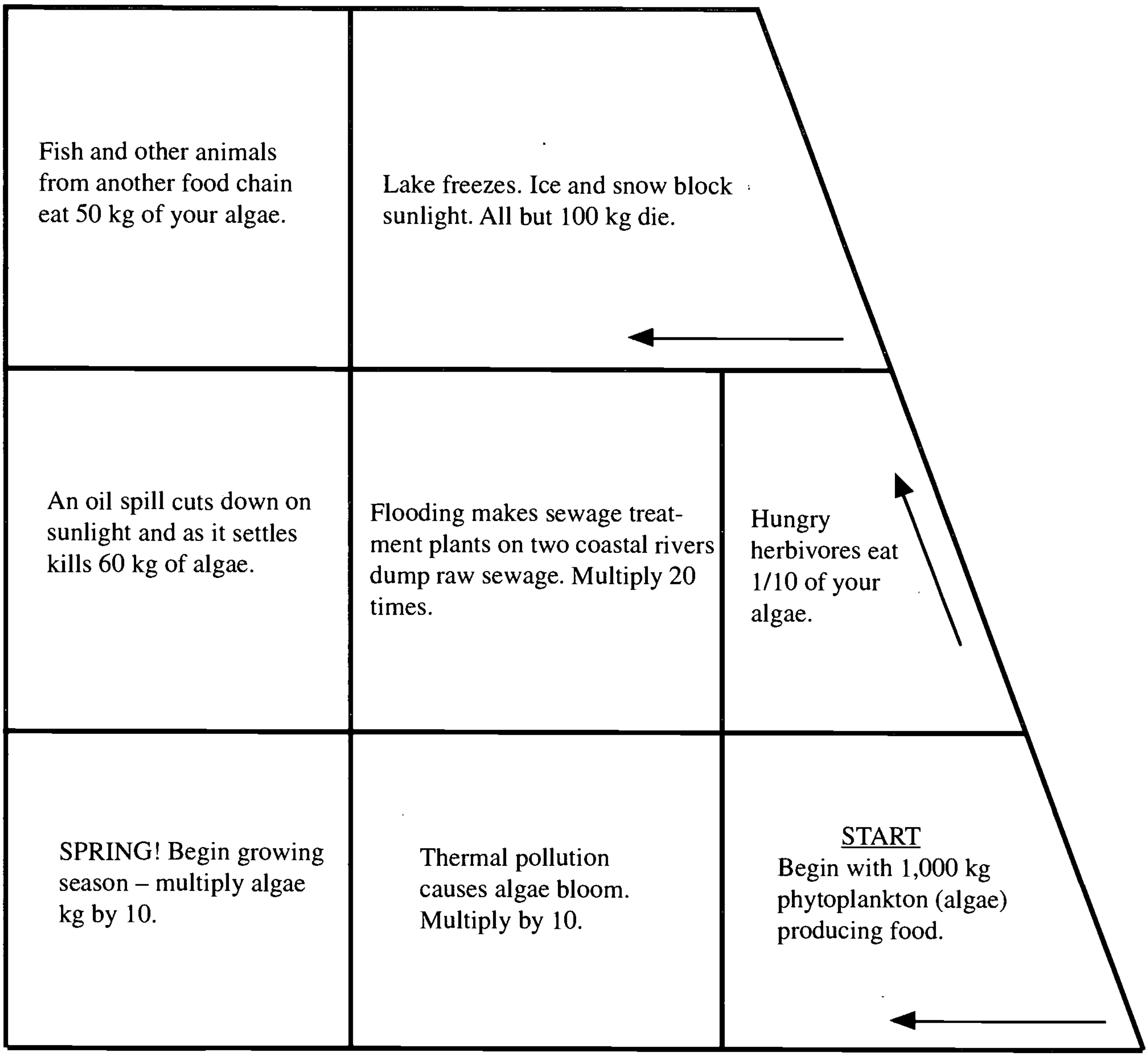
Save this card until you need it. Coast Guard saves the day and cleans up the oil spill. You lose only 1/2 your algae.

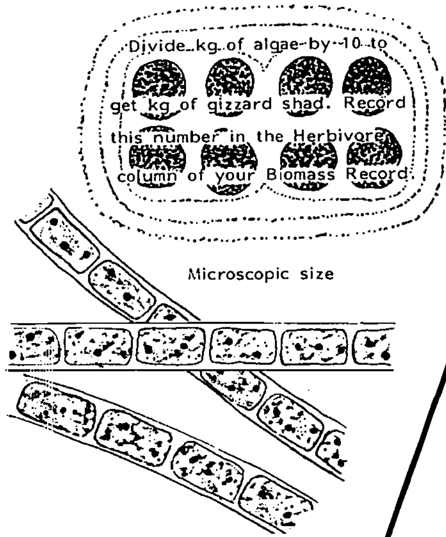
Algae that died in another bloom start to decay and release nutrients into the water. Add 50 kg.

U.S. Army Corps of Engineers stops dumping dredge spoils into the lake. Add 50 kg.

A power plant dumps hot water killing all except blue-green algae. Lose 200 kg.

Walleye game board. Copy onto heavy paper and assemble as shown on p. 59.





Chemical pollution reduces population by 50 kg.

Draw a productivity card.

Silt from spring floods blocks sunlight. 1/2 algae die.

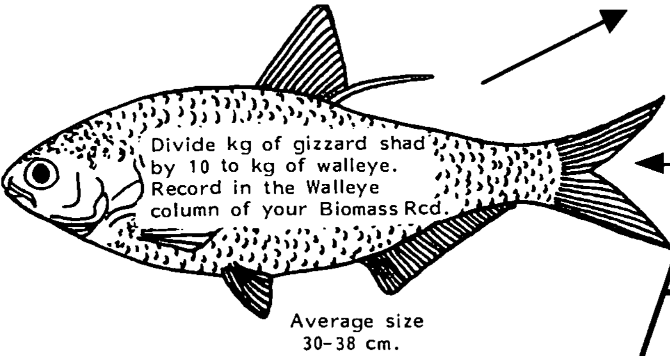
Microscopic animals eat 1/2 your algae.

A new phosphate detergent makes billowy suds on the lake. Algae bloom but only 1/10 survive due to oxygen lack.

Fertilizer runoff from fields increases algae nutrients. Multiply 20 times.

Draw a productivity card.

Algae bloom uses up oxygen and nutrients. Lose 1/2 your algae.



Algae bloom uses up 0_2. All but 25 kg die.

Breeding grounds wiped out by landfill. Lose 1/2.

Power plant impinges and entrains shad. Lose 1/2.

Kingfishers, herons and other fish-eating birds eat 10 kg of your shad.

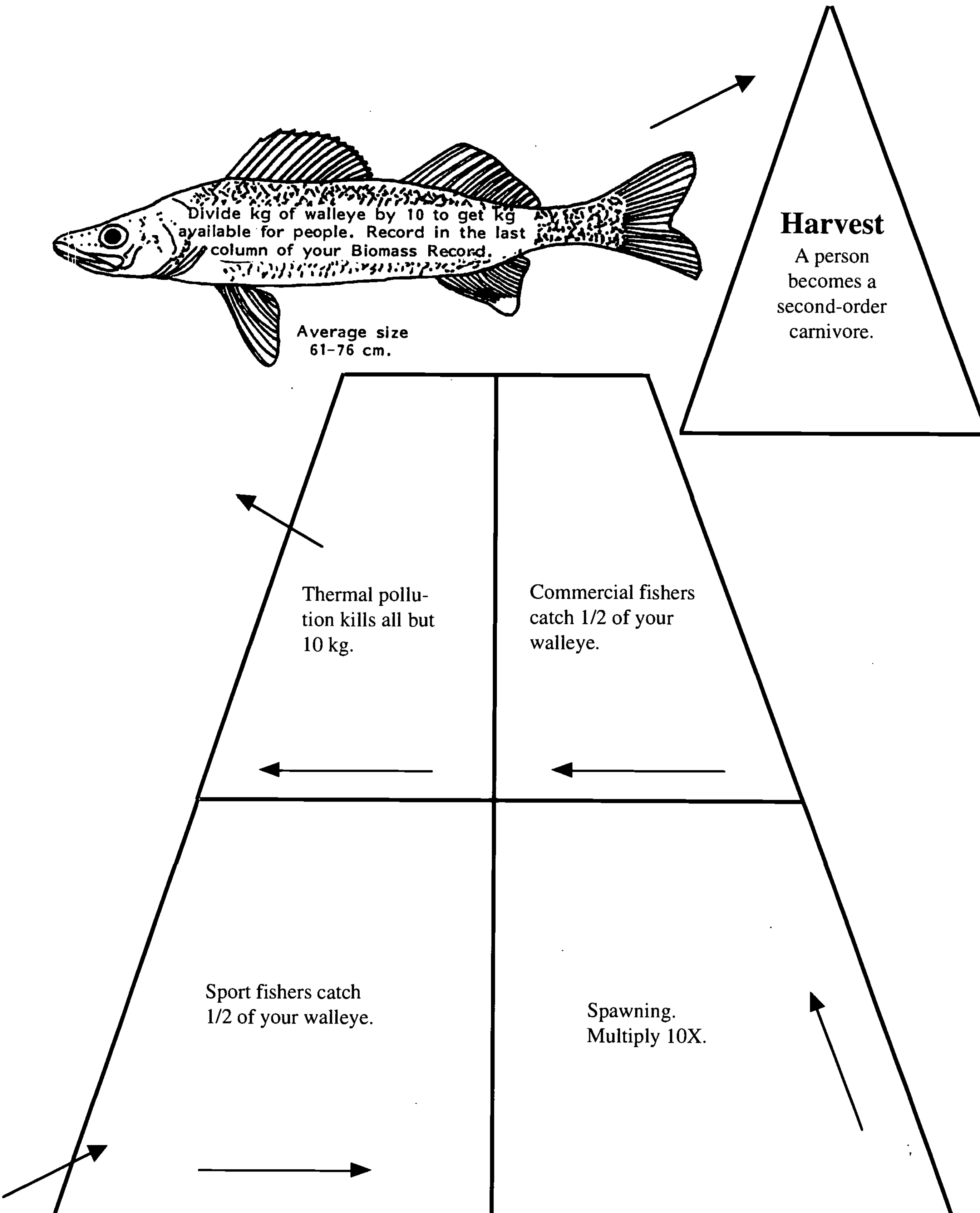
PRODUCTIVITY CARDS

Factory dumps hot water from its machines. Multiply 2X. (Shad love warm water.)

Severe winter kills 1/2 of your shad.

Spawning. Multiply 10X.

Power plant shuts down. Water temperature drops and kills 1/10 of your shad.


Divide kg of walleye by 10 to get kg available for people. Record in the last column of your Biomass Record.
Average size 61–76 cm.
Harvest
A person becomes a second-order carnivore.
Thermal pollution kills all but 10 kg.
Commercial fishers catch 1/2 of your walleye.
Sport fishers catch 1/2 of your walleye.
Spawning. Multiply 10X.

What does a biomass pyramid tell us?

This investigation should follow the walleye game. Although the results of the game depended on the luck of the spinner and the "Productivity Cards," many of the minor and major disasters described on the cards and on the game board actually are happening or have happened.

At each level of a biomass pyramid energy is lost or "wasted." This is energy that cannot be passed on as food from level to level. Lost energy is one reason why it takes so much algae for so few gizzard shad and even fewer walleyes.

About 40 percent of the energy of algae is lost through respiring, growing, reproducing, and waste removal. Seventy-five percent of the energy of herbivores is lost through eating, respiring, waste removal, molting, growing, and reproducing. First-order carnivores "waste" 55% of their energy in their normal body activities. Because of this, much less energy is available for producing biomass. Therefore, much less biomass ends up at the top of a pyramid.

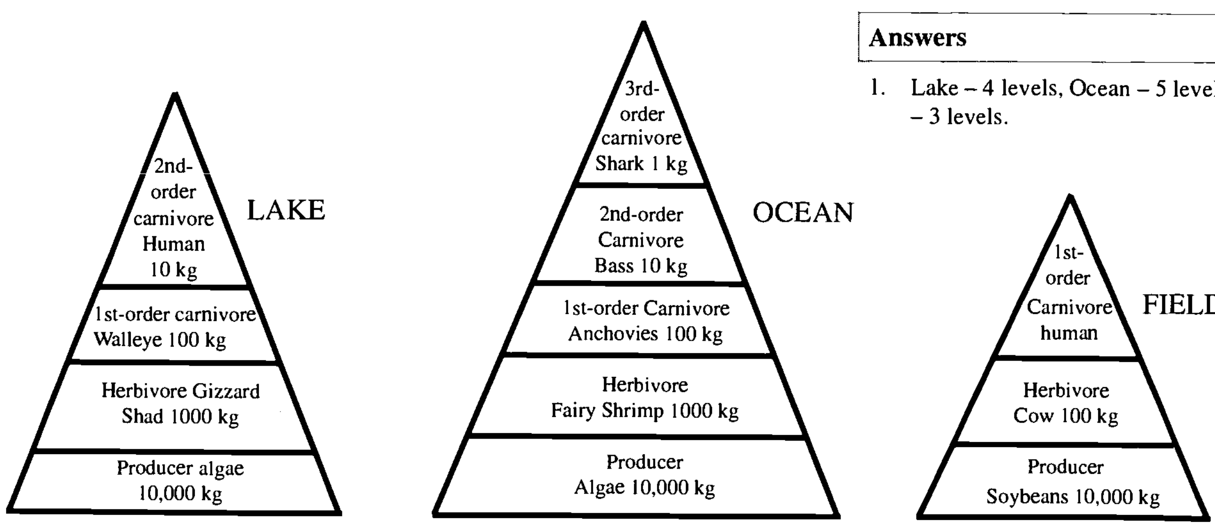
Objective

When you have completed this investigation, you should be able to compare the biomass pyramids of lake, land, and ocean environments in regard to their complexity and energy transfer.

Procedure

Use the following biomass pyramids to answer questions 1-3.

1. Count and compare the number of levels in the three pyramids. Remember, more levels mean more lost energy.



Source

OEAGLS EP-11, *To Harvest a Walleye,* Activity B, by Susan Leach, Gabriele Reil and Rosanne W. Fortner.

Earth Systems Understandings

This activity continues the concepts of "Who can harvest a walleye?" in examining several food pyramids. It addresses ESU 4 in that combinations of subsystems create pyramids for different organisms.

Materials

- Pen or pencil.

Answers

1. Lake – 4 levels, Ocean – 5 levels, Field – 3 levels.

Answers

2. The field pyramid provided the most food for people since food from lower levels of the pyramid is being utilized. "Ocean" is not acceptable as an answer here. Since this is the tallest pyramid, students tend to think that this provides the most food. They forget that more levels means more lost food energy. This pyramid is an example of the many food pyramids that do not involve people.

3. Increasing the number of producers and/ or harvesting lower on the pyramid would increase available kg of food. Students may have other ideas that are correct.

4. The field pyramid might be completed with pigs or cows, 10 kg; and people, 1 kg; or with squirrels, 10 kg; and bobcat, 1 kg. The forest pyramid might be completed with nuts or acorns, 100 kg; and people, 1 kg. This question is an open one, and any organisms within reason should be accepted.

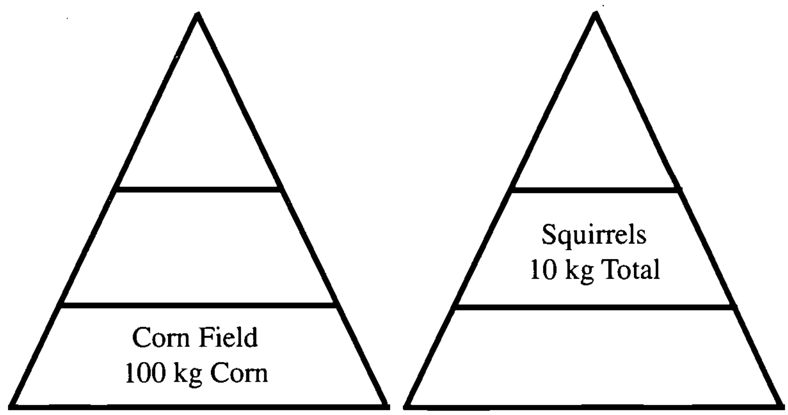
2. Which pyramid provides people with the most food?

3. What might be a way of increasing the number of kilograms that people could harvest from lakes and oceans?

A biomass pyramid is not just a way of showing who eats what and how much they eat. It is also a simple way of showing how different parts of an ecosystem are related.

4. Fill in on your worksheet some species of plants and animals that would fit the food pyramids below.

Put in the amounts of each species in kilograms that would be needed to keep each level going. Assume only 1/10 of the biomass can be transferred from one level to another.



5. The two pyramids ought to read from the bottom up: lettuce (10 kg), people (1 kg); and grass (10 kg), cattle (hamburger) 1 kg; people (1/10 kg).

NOTE: Students often insert hamburgers as a separate level, not realizing that they come from cattle. Also, the math seems to confuse some students, who multiply instead of dividing by 10.

6. 1/10 kg. Again, watch the math. The question asks how much biomass is available to the student, not how much is in the hamburger.

7. 10 kg.

8. Meats are usually higher priced.

5. On your worksheet, make up two food pyramids that you are in, based on a lettuce salad (one pyramid) and hamburgers from cattle (the second pyramid). Let each pyramid begin with 10 kg of producer.

6. If you start with equal amounts of producers in these pyramids (10 kg) and you keep only 1/10 of the energy going from each level to the next one above it, how much biomass is available to you from the hamburger?

7. To have a meal that provided 1 kg of lettuce biomass, you would have to eat 1 kg of producer (the lettuce). If you ate 1 kg of hamburger, how many kg of producer would you be eating indirectly?

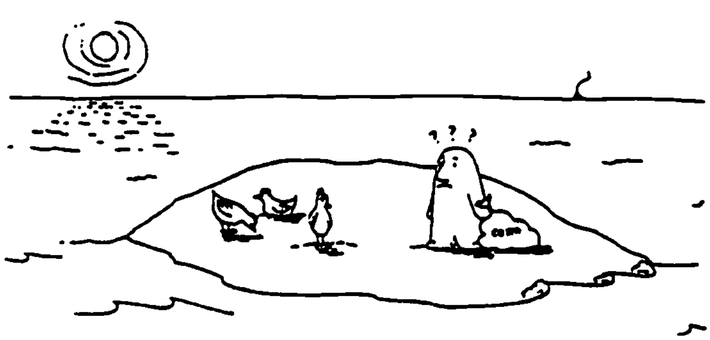
8. Which foods are usually more expensive, meat or plant products?

9. A biomass pyramid is also an energy pyramid. Based on your answers to questions 4 and 5, does it make more sense to get your energy from eating organisms on low levels of a pyramid or from eating those on higher levels?

10. Look back at the Walleye Game. If you had to recommend a kind of fish for someone to eat that caused the least amount of energy to be wasted, which would it be?

Gizzard shad are low on the Great Lakes food pyramid. Today shad are used for oil and animal protein meal, which is often fed to livestock. This wastes energy from two pyramids – the shad and the cow. If we used them directly, much less energy would be wasted in reaching the top of the pyramid. Some ways that shad could be prepared for use as human food might be as fish sticks, fish cakes, or a smoked product like herring or sardines.

The Great Lakes aren't the only place where food is wasted because we eat "high" on the pyramid. The oceans produce much food that people never use. We boil kelp to get gelatin for things like ice cream, but there are many more low level pyramid foods that we can eat.



REVIEW QUESTION

You are stuck on a desert island with nothing on it except for three chickens and a big sack of corn. What would you do in order to get the most food energy? Give reasons. (Remember, chickens are higher on the pyramid than corn.)

EXTENSION

In the activity you have noticed that energy is "lost" going from one level of a pyramid to another. From other classes you may have heard the phrase "energy is neither created nor destroyed." Where does the energy go in terms of the biomass pyramids you studied? Draw a diagram that illustrates your ideas.

Answers

9. Low levels, because very little energy has been "wasted" on life processes. (Lower levels are generally less expensive, too.)

10. Gizzard shad, as it is the lowest fish on the pyramid.

Notes

How do people decide what they are going to eat? Ask your students. Some possible ways include the availability of the food – strawberries in season, for example. Other people will choose foods because they look good, smell good, or they cost a lot and therefore must be good! On the other hand, foods may be avoided simply because the individual parts are not recognizable (as in a quiche or casserole), or because people have heard something about the food that indicated it was not good. Maybe the animal it came from is ugly or is one that people ordinarily don't eat.

One organism in this last category is the sheepshead, or freshwater drum. The name sheepshead, as much as any other factor, has probably prevented some people from using this fish as food. As the Walleye Game has indicated, the relative abundance of the organisms on lower pyramid levels makes them attractive as a source of human food. Commercial shore seiners in Sandusky Bay can collect 40 tons of drum in one haul, according to the Ohio Division of Wildlife. Most of the drum found in commercial nets are discarded as trash fish. Few people realize that proper preparation can produce a tasty fillet. Ohio Sea Grant has explored ways to develop markets and marketing methods for the drum and other underutilized species (including gizzard shad) as human food. Those who look to the oceans as the source of food for the future would do well to look to the lakes also!

Answer to Review Question

The students ought to answer that they would eat the chickens and then the corn, since feeding corn to the chickens would waste energy. Some answers to this question can become quite elaborate. Be flexible in accepting student ideas.

What is a food web?

A food pyramid is a very simple way of looking at a bigger picture called a food web. A food web is made up of all the different plants and animals that have an effect on one another by their feeding habits. A group of food pyramids meshed together make a food web.

Objectives

After completing this activity you will be able to:

- Describe how organisms are related to each other in a food web.
- Give examples of how factors that impact one part of a food web can also affect other parts of the environment.

Procedure

1. Figure 1 is a model of a food web that you might find in the Great Lakes. On it, draw arrows from the organisms that are being eaten to the ones that are eating. Remember that organisms on higher levels eat those on the lower levels. For instance, herons eat lake trout and sculpin, so you would draw arrows from the lake trout and the sculpin pointing to the heron. Since lake trout eat diving beetles, you would draw an arrow from the diving beetles to the lake trout. You may use your own judgment about who eats what. Sizes of the organisms and their positions in the food chain should provide clues. The food chain position given for each carnivore is the most common one for that organism. It doesn't mean that the animal can only eat organisms immediately below it. Some animals that are scavengers can eat organisms from all levels of the chain.

   There are many correct answers to this activity.

2. The Pete Seeger song entitled "The People Are Scratching" deals with the problem of removing organisms from the food web. Words and music are reprinted here. The song is on an album called *God Bless the Grass* (Columbia #CL 2432).

   Play or sing the song and answer the questions to reinforce the importance of each link in a food chain.

Source

OEAGLS EP-11, *To Harvest a Walleye,* Activity C, by Susan Leach, Gabriele Reil and Rosanne W. Fortner.

Earth Systems Understandings

The food web activity addresses ESU 1, artistic expression, and 4, the natural processes that make Earth unique.

Materials

- Figure 1.
- Song lyrics or taped song.

Teacher's Notes

Since most animals eat more than one thing, a network of lines like a spider's web will result. Since there are several species of most of the organisms shown, many different webs are possible.

Emphasize to the students that such a web is like a complex food pyramid. If one part is removed, the whole system will be out of balance.

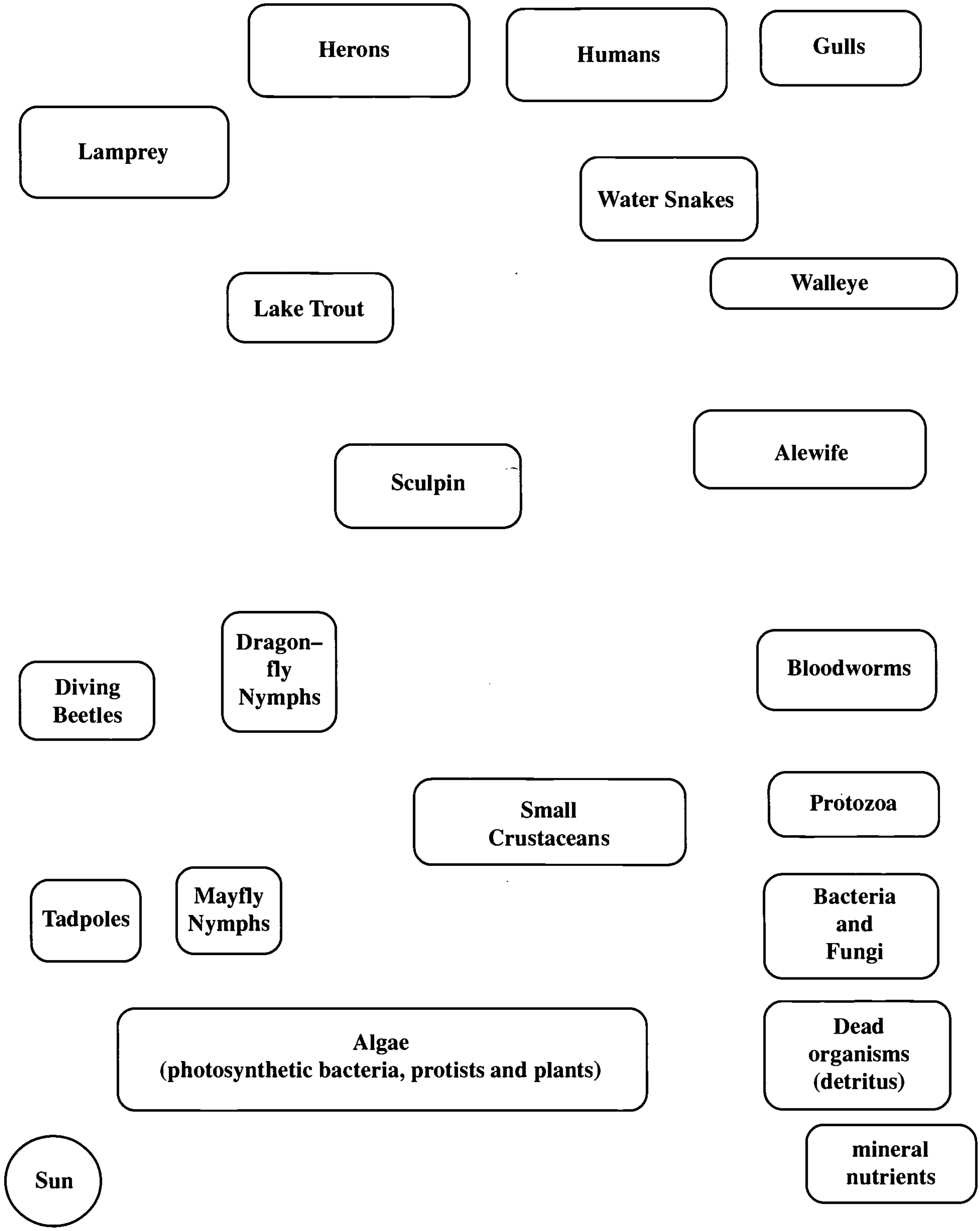


Figure 1. Organisms in a Great Lakes Food Web.
Source: Modified from NSTA Great Lakes JASON Curriculum

"The People are Scratching"

by Ernie Marrs, Harold Martin, and Pete Seeger

Come fill up your glasses, set yourself down
I'll tell you a story of somebody's town
It isn't too near and it's not far away,
It's not a place where I'd want to stay.

> The people are scratching all over the street
> Because the rabbits had nothing to eat.

The winter came in with a cold icy blast
It killed off the flowers and killed off the grass.
The rabbits were starving because of the freeze;
They started eating all the bark on the trees.

(Chorus)

The farmers said, "This sorta thing won't do;
Our trees will be dead when the rabbits get through.
We'll have to poison the rabbits it's clear
Or we'll have no crops to harvest next year.

(Chorus)

So they bought the poison and spread it around
And soon dead rabbits began to be found.
The dogs ate the rabbits and the farmers just said
"We'll poison those rabbits 'til the last dog is dead."

(Chorus)

Now up in the sky there were meat-eating fowl,
The dead rabbits poisoned the hawks and the owls.
Thousands of field mice the hawks used to chase
Started multiplying all over the place.

(Chorus)

The fields and meadows were barren and brown;
The mice got hungry and moved into town.
The city folks took the farmer's advice,
And all of them started to poison the mice.

(Chorus)

There were dead mice in all the apartments and flats.
The cats ate the mice and the mice killed the cats.
The smell was awful and I'm glad to say
I wasn't the man hired to haul 'em away.

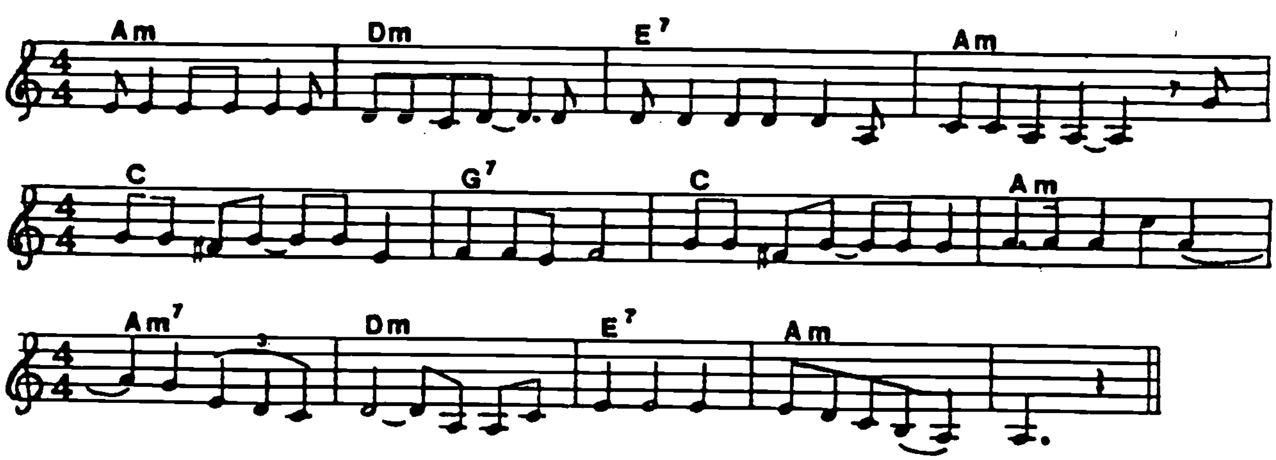
(Chorus)

Well, all through the country and all through the town,
There wasn't a dog or a cat to be found.
The fleas asked each other, "Now where can we stay?"
They've been on the people from then till this day.

(Chorus)

So all you small creatures that live in this land
Stay clear of the man with the poisonous hand.
A few bales of hay might keep you alive;
But he'll pay more to kill ya than to let you survive.

(Chorus)



3. Interpret the song by discussing these questions with your class.

   a. What is making the people scratch?

   b. What natural factor was responsible for starting all the problems described in this song?

   c. Diagram the food web that the song describes.

   On your diagram, put an X on the names of animals that the people poisoned on purpose.

   Circle all the other animals that died from eating the X animals.

   d. What is meant by the last line of the song?

Review Question

If the herbivores were taken out of a food web by a disaster, what would happen to the producers? the carnivores?

Extensions

- If people harvested all the carnivores in a food chain, what would happen? Is it a good idea to harvest all the carnivores?
- If a new organism came into the environment and held the same position in the food web as a native organism, consider all the possibilities of what might happen. Are all non-native species "bad" for the food web? Read about the impact of introduced plants and animals in your state's Sea Grant newsletter.

What factors affect the size of a natural population? (A Great Lakes fish example)

Each spring hundreds of thousands of yellow perch deposit their eggs over vegetation in the shallow waters of the Great Lakes shoreline. A female perch can lay jelly-like ribbons of up to 50,000 eggs at one time. At this rate, will the lakes soon have a population explosion of yellow perch? Why are so many eggs laid by each fish? How does nature control population size? Can people also affect fish populations?

OBJECTIVE

When you have completed this activity, you should be able to:

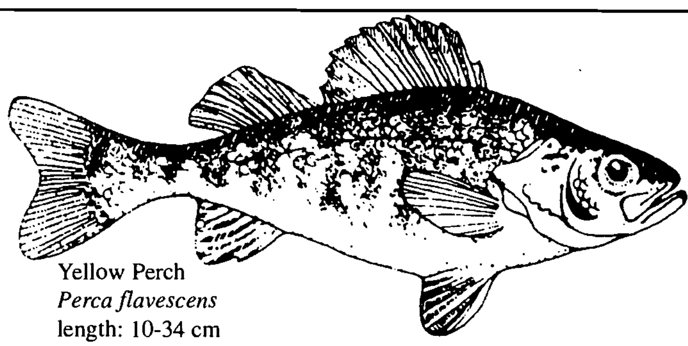
- Describe the life cycle of the yellow perch, a common Great Lakes fish.
- Analyze natural and human-caused factors that can affect Great Lakes fish populations at each stage of their life cycle.

PROCEDURE

Playing the Perch Game

In this activity you will follow yellow perch (fish) populations as they mature.

A. Object of the game: The first player to have one male and one female fish survive to spawn is the winner. Another more important object is to find out the things that can happen to perch populations. Be sure you read the information in the board spaces and on the game cards. If you read them out loud, all players can learn about what is happening to your perch.



Yellow Perch
Perca flavescens
length: 10-34 cm
weight: 112-568 g.
coloring: bright green to olive to golden brown on back; yellow-green, yellow on sides; grey to milk-white below
common names: perch, lake perch, American perch

Figure 1. Characteristics of Yellow Perch (Fish of Lake Michigan, University of Wisconsin, 1974).

Source

Modified from OEAGLS EP-9, "Yellow Perch in Lake Erie" by Rosanne W. Fortner, Gabriele Reil, and Susan Leach.

Earth Systems Understandings

The activity addresses ESU 2, 3, 4, and 5.

Materials

- Perch Life Cycle game board.
- Spinner.
- Place marker tokens (one per student).
- CHANCE cards.
- Record sheets.

(one set of game materials for every 3-4 students).

It will be necessary for you to construct the game materials using the pages following the activity. These pages can be cut out as they are, or they can be glued to cardboard sheets and then cut out.

Teacher's Notes

This investigation consists of a board game designed to introduce the stages of the perch life cycle and the forces affecting the perch population at each stage.

Twenty to thirty minutes are needed to play the board game the first time. Students may want to play again, and a second round can usually be finished during the same class period.

Teacher's Notes

The numbers used in the game reflect reality, but are obviously not exact. They were chosen to allow reasonably simple mathematics while indicating the relative impact of the various factors affecting the perch population.

The game chart may need some clarifying information that you can provide. For instance, some of the factors affecting perch may be considered either natural or human-caused. An algae bloom may occur naturally with seasonal changes, or it may be induced by phosphates being added to lake water. Diseases likewise may be caused by nature or by humans' effect on the water. The stocking of pike in the lake by people has the effect of reducing perch populations by the natural process of predation.

The sample summary sheet included with the game board glossary is intended to serve as your guide only, not as a list of "correct" answers. Students may, for example, wish to list predators separately (kingfishers, pike, etc.). Discussion of possibilities will contribute to student understanding of the concepts in the activity.

B. The game board: The shape of the board represents the shape of a yellow perch. At the tail is an area marked START. Other shaded areas stand for important events in a perch's life: hatching, "birthdays," and maturity. Some of the areas tell you how large or how old your fish are when you have passed that point on the board.

The events of the shaded areas happen to your population even if you don't land exactly on the areas. Simply passing such a space means that the event has happened.

C. How to begin: Two to four people can play. Choose a token to represent your perch population and place it on the START space of the game board. Each population begins with 50,000 eggs. Record this number on the record sheet for each player.

The person with the highest total on two spins of the spinner plays first. The one with the next highest total goes second, and so on. CHANCE on the spinner counts as zero.

D. How to play: When your turn comes, spin the spinner and move your token clockwise the number of spaces indicated. If the spinner points to CHANCE or if you land on a space marked CHANCE, draw a CHANCE card from the top of the deck and follow the instructions on it. If the card does not say "KEEP THIS CARD," place it back on the bottom of the deck before the next player's turn.

As you play, record the size of your perch population on your record sheet. In most cases, males and females are added together to get the population size, but some events affect only one sex of the fish. Unless you are told to do differently, assume that half of your fish are females and half are males (see "hatching" space).

NOTE: CHANCE cards refer to fish, not to eggs. If you spin a CHANCE before your eggs hatch, spin again.

E. Losing all your perch: If the space you are on or the CHANCE cards drawn cause you to lose more fish than you have on your record sheet, your population has been wiped out. Depending on where you are on the board, this can have two different effects:

1. If your eggs have not hatched when they are all wiped out, go back to START and begin all over again with 50,000 eggs.

2. After the eggs hatch, your population is expected to be on its own. If you lose all your fish, you are out of the game.

F. Winning the game: The first person to land exactly on the SPAWN square with at least one male and one female is the winner. If all players but one are wiped out, the remaining player is still not the winner until his or her fish make it to spawning. If no fish make it to spawning, your team may start the game over again.

G. When the game is over: Using the game board spaces and the CHANCE cards, complete the game chart in Figure 2 and answer the following questions.

INTERPRETING YOUR RESULTS

1. Why is it an advantage to the yellow perch to lay so many eggs?
2. In which part of the perch life cycle are the most animals lost? Why do you suppose this is true?
3. What destroys most of the perch that become mature?
4. Anglers and commercial fishers wish there were more fish to harvest. In what ways could the numbers of perch be increased?
5. Could factors like those that affect perch in the Great Lakes also affect fish in the ocean? Do you think that these factors have as big an effect on fish in the ocean? Explain your answer.

REFERENCES

Great Lakes Instructional Material for the Changing Earth System (GLIMCES) by Rosanne W. Fortner, Project Director, Heidi Miller and Amy Sheaffer, editors. 1995. Columbus: Ohio Sea Grant Education Program, The Ohio State University. Refer specifically to the chapter that investigates the potential effect of climate change on Great Lakes fish.

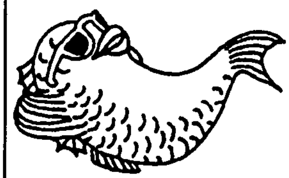
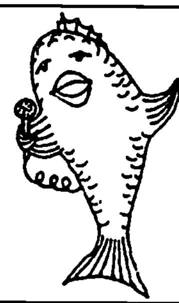
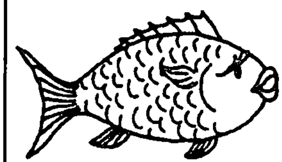
More information about yellow perch can be found on the Internet at http://www.seagrant.wisc.edu/communications/publications/FISH/yellowperch.html. Web addresses sometimes change. Do a search using the words "yellow perch" if necessary.

Answers to Interpretation

1. Laying many eggs is an adaptation for the perch's survival. There are many hazards to the developing perch, and beginning with large numbers helps to insure that at least two fish will survive to replace the parent fish.
2. Largest losses occur among eggs and fry. Be flexible in accepting other student answers. Students may attempt to add up all losses at each stage rather than responding intuitively with this answer.
3. Most mature perch are claimed by commercial and sport fishing.
4. Numbers of perch can be increased by stocking, protection of spawning habitat, and elimination of some obstacles to survival (pollution, fishing, etc.).
5. Yes, such factors also affect ocean fish. For some factors, such as pollution, the effects in the ocean may not be as great because of dilution in a greater volume of water. Algae blooms and other seasonal factors may also be less significant in the oceans.

PERCH POPULATION RECORD

Player's Name:

Token				
Size of Population				

Calculating Space

Figure 2. Factors Affecting Perch.

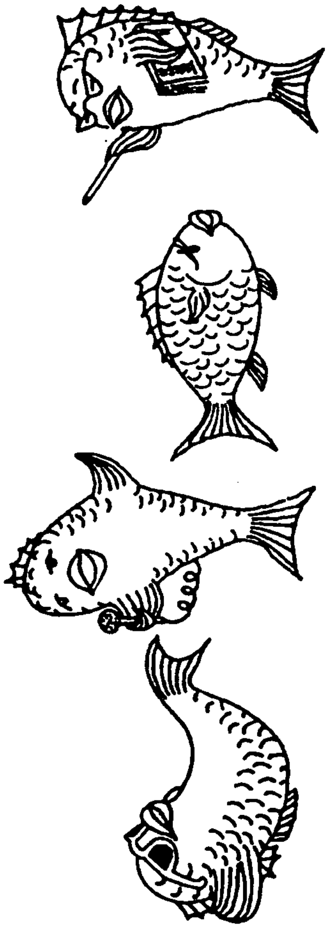
Stage of Life Cycle	**Natural Factors**	**Effect of Factors:** + for increased pop. - for decreased pop.	**Human Factors**	**Effect of Factors** + for increased pop. - for decreased pop.
Eggs (use no CHANCE cards)				
Young Perch (hatching to 2 years)				
2-3-year-old Perch				
Mature Perch				

Game Board Glossary

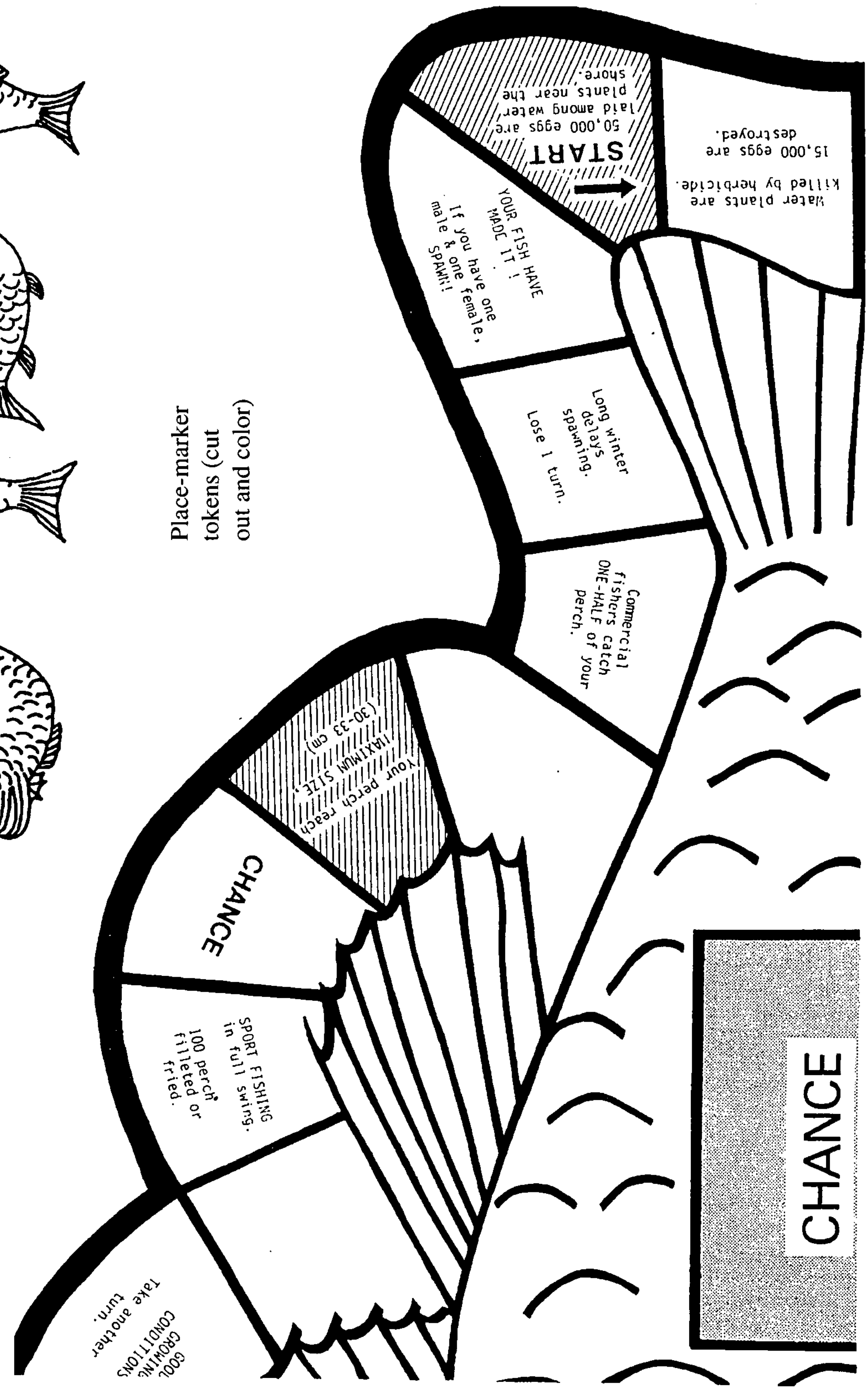
1. **dredge** – to dig out the bottom of a waterway in order to deepen the water.
2. **fertilization** – the uniting of male and female sex cells (sperm and eggs).
3. **fillet** – to cut off the strips of fish flesh along the fish's spine and ribs.
4. **fingerling** – a young fish, about the length of a finger.
5. **gillnet** – a net made of fine threads that entangle a fish's gills. It looks like a tennis net.
6. **herbicide** – a chemical that kills plants.
7. **heron** – a large bird that eats fish.
8. **kingfisher** – a bird that eats small fish.
9. **marina** – a place where boats are docked and serviced.
10. **mature** – able to reproduce.
11. **spawning** – the depositing of eggs by fish.

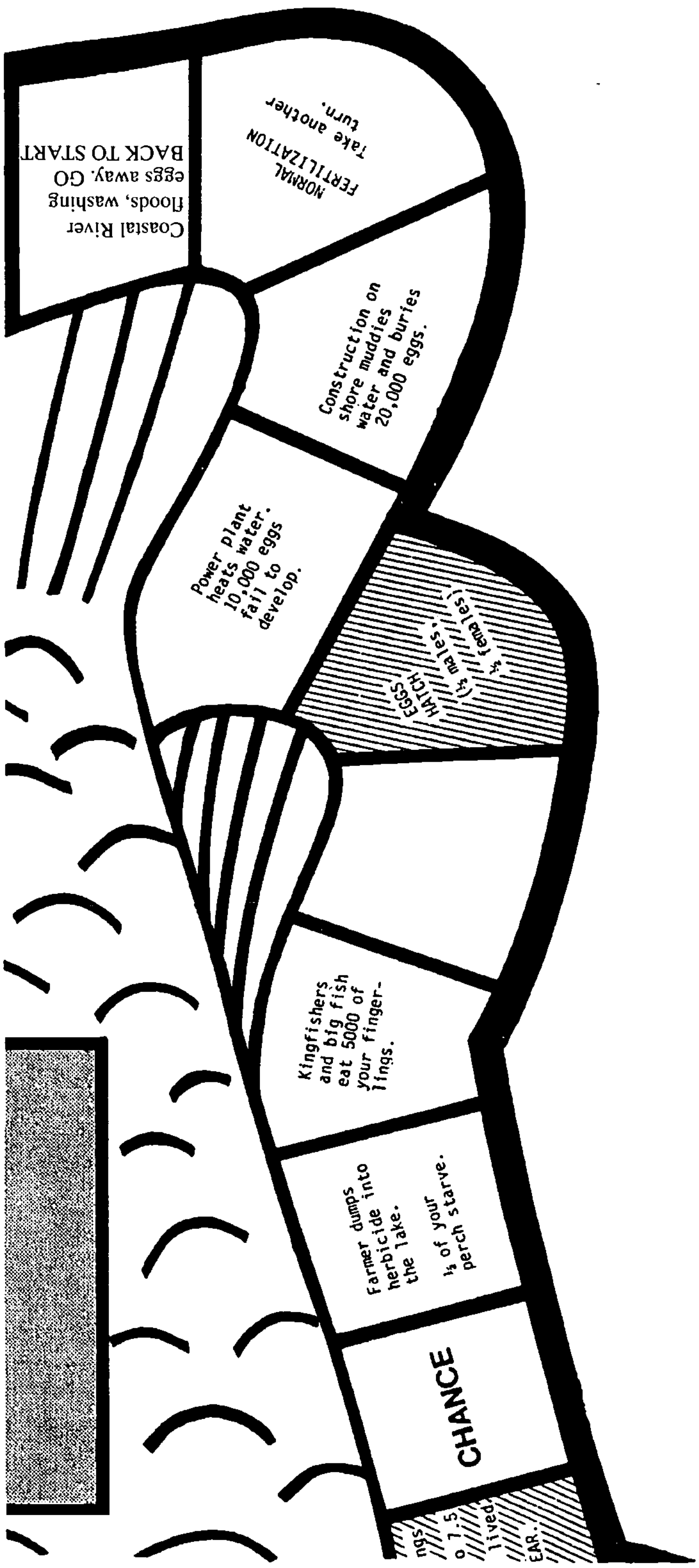
Figure 3. Factors Affecting Perch (Sample Summary Sheet for Teacher Use).

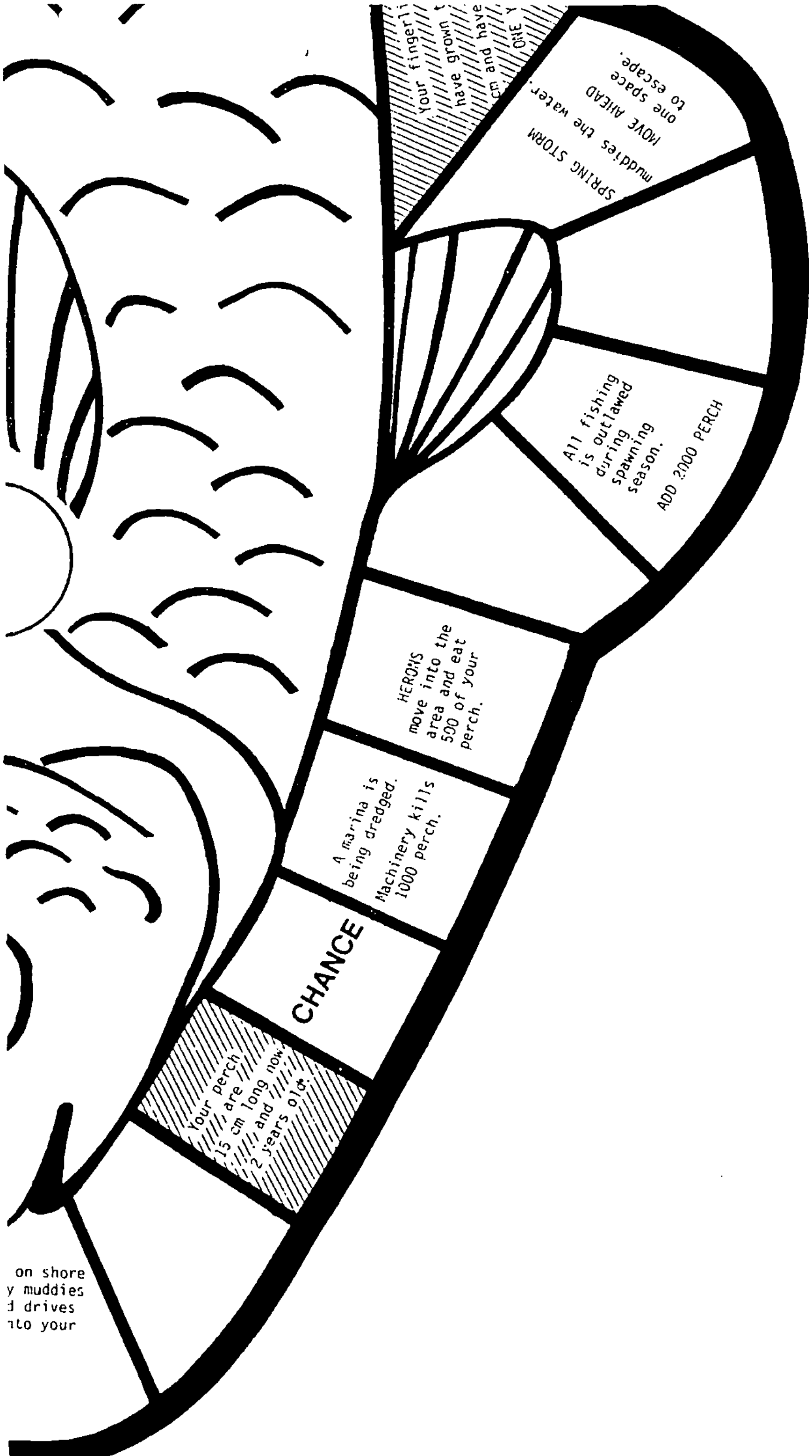
Stage of Life Cycle	Natural Factors	Effect of Factors + for increased pop. – for decreased pop.	Human Factors	Effect of Factors + for increased pop – for decreased pop.
Eggs (use no CHANCE cards)	*Flood	–	*Herbicide *Construction on shore *Power Plant	– – –
Young Perch (hatching to 2 years)	*Predators *Rainy spring season *Storms *Disease	– + – –	*Herbicide *Power plant *DOW stocking *Algae bloom *Oil spill *Sewage plant failure *Entrainment	– – + +/– – – –
2-3-Year-Old Perch	*Fungus *Disease *Predators	– – –	*Construction on shore *Gill nets *Algae bloom *Oil spill *Sewage plant failure *Impingement *DOW stocking	– – +/– – – – +
Mature Perch	*Disease	–	*New fishing lure *Marshes filled in *Chemical dump *Algae bloom *Oil spill *Sewage plant failure *Impingement *DOW stocking	– – – +/– – – – +



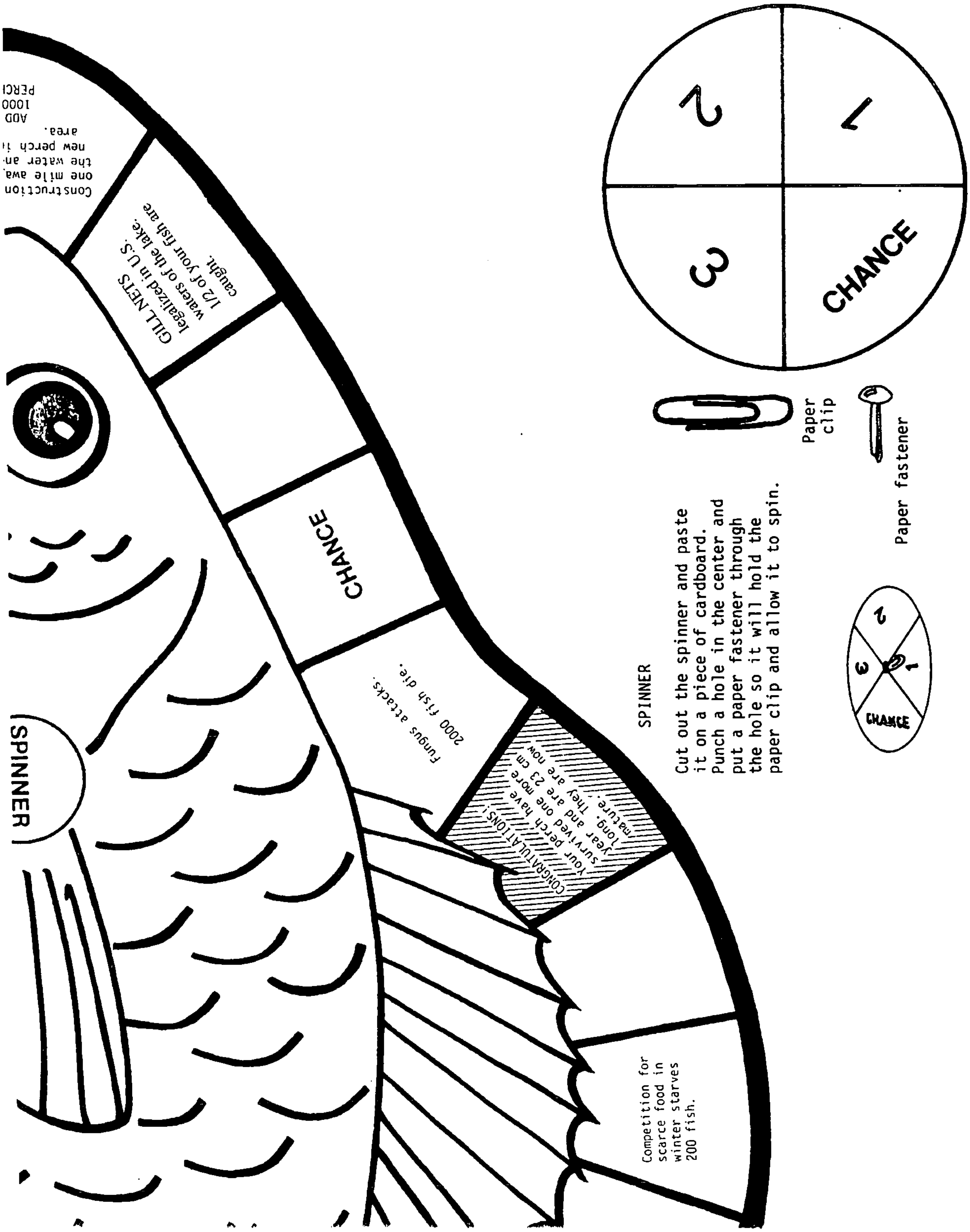
Place-marker tokens (cut out and color)




Coastal River floods, washing eggs away. GO BACK TO START
NORMAL FERTILIZATION Take another turn.
Construction on shore muddies water and buries 20,000 eggs.
Power plant heats water. 10,000 eggs fail to develop.
EGGS HATCH (½ males, ½ females)
Kingfishers and big fish eat 5000 of your finger-lings.
Farmer dumps herbicide into the lake. ½ of your perch starve.
CHANCE



BEST COPY AVAILABLE


Construction one mile awa[y] ... the water an... new perch i[n] area.
ADD 1000 PERC[H]
GILL NETS legalized in U.S. waters of the lake. 1/2 of your fish are caught.
CHANCE
Fungus attacks. 2000 fish die.
CONGRATULATIONS! Your perch have survived one more year and are 23 cm long. They are now mature.
Competition for scarce food in winter starves 200 fish.
SPINNER
1
2
3
CHANCE
Paper clip
Paper fastener
SPINNER
Cut out the spinner and paste it on a piece of cardboard. Punch a hole in the center and put a paper fastener through the hole so it will hold the paper clip and allow it to spin.

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Chance Cards (cut apart)

Division of Wildlife stocks 20,000 new perch in the lake. Add 5,000 of these to your population.	Perch-eating pike are stocked in the lake. Lose all but 1,000 of your perch if they are smaller than 23 cm.	Sport fishing banned this year because of low populations. Take another turn.
Excellent growing conditions this year. Take another turn.	Pesticides kill zooplankton and aquatic insects. Lose 1 turn while your fish move to new feeding areas.	Algae bloom results in a temporary abundance of food. (Perch eat zooplankton which eat the algae.) Take another turn.
Wastes from a chemical industry stunt the growth of your population. Lose 1 turn.	A rainy spring season raises the lake level, and flooded shores create new spawning grounds. Each perch population under 15 cm gains 2,000 fish.	The legislature establishes a perch fishing season (5 months) instead of allowing year-round sport fishing. KEEP THIS CARD; it will cancel your next loss of perch.
Heavy storms affect perch population. Wave action and habitat destruction kill 500 fish less than 15 cm long. If your fish are larger they survive.	Anglers develop a new, more effective lure. If your fish are more than 23 cm long, 500 are caught.	Shoreline marshes filled in for new homesites. Half of your population will not find suitable spawning grounds. If your fish are under 3 years old, this card has no effect.

Chance Cards (cut apart)

Commercial fisheries can now use a new sonar to find schools of fish. Lose 750 of your perch population if they are over 15 cm long.	A parasite infects your population. Males are only weakened but most females become sterile. Only 100 of your female perch are now able to spawn.	Algae blooms cut down on available oxygen by respiration and decomposition. 1,000 fish die in <u>all</u> populations.
Sewage plant fails. Wastes in the water use up oxygen, killing half of your perch population.	An oil tanker breaks up in a storm and all but 500 of your fish die from effects of the oil spill.	Disease weakens your perch population. All but 1,000 die.
A power plant pulls lake water in to cool its machines. If your perch are less than a year old, 5,000 are sucked up. 1,000 perch over 1 year old are trapped at the intake pipes and suffocated.	SAVE THIS CARD!!! The Division of Wildlife doubles its number of patrol boats to enforce fishing rules. Your next loss of <u>mature</u> fish is cancelled.	

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How can a natural fish population be managed?

This activity should follow the perch game (fish population). Now that you have learned of the many things that can happen to a natural population, using yellow perch as an example, you know why it is sometimes necessary to make rules to protect them. The organization responsible for making and enforcing those rules is called different things in different states and provinces (see the list at the end of the activity). For this activity we will call it the Division of Wildlife.

OBJECTIVE

In the role play you will evaluate some methods used to manage a Great Lakes fish population.

PROCEDURE

Many people and organizations are affected by a fishery management policy. The interested groups all want the policy to benefit them. Your teacher will assign you to represent one of these interest groups:

Division of Wildlife (DOW)
Commercial Fishers Co-Op
Sport Fishers
Shoreline Engineers for Development (SED)
Save the Perch
Consolidated Power Company

The events and conditions in the roles are based on those in Lake Erie. Groups are fictitious but represent genuine interests.

Source

Modified from OEAGLS EP-9, "Yellow Perch in Lake Erie" by Rosanne Fortner, Gabriele Reil, and Susan Leach.

Earth Systems Understandings

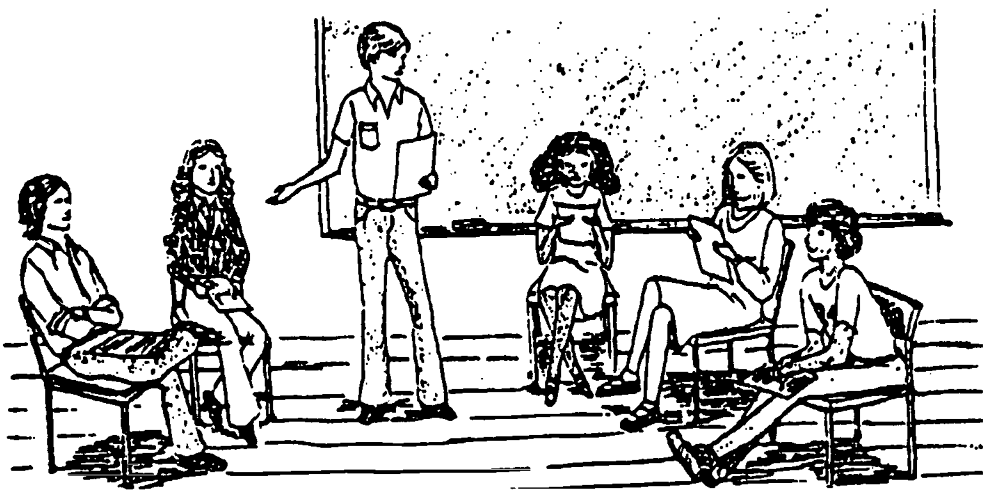
The role play applies to ESU 2, 3, 4, and 7.

Materials

- Role descriptions included with the activity.

Teacher's Notes

Using information gained in the activity, "What factors affect the size of a natural population?", students participate in a role-playing situation. Various interest groups provide input on the development of a perch management policy for the Great Lakes.



Additional Notes

Students work in groups of 6, with each student having a different role. "Extra" students should be assigned the Division of Wildlife role and placed as the 7th member of other teams.

Each student should get a copy of one of the six role descriptions. This activity requires students to think about their roles for a time before the actual simulation begins. Distribute role descriptions early so that plans can be prepared overnight. The simulation itself can be completed in one class period, with time allowed for discussion. It is best to keep your own participation in this activity to a minimum, unless students have difficulty interpreting the demands of their roles. Arrange the classroom to facilitate discussions within the groups of 6 or 7 students.

The Division of Wildlife (DOW) is considering the following proposals for managing the perch in the Great Lake nearest your area:

1. Increase the survival rate at the egg stage by:

   A. Recommending a ban on construction along the lake shore within 1/2 mile of the lake, thus preserving existing spawning grounds.

   B. Recommending that industries that use water for cooling must limit the temperature increase in that water to 0.5°C, since spawning and hatching depend on water temperature.

   C. Preventing dredged materials from being dumped back into the lake where they would cloud the water and possibly spread dangerous pollutants.

2. Increase the annual harvest by:

   A. Delaying the start of the commercial fishing season until June 1, when spawning will be over.

   B. Allowing commercial fishers to use gill nets from October 1 to December 10 to catch perch 20 cm or longer. Gill nets are now in use in other parts of the lake. They result in a larger catch than the trap nets and seines now used in your region.

   C. Banning commercial fishing within 2 miles of the shoreline, so sport fishers (anglers) will be able to catch more.

Study your role description and be prepared to try to convince others that what your group wants would really be the best for everybody. Your activity schedule will be:

1. Meet with representatives of the other interest groups. The DOW representative will be able to explain what the agency proposes to do to manage the perch populations.

2. Explain why your interest group is for or against the proposals and present a policy that you wish the DOW to enforce.

3. Within your group of representatives, reach a decision about the best proposal or write a new one. Give this to the DOW person as your group's recommendation.

4. All DOW representatives meet and choose the best perch management policy. While they are meeting, all the interest group representatives write letters to the people they represent, telling how they have worked for the group's cause and what results have been so far.

5. The DOW announces what its new perch management policy will be. DOW representatives answer any questions from the interest groups. Record the DOW decision on your worksheet.

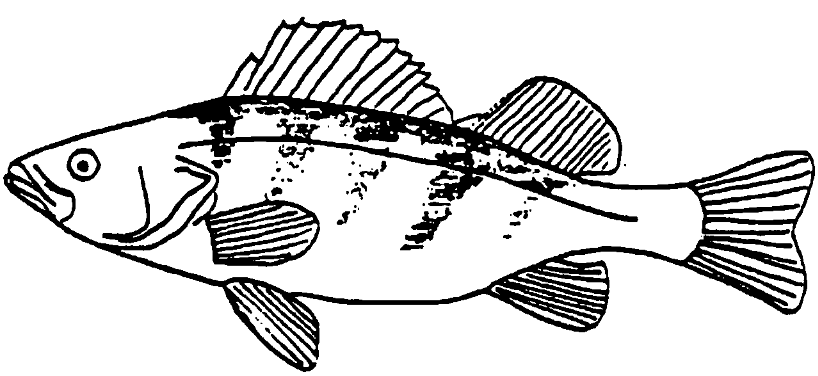
6. Was this decision fair to all parties concerned? If not, what interest groups would suffer because of the new policy? Explain on your worksheet.

7. Will the new policy produce the optimum sustainable yield of perch in the lake? Explain.

Teacher's Note

One or two students should be familiar with all the roles so they can act as observers to the debate process and offer comments as appropriate.

Eight states, two provinces, two countries and the First Nation tribes border the Great Lakes/St. Lawrence system. All these governments try to manage fisheries in the best interests of their people. Regulation of fisheries in the ocean involves the same difficulties as in the Great Lakes. Such factors as territorial waters claimed by coastal nations, rights to migratory fish, subsistence fishing, protection of endangered species, and ways to enforce fishing laws must all be considered. Your class may wish to find out what happened to world fisheries when countries declared their own 200-mile territorial seas.



Roles for group members

Pat Trapper – DOW

As a biologist and representative of the Division of Wildlife, it will be your responsibility to inform the public about what is being done and what needs to be done to manage the perch fishery in the lake. The term **fishery** refers to the industry or occupation of catching, processing and selling fish. As far back as the 1860s, the perch fishery was very active.

Sport and commercial fishers alike value the perch for its delicious, flaky white flesh. As the fishery manager, your goal is to work toward an "optimum sustainable yield" of perch. **Yield** refers to the number of fish caught (harvested). **Optimum** means the most or the biggest possible, with all factors considered. An optimum yield of perch is the best number to catch each year without interfering with the normal workings of the population or with other populations in the lake. If this best number can be repeated in the harvest over the coming years, it is said to be a **sustainable** yield. The goal for the Great Lakes, then, is to develop regulations that will allow the optimum number and weight of perch to be harvested each year.

Your proposals are to:

1. Increase the survival rate at the egg stage by:
   - A. Recommending a ban on construction along the lake shore within 1/2 mile of the lake, thus preserving existing spawning grounds.
   - B. Recommending that industries that use water for cooling must limit the temperature increase in that water to 0.5°C, since spawning and hatching depend on water temperature.
   - C. Preventing dredged materials from being dumped back into the lake, where they would cloud the water and possibly spread dangerous pollutants.
2. Increase the annual harvest by:
   - A. Delaying the start of the commercial fishing season until June 1, when spawning will be over.
   - B. Allowing commercial fishers to use gill nets from October 1 to December 10 to catch perch 20 cm or longer. Gill nets are now in use in other parts of the lakes. They result in a larger catch than the trap nets and seines now used in your region.
   - C. Banning commercial fishing within two miles of the shoreline, so sport fishers (anglers) will be able to catch more.

These two proposals are not the only possible answers to the perch decline problem, of course. They certainly will not satisfy all the people that will be affected. It will be your job to explain why both proposals are good ones. Other groups may wish to prepare a third proposal for the DOW to consider. If you favor one proposal or another, hold your opinion until others have presented theirs. As the most knowledgeable member of the group where perch are concerned, your opinion should be well thought out, for your judgment is highly respected.

When your group has agreed on a management plan, it will be your job to meet with other DOW representatives and arrive at a decision that will satisfy as many of the public's demands as possible. Report your decision in a public hearing and predict how your management plan will provide an optimum sustained yield of perch.

More information about yellow perch can be found on the Internet at http://www.seagrant.wisc.edu/communications/publications/FISH/yellowperch.html. Web addresses sometimes change. Do a search using the words "yellow perch" if necessary.

Dr. J. E. Gillman – STP (Save the Perch)

You are a professor of **ecology** (the study of relationships in the environment) and **ichthyology** (the study of fish) at Clearwater University. As head of your department, you have watched the Great Lakes environment change over the years. You want to keep perch as a game fish and as an important link in the ecosystem that makes up the lake. In order to keep the perch population going in the lake, you want the Division of Wildlife to protect the marshes along the lake shore.

This will serve:

1. To preserve the perch breeding grounds and
2. To provide habitat for the waterfowl and other birds that are a vital part of the area.

You want the people to understand that what affects one area of the lake will affect all areas. The areas you want to protect serve many functions, such as preservation of fish and wildlife, barriers to wind and wave erosion of the shore, natural water purifiers, natural flood control, and traps for the sediments carried into the lake by streams.

Beyond all this, you want to get the population of perch higher than it is now in order to restore the natural balance of the lake. This would require a 2-year ban on perch fishing, followed by stronger fishing regulations in later years. You also want sport fishing to be regulated by season as well as by limits, so people can only catch a certain number of perch.

You want perch fishing to be done only with particular kinds of lures, such as spinners, and you would also like to set a size limit, such as 20 cm (8 inches) or longer, for "keeper" fish.

A power plant that has just begun operation on the lake is threatening the perch in another way. The plant pulls water from the lake to cool its machinery. Screens cover the openings of the intake pipes, but baby perch can be sucked through the screens and into the pumps where they are "entrained" and killed. A single large power plant or other industry on the lake can entrain nearly 3,000,000 baby perch in one year.

In addition to protecting spawning grounds and regulating fisheries, then, some drastic measures are needed to prevent further loss of perch to industries and power plants using lake water. Think about what could be done and try to present your ideas as a compromise proposal.

For information from other environmental groups, consult the "Amazing Environmental Organization Web Directory" using the url address http://www.webdirectory.com/. Explore the search tool with "freshwater fish" and related topics and issues.

QUESTIONS TO CONSIDER FOR THE ECOLOGIST'S ROLE

1. Which of the Division of Wildlife proposals do you favor?
2. What are you willing to give up in order to have as many of your ideas as possible accepted?

"Ace" Angler – Sport Fisher

Ever since you were no more than a fingerling yourself, you've been fishing in the lake. Your dad has told you what it was like to catch enough blue pike in an hour to last for 2 weeks. Your grandfather can remember catching a muskie or two. Now most sport fishers go after walleye, which is a good fighting fish. You caught a walleye once, but for a good big catch you prefer perch. Before there was a limit, you once caught 100 perch in 3 hours!

When you've caught a good sized perch (20 cm or longer) you have a nutritious meal. Besides its excellent flavor, perch has more protein and less fat than beef, pork, or poultry.

Since you are a business person by profession, you have little free time to devote to fishing. You appreciate the fact that you are not limited to a certain season for catching perch. Ice fishing around the islands is particularly enjoyable, but there are many good fishing areas all year round.

Canadian commercial fishers are now getting almost all the perch caught in the Great Lakes. The U.S. catch is almost totally caught by sport fishers. As a sport fisher you would like to protect this advantage. These facts may help you.

A. A resident sport fishing license costs $15.00 a year or for a 3-day, out-of-state, visitor's license (Ohio, 1996). Anglers are providing the state with a lot of money, and in return you have a right to get something for it (more fish). As an example of the amount of sport fishing that occurs, in 1991 the lake (Erie) supported 7,082,000 angler days. The Great Lakes states have many anglers who contribute to the economy of the region. Total angler expenditures for the state in the same year were $861,554,000. (Total angler expenditures in 1991 were as follows: Michigan, $1,286,368,000; Illinois, $1,111,262,000; New York, $867,242,000.) You want to remind the DOW of the economic benefits of fishing activities.

B. You have found that fishing near a power plant is great because the warm water has lots of food in it to attract fish.

C. Commercial licenses provide only about $25,000 a year in state revenues, and you really don't think that entitles them to as many fish as sportspeople take. Even though the state's dockside value in dollars of the commercial harvest of yellow perch was $1,118,228 in 1995, you think that sport fishing should receive more consideration since sport fishers support the economy through tourism and other ways.

D. In 1991 Canadian commercial fishers harvested 2,300 tons of all types of fish combined on the lake (Erie) which amounted to 59 million Canadian dollars and approximately two-thirds of the total Great Lakes catch. You would like the U.S. to convince the Canadian government to cut the commercial perch harvest. That way, there will be more perch for U.S. sport fishers. Canadian fisheries information is found at Canada's Department of Fisheries and Oceans Web site – http://www.ncr.dfo.ca/home_e.htm/. See also the Canada Centre for Inland Waters, Bayfield Institute Web site – http://csx.cciw.ca/dfo/dfo-home.html; research includes fisheries and habitat management, a Great Lakes laboratory, hydrographic services, small craft harbor, and ships support. (Source: Government of Canada).

QUESTIONS TO CONSIDER FOR THE SPORT FISHER'S ROLE

1. Which of the Division of Wildlife proposals do you favor?
2. What are you willing to give up in order to have as many of your ideas as possible accepted?

Sandy Shores – Shoreline Engineers for Development (SED)

You represent an agency committed to developing the Lake shoreline for the benefit of the state. Each year millions of tourists travel through the Great Lakes area. More lakeside motels, amusement parks, and scenic highways would capture more tourist dollars for the state. Private individuals are also looking for lake shore property for vacation homes. More people would come if they had places to live. There are dozens of contracting companies just waiting for SED to give them the go-ahead signal so they can begin a massive construction effort and make the shore a real showplace.

There are some problems, however. First, such development would require massive earth-moving efforts. There must be dredging for marinas, scraping for roads and parking lots, and piling for landscape purposes. Some of your contractors have not used proper erosion control methods in the past, and they have been responsible for some bad erosion problems. You must try to overcome their bad reputation by promising strict rules for erosion control. If such heavy erosion occurred on the lakeshore, the lake would be muddy, and nobody would want to visit there.

The law requires that Lake ports be dredged each year to maintain a depth of 28 feet so freighters can dock. This is one of SED's responsibilities. Ordinarily, dredged materials are dumped in diked areas in the lake, where they eventually form new islands. Fishing is great around islands, so the sport fishers should be attracted to these areas. The DOW, however, is proposing that dredged materials be dumped inland. To see how the Army Corps of Engineers handles dredging issues, find information about the Waterways Experiment Station Hydraulics Laboratory which does dredging research (http://hlnet.wes.army.mil/research.htm). See if you can also find two USACE dredging projects and photographs online for your presentation to DOW.

Finally, the DOW wants to ban construction within 1/2 mile of the lakeshore. This would spell disaster for SED's plans. People come to see the lake and to play around it. If they have to hike such a distance from their motels, they probably won't even bother to come. What kind of scenic view can you get from that far away? You think it would be a terrible mistake to let this measure pass. The state would lose millions of dollars in tourist trade and property taxes without shore development.

QUESTIONS TO CONSIDER FOR THE SHORELINE ENGINEERS FOR DEVELOPMENT ROLE

1. What changes in the proposal will you recommend?
2. What are you willing to give up to get most of your ideas accepted?

Terry Watts – Consolidated Power Company

You are the plant manager of the Water Hole Power Station on the Lake. Water Hole is a 20-year-old fossil fueled (coal fired) power plant. It has a once-through cooling system, meaning that it draws in water from the lake, uses this water to cool its steam condensers, and then discharges the water directly back to the lake. This also means that Water Hole does not have a cooling tower. It uses over 500,000 gallons of water per minute (gpm), which it discharges 15°C warmer than it was when it entered the plant.

You have an **impingement** problem at Water Hole. During the winter, large numbers of gizzard shad enter the intake canal and are trapped against screens which are place in the canal to remove large fish and debris. These would damage the internal workings of the plant if they were allowed to go through it. Last year so many fish piled up on the screens that no water could pass and you were forced to shut down Water Hole. Damages amounting to $100,000 resulted when the screens were smashed by the pressure of the fish and water. You would like DOW to suggest an inexpensive method to solve this problem.

DOW has found that you also have an entrainment problem at Water Hole. Entrainment occurs when hot water in the plant kills fish eggs and larvae (**fry**) which are carried along (**entrained**) in the intake current. DOW estimates that during a single spawning season Water Hole kills 3,000,000 fry.

If DOW requires you to reduce the temperature of your discharge to 0.5°C above the intake temperature it will be necessary to install a cooling tower. This tower would reduce your entrainment and impingement problems by 95% since your intake volume would be reduced from 500,000 gpm to 20,000 gpm. However, this tower would cost between $20 and $35 million and would reduce your net power output from 600 megawatts to 550 megawatts. All these costs would be passed on to consumers, raising the average electric bill by 25%. You feel this is unacceptable and unfair, especially to the many consumers in your area who are not fishers and who do not eat perch or use the lake for recreation.

DOW Proposal 1 makes power production more expensive. You would favor some proposal that would cut your costs, not raise them. For more information, consult the Great Lakes Information Network about industries in the region. The address is http://www.great-lakes.net/ and one association for utility companies is the Council of Great Lakes Industries involving interests in the U.S. and Canada. Investigate the Environmental Stewardship Reports of the Council (http://gopher.great-lakes.net:2200/1/partners/CGLI/pub/steward).

QUESTIONS TO BE CONSIDERED FOR CONSOLIDATED POWER ROLE

1. Which proposition do you favor?
2. What are you willing to give up (compromise) in order to get what you want?

Captain Fisher – Representative of Fishing Fleet and Buyers Co-op (Commercial Fisher)

Your father fished in the same boat you do, and you took over his business when he got older and retired. When your father left you the boat and nets, he told you to always stand behind the co-op and help other fishers as much as possible. You know that as an international resource, fishing has limits. You are concerned about the availability of fish for those in the Co-op.

You want the Division of Wildlife to permit you to use **gill nets** and seek agreements between the U.S. and Canada regarding fishing resources. Since you know the best selling fish are the bigger ones, you are willing to settle for a kind of gill net that will let other perch through and will only catch those over 20 cm (8 inches) long. You also want a longer season so you can catch more fish. Because all this will lower the number of fish in the lake, you want the Division of Wildlife to stock more perch in the lake. If all goes according to plan, the price of perch will go up. Last year you made only $16,000 from fishing. You need this money to buy new nets and to overhaul your boat. If you do get all of these things done, then you can catch perch for the new fast food Perchburger.

You need to know this information:

1. The fish processors in your organization are pushing for much greater use of Lake fish. To bring more fish from Maine or Florida is very expensive, and lake fish have the same flavor and nutritional value as the "imported" types.

2. The state's dockside value in dollars of the commercial harvest of yellow perch alone was $1,118,228 in 1995. When including additional species such as white bass and others, the total value was $1,943,152. This is very good for the state's economy. Your competition for fish includes sport fishers, however. A national survey calculated that in 1991 anglers spent about $497 million in the state on trip-related expenses alone not to mention equipment costs (Other states spent more: for example Illinois and Michigan had amounts of over $573 and $500 million respectively.) As an example of the amount of sport fishing that occurs, in 1991 there were 7,082,000 angler days on the lake (Erie) as a whole. Perch fishing means a lot of money for local areas.

3. Canada supports its commercial fishery and therefore the Canadians are very successful with perch fishing. The DOW should support U.S. fisheries so we can receive the same benefits.

4. Fish caught locally will cost consumers less than fish from the ocean. People would eat more fish and be healthier if fish didn't cost so much.

Consult the COMCAT Internet site for more information: http://www.nbs.gov/irm/CaisCOMCAT.html

COMCAT contains commercial fish catch data for the Great Lakes from 1971 to the present time. Data include species caught, location, month of take, total catch in pounds, and dollar value. Data are used for economic forecasts, evaluation of fish populations, and stocking calculations.

QUESTIONS TO ANSWER FOR THE COMMERCIAL FISHER ROLE

1. Which position do you favor?
2. What are you willing to use to bargain in order to get the things you want?

References and Other Resources

Department of Natural Resources Division of Wildlife in your own area – see fishing publications. Examples:

Illinois DNR, Office of Resource Conservation, Division of Fisheries;
Indiana DNR, Division of Fish and Wildlife;
Michigan DNR, Fisheries Division;
Ontario Ministry of Natural Resources, Policy and Planning Division, Resource Stewardship and Development Branch – http://govonca3.gov.on.ca/MBS/english/programs/MNR1369.html

Hushak, Leroy J., George W. Morse and Kofi K. Apraku. 1986. "Regional impacts of fishery allocation to sport and commercial interests: A case study of Ohio's portion of Lake Erie." *N. Am. J. Fisheries Management* 6:472-480. Also available from Ohio Sea Grant.

Hushak, Leroy J., Jane M. Winslow and Nilima Dutta. 1988. "Economic value of Great Lakes sportfishing: The case of private-boat fishing in Ohio's Lake Erie." *Trans. of the Am. Fisheries Soc.* 117:363-373. Also available from Ohio Sea Grant.

National Survey of Fishing, Hunting and Wildlife-Associated Recreation. State Overview. Issued December 1992. U.S. Department of the Interior, U.S. Fish and Wildlife Service.

White, Andrew M. 1993. "History of Changes in the Lake Erie Fishery." In *The Great Lake Erie*. Edited by Rosanne W. Fortner and Victor J. Mayer, Columbus: Ohio Sea Grant College Program, The Ohio State University.

See Internet sites related to yellow perch *Perca flavescens*. One example is http://h2o.seagrant.wisc.edu/communications/publications/FISH/yellowperch.html.

What is the ecological role of an estuary?

To most people, an **estuary** (es-chew-airy) is a place where fresh water meets the sea. In its broader meaning, an estuary is that part of the mouth of a stream in which the water level is influenced by the lake or sea into which the stream flows. The Great Lakes have some estuaries. Old Woman Creek on Lake Erie has an estuary that has been set aside by the state and federal governments as a "state nature preserve" and "national estuarine research reserve." Why should the government bother to preserve an estuary such as Old Woman Creek? There are many reasons:

1. The estuaries of the world serve as breeding grounds for many important animals that live in deeper waters.
2. An estuary has a wide variety of habitats available for wildlife to use as nesting and feeding sites. Thus, estuaries harbor a lot of biodiversity.
3. The sediments and waters of an estuary are places where nutrients are recycled and where the basic things needed for life are made available to a wide variety of organisms.
4. Estuaries serve as buffer zones to filter pollutants. Runoff from the land is cleansed before it enters a lake or ocean, and the effects of flooding and water level changes are lessened.
5. Estuaries are "endangered ecosystems." Because of their quiet waters and nearness to lakes or oceans, estuaries are often attractive places for marinas, home sites, and tourist developments. Few estuaries still exist in their natural conditions.

In this investigation, you will examine some of the characteristics of the estuary at Old Woman Creek, near Huron, Ohio. The things you will learn about this estuary will show you the importance of estuaries worldwide.

An estuary contains some areas that are almost always under water, some areas that are almost always dry land, and some areas between these two extremes. Each of these environments has a set of plants that can survive best under the given conditions. Each set of plants has a special role to play in the estuary and contributes to diversity of both plants and animals at Old Woman Creek.

OBJECTIVES

When you have completed this investigation, you will be able to:

- Describe the methods used by ecologists to sample populations of plant and animal life in aquatic ecosystems.
- Give a general description of the living communities that are found in different depths of water in an estuary.
- Give examples of how plant communities are important to animal life in an estuary.

Source

Modified from OEAGLS EP-016A, "The Estuary: A Special Place," by Rosanne W. Fortner and Ron Mischler.

Earth Systems Understandings

The activity addresses ESU 2, stewardship, 3, science methods and technology, and 4, interactions.

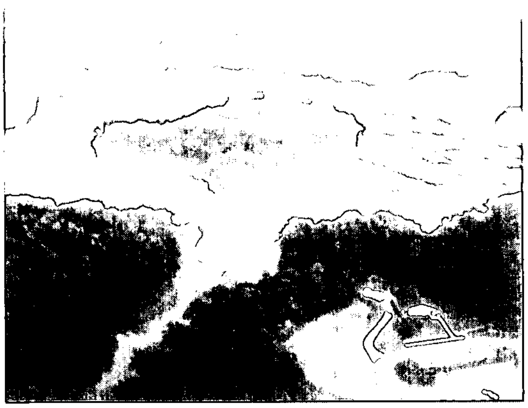
Materials

- Colored pencils.
- Ruler.

Procedure

Figure 1 is an aerial photograph of the Old Woman Creek estuary, east of Huron, Ohio, on the shoreline of Lake Erie. Figure 2 shows the land use and plant types (called "vegetation") in the same area. Each symbol drawn by the computer stands for the main characteristic of an area equal to about 1/4 of an acre. One-quarter of an acre is equal to about 930 square meters. That's a bit bigger than an average school classroom.

Figure 1. Aerial photograph of Old Woman Creek Estuary.



1. With your pencil, outline the main parts of the Old Woman Creek Estuary on the computer map.

   A. Begin by outlining the beach areas (marked by "K"). One beach that runs along the shore at Oberlin Beach has been outlined as an example. West of Oberlin Beach lies the mouth of Old Woman Creek, and another beach begins just west of that.

NOTE: The mouth of the creek (where it joins the lake) is drawn in one place near the word "Old," but there is really a sand spit there that shifts back and forth over time. Figure 1, taken in 1976, shows another possible position of the spit.

   B. The estuary itself is surrounded almost entirely by deciduous forest (marked by ♠). Look on either side of the creek and find the border of the forest. Draw a line that separates the forest from the estuary. You will also find a patch of forest just below the "B" in "BERLIN." Outline this forest with another line.

   C. What three types of features (see symbols) are now shown to lie within the estuary itself? Remember, the estuary is surrounded by deciduous forest, but the deciduous forest is not a part of the estuary proper.

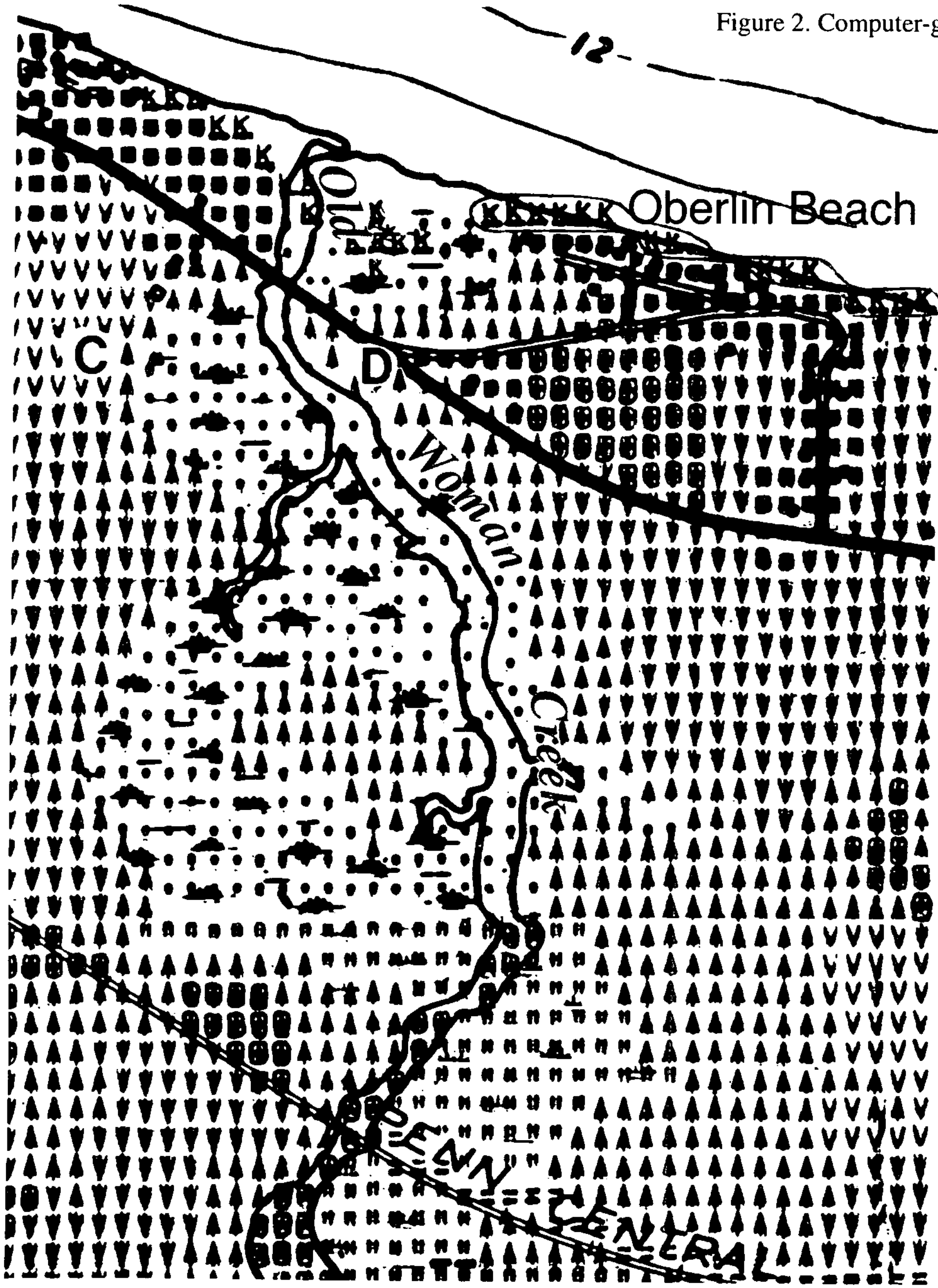
   D. Use colored pencils to shade in the following features:

   Green: Forest on border of estuary and on the island.
   Blue: The open water of the lake and the main stream channel.
   Brown: The marshy and non-forested wetland areas of the estuary.
   Yellow: The beach.
   Red: Residential areas.

Answer

C. Marsh, open water, and deciduous forest.

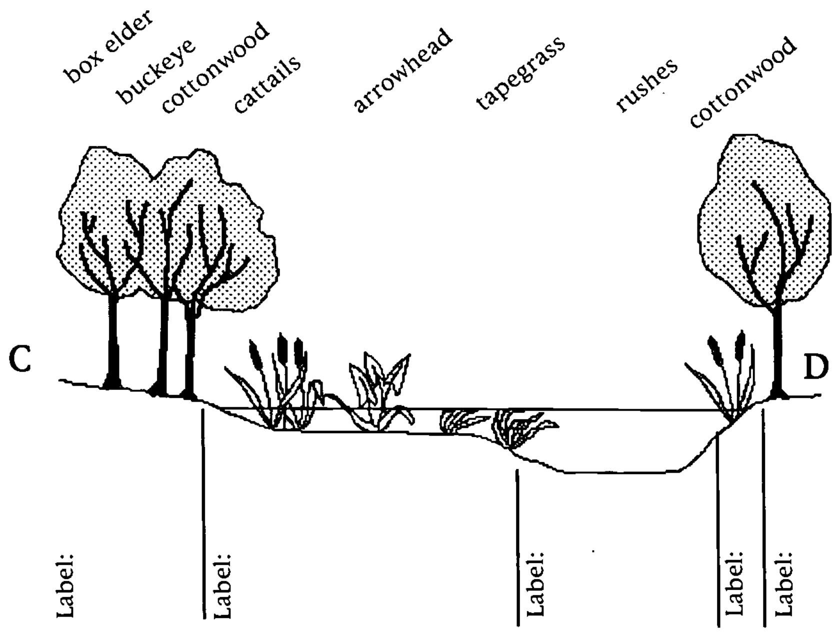
Figure 2. Computer-generated Map of Old Woman Creek Estuary.



COMPUTER MAP SYMBOLS

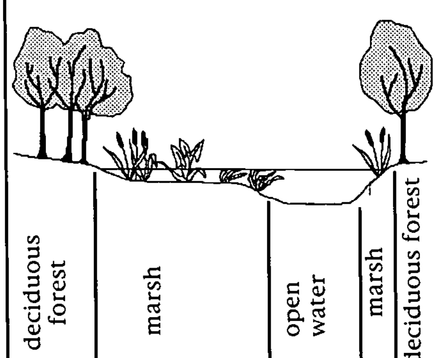
- homes (residential area)
- rangeland (cattle grazing, unused fields, etc.)
- deciduous forest
- stream or canal
- open water
- non-forested wetlands
- marsh or swamp
- beach
- row crops (corn, soybeans, etc.)
- cover crops

Figure 3. Transect and Profile Across Old Woman Creek Estuary.



Teacher's Figure 3. Transect and Profile Across Old Woman Creek Estuary.

Labels under Figure 3 should be as follows:



2. Sampling the populations.

A. With your ruler, draw a line straight across Figure 2 between points C and D. This will be called your transect line. Ecologists (people who study the environment) use a *transect* as a way to sample the populations of living things in a community. For example, by naming and counting the plants along a transect, they get an idea of what the whole plant community is like, without counting and naming every organism in the whole community.

B. Figure 3 represents your transect line and the plants that might be found along it. It is drawn as a profile so you can tell the location and depth of the water. Figure 3 represents a transect approximately 2.3 times as long as line C-D in Figure 2. That means all its parts are that much bigger. Label the parts of Figure 3 to show the type of features (from the computer map) that your transect line crosses. Then turn to the Appendix for descriptions of the plants.

C. Which area of the estuary has plants rooted in fairly dry soil? What do these plants provide for the animals that live nearby?

Answer

C. Forest plants are rooted in dry soil. These plants could provide nest sites, protection (places to hide), and food for the animals.

Figure 4. Animals' Use of the Transect Area of Old Woman Creek Estuary.

Animals observed in a typical Great Lakes estuary during one week

ANIMAL	HOW MANY	AREA	ACTIVITY: Hunting	Eating	Reproducing	Hiding	Other
Raccoon	1	forest edge		X			washing fo
White-tail deer	2	forest		X		X	drinking
Fox	1	forest	X	X			
Songbirds	21	forest edge		X	X		nesting
Black snake	1	forest	X			X	
American egret	8	forest			X		nesting
American egret	15	marsh	X	X			
Green heron	2	marsh	X	X			
Kingfisher	4	marsh	X	X	X		
Water snake	1	marsh	X	X			swimming
Seagull	4	marsh		X	X		
Carp	8	marsh		X	X		
Yellow perch	60	marsh		X	X		
Yellow perch	12	open water		X			swimming
Freshwater drum	9	marsh		X			
Gizzard shad	150	marsh			X		swimming
Gizzard shad	30	open water		X			
Clam	17	marsh mud		X	X		
Emerald shiner	42	open water		X			
Walleye	84	marsh		X	X		

D. What area(s) have plants with roots <u>submerged</u> (underwater) but leaves <u>emergent</u> (sticking out of the water)? Which areas have plants submerged?

Answers

D. Marsh areas have emergent plants. Some submerged plants are in the open water areas and the marsh.

Each of the areas crossed by the transect line is able to support a group of animals. Suppose the area is watched for one week. Figure 4 is a list of the larger animals that might be seen and their activities.

Remember, these plant communities and their animal visitors are only being <u>sampled</u>. There are many more organisms in the estuary than we have mentioned here.

E. In which part of the estuary would you find the largest number of animals?

E. The marsh has the greatest number of animals.

F. What are the two main activities carried on by animals in this area?

F. Most of the animals are eating or reproducing there.

G. Your answers to questions D and E should all be the same. Why would an area with many aquatic (water) plants be visited by such a large number of different animals? (Hint: See the list of animal activities in Figure 4.)

H. Perhaps you have listed "eating" in some of your answers above. Which of the animals in Figure 4 might be using the marsh plants as food?

I. What is the bottom of the estuary marsh probably like: muddy or rocky? Why do you think so?

The plants in an estuary tend to slow down the stream's flow. When water slows down, it cannot carry as much sediment. Much of the stream's load of sediment is, therefore, deposited in the shallow areas where plants are rooted in the water. Pollutants suspended in the water may also be trapped in the estuary this way.

J. Much of the Old Woman Creek area marked "marsh" on the computer map does not appear that way in Figure 1. An estuary isn't always marshy and a marsh isn't always an estuary. Look back at the introduction and find the "larger meaning" of the term estuary. Write that meaning on your worksheet.

K. Based on this definition, why doesn't the Figure 1 photograph show much marshy area?

Answers

G. The plants provide food, nest sites, and protection.

H. Most of the fish listed are plant eaters when they are young. Carp eat plants as adults, too. Songbirds may eat the seeds of the plants.

I. The bottom of the estuary is muddy. This provides the plants with something to hold their roots in place.

J. An estuary is that part of the mouth of a stream in which the water level is influenced by a lake or ocean into which the stream flows.

K. The water level must have been (actually was) higher when the picture was taken than when the computer map was made.

Review Questions

1. Define estuary. Where are estuaries found? What are some of the functions served by estuaries that affect an ecosystem?
2. Give a general description of the types of plants found in different depths of water in an estuary.
3. List some ways in which plants are useful to animals in the estuary. Are there ways that animals are useful to the plants?
4. Describe a method by which scientists can sample a macroscopic community. (Hint: See the procedure to the activity.) What do you think are the challenges in trying to find a representative sample of all of the organisms in an estuary?

EXTENSIONS

1. How might the roles of plants vary in different depths of water in an estuary?

2. Refer to the computer map noting the different types of land uses in the region. What impact could land use have on the estuary? Do research to find examples you can use to support your answer.

3. What are some important estuaries in the Great Lakes region? Are there any near your school? Do an Internet search for information about estuary environments in the Great Lakes region. Begin with the examples here and add more sites:
   Old Woman Creek has its own Home Page – http://inlet.geol.sc.edu/OWC/home.html
   Milwaukee Estuary Area of Concern, http://epaserver.ciesin.org/glreis/nonpo/nprog/aoc_rap/michigan/milwaukee-home.html

REFERENCES

Archie, Michele, writer and Ellen Lambeth, copy editor. *The Wetlands Issue: What should we do with our bogs, swamps and marshes?* 1992. North American Association for Environmental Education (NAAEE) Environmental Issues Forum, with support from the Kettering Foundation. Troy, OH: NAAEE.

NOAA is responsible for the nation's management of estuaries. Find more information about NOAA's work with National Estuarine Research Reserves. Old Woman Creek is one of the areas included under this program. Web sites include: National Ocean Service, National Oceanic and Atmospheric Administration, Sanctuaries and Reserves Division, http://www.nos.noaa.gov/ocrm/srd/; and National Estuarine Research Reserve, Old Woman Creek – http://wave.nos.noaa.gov/ocrm/nerr/reserves/nerroldwoman.html. Web sites sometimes change. Do a word search to find related sites.

The Environmental Protection Agency is also a source for information about wetlands. The agency operates a Wetlands Information Hotline (1-800-832-7828) and provides educational materials and referrals to other educational resources. Contact the E.P.A. for a "Wetlands Information Hotline Publication List," or a "Wetlands Reading List, Prekindergarten through Grade 12." Other materials should be available depending on the grade level. E-mail: wetlands-hotline@epamail.epa.gov. Information is available over the internet http://www.epa.gov/OGWDW/wetline.html. Additional EPA's web sites of interest include: Coastlines homepage http://www.epa.gov/nep/coastlines, a publication which featured an article about Old Woman Creek Estuary; Office of Water, National Estuary Program: Bringing Our Estuaries New Life, http://www.epa.gov/nep/nep.html.

Wonders of Wetlands Reference and Activity Guide (*WOW!*). A 325-page curriculum for wetlands with 45 activities. Order from: The Watercourse/Project WET Fund, 201 Culbertson Hall, Montana State University, Bozeman, Montana 59717-0057
Phone: (406)994-5392; Fax: (406)994-1919

Local and state governments may provide wetland guides for your area. Contact your state's natural resource agencies for more information.

APPENDIX

Macroscopic Plants of the Estuary (Old Woman Creek)

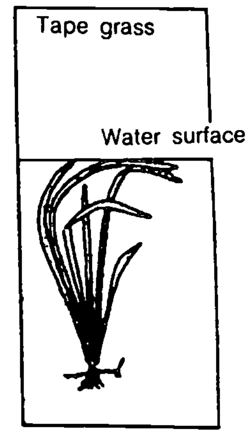
Trees (Rooted on land. Excess water around root system may destroy some trees.)

Box elder

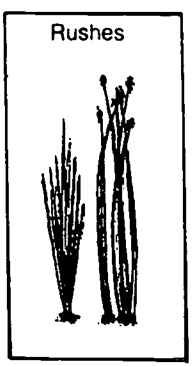
Cottonwood

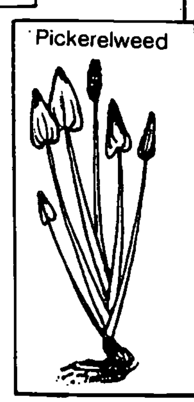
Buckeye

Submerged plants (Roots and leaves underwater.)



Emergent plants (Roots in water, but leaves and seeds emerge into the air.)





How does the estuary serve as a nursery?

Among their many functions, wetlands serve as important protective breeding and nursery grounds for fish and other aquatic animals. Aquatic animals such as plankton establish themselves as essential links in the food chain by providing food sources for fish populations. Changes resulting from human activities near the estuary may have severe effects on the aquatic community. Plankton and fish may not be able to adapt to the change, causing a deficiency in food supplies for organisms in the upper food chain.

OBJECTIVES

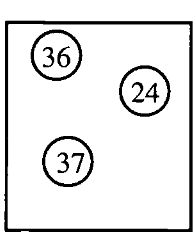
When you have completed this activity, you should be able to:

- Demonstrate the methods used by ecologists to sample populations of plant and animal life in the water.
- Classify the types of organisms that are found as plankton in an estuary.
- Predict the effects of some human and environmental forces on conditions in an estuary.

PROCEDURE

A *sample* is one method that ecologists use to examine a population without observing and counting every organism. A sample can be taken by randomly choosing an area of a certain size and counting all the organisms present. To see how this works, do the following:

1. Take a canning jar ring and drop it anywhere on this page. Count the number of times the letter **E** appears in the circle.
2. Repeat this two more times. Add up your three counts and divide the total by 3. This gives you the average number of **E**s in an area of 43 cm^2 (the area inside the ring).
3. To estimate (make an educated guess about) the total number of **E**s on the page, multiply your average by 9.2, since the page is about 9.2 times as big as the area inside the circle. Round to the nearest whole number.



$$\begin{array}{r} 36 \\ 24 \\ +37 \\ \hline 97 \end{array}$$

97 / 3 = 32.3

32.3 x 9.2 = 297

Source

OEAGLS EP-16 "The Estuary: A Special Place" by Rosanne W. Fortner and Ron Mischler.

Earth System Understandings

This activity focuses on ESU 3, science methods and technology, 4, interaction, and 5, change through time. See the introduction to the activity set.

Materials

- "Plankton samples" in Figures 2 and 3.
- Ring from a canning jar (wide mouth, having an inside diameter of 7.4 cm).
- Pencil.

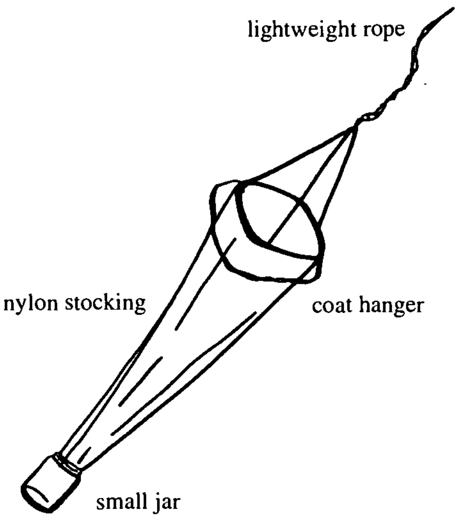
Teacher's Note

Have the students practice the technique and calculations for the **E** "population" on one or two printed pages before going on to the plankton pages.

If for some reason you wish to use the regular-mouth jar rings, having the i.d. of 5.7 cm, use 25.5 cm^2 for the area in Step 2, and use 15.4 for the multiplication factor in Step 3.

In sampling for Figures 2 and 3, students will often have organisms that are only partly visible in the ring. Follow the general rule that if one half of the organism or more is visible, the students should count that as one whole organism. For algae clumps, it is probably most accurate to count every strand of algae as a different organism, rather than counting clumps or clusters.

Figure 1. Student-made Plankton Net.



Hint

In the table on the worksheet, the first type of algae listed is Diatoms. When recording your sample, count both kinds shown, and list them together as Diatoms. Do the same for the green and blue–green algae. The number you write will be a total for both species in each category. In the case of the zooplankton, only one species of each of the different groups is shown.

Answers to Procedure

For most of the following, results would probably be more accurate if the entire class would pool its information.

A. 1. Spring
   2. Summer
   3. Spring
   4. Summer
   5. Spring
   6. Spring
   7. Summer

Now let's pretend that a jar of water has been collected from the Old Woman Creek estuary. It was collected in a special way. A plankton net (Figure 1: student–made plankton net) was towed behind a boat for about five minutes. The net had a jar at the end that caught all the tiny organisms in the water, while the water escaped through holes in the net.

The jar of water has thousands of organisms in it. You can tell they are there because they keep the water churned up in the jar, but you can't see them well enough to tell what they are. You need a microscope.

Figures 2 and 3 show some of the animals you might see through the microscope. Figure 2 is from a plankton sample collected in May, and Figure 3 is from an August sample. Look at the organisms shown and compare them to the pictures in the chart on your worksheet. Be sure you tell which are algae, zooplankton, and fish larvae.

4. Repeat the sampling method you used for the letter e but this time sample the organisms in Figures 2 and 3. It is best if you actually trace your sampling circles on Figures 2 and 3. This will make it easier for you to record on the chart and still not disturb your sample (move the ring). Also, you can come back to your samples and recheck them as the need arises. Record your results on the worksheet.

Figures 2 and 3 are based on actual plankton samples collected along the Lake Erie shore. Both the numbers and types of organisms are therefore fairly accurate examples of what may be found in the Old Woman Creek area.

Hopefully, those of you who said, "But why not just count all the Es?" on the **E** sampling page can see better why scientists frequently resort to sampling techniques. (Imagine a scientist trying to count all the individual organisms in the estuary!)

5. Answer the following questions based on the samples you "collected."

A. Which season had these characteristics?
   1. The greatest number of diatoms
   2. The greatest number of blue-green algae
   3. The greatest number of zooplankton
   4. The warmest water
   5. The most gizzard shad larvae
   6. The most yellow perch larvae
   7. The most sheepshead larvae

B. Young perch eat a lot of algae. Which season would have the most food for baby perch? In which season are the perch spawned (eggs deposited)?

C. Do all the types of fish in the sample spawn at the same time? How can you tell?

D. You have noted that the water is warmer in which sample? Water temperature is an important factor in determining when fish spawn. Which species appear to require warmer water for spawning?

E. What would be the advantage of having different fish spawn at different times?

F. Fish may enter an estuary to spawn. Based on what you learned in the previous estuary activity, why else might fish come into the estuary?

G. You now have information about the microscopic organisms in an estuary. In "What is the role of plants in an estuary?" you investigated the activities of some of the macroscopic (visible to the unaided eye) organisms in an estuary. Using what you have learned, predict the effect of the following events on the plants and animals of the estuary.

1. Heavy spring rains raise the level of the creek 1 foot higher than it is now. The water also flows very fast.
2. Hot water is dumped into the estuary by a utility company.

Answers to Procedure

B. Perch spawn in spring (March-May). There is more food for them in summer, however. Note that they have yolk sacs in the May plankton sample. The larvae use the yolk as food, then begin to feed on algae.

C. No. There are no bass or sheepshead in the May sample. They appear as yolk-sac larvae in the August sample.

D. Summer water is warmer. Sheepshead and white bass appear to require warmer water for spawning.

E. Spawning times could be related to the availability of food for the larvae. There may also be temperature tolerances of the fish to be considered, and some fish are sensitive to overcrowding. Another reason could be to keep species from interbreeding. Discuss all possibilities that students suggest.

F. Fish might also enter the estuary to eat or to find shelter among the water plants.

G1. Rooted plants may be washed out or completely submerged which would kill plants that are ordinarily emergent. The mud of the bottom could be washed out, preventing plants from becoming reestablished. Plankton would be swept out into the open water of the lake. Adult fish might find more spawning sites in the submerged plants, but there is a greater chance of eggs and larvae washing away into the lake where they could be killed by temperature changes or eaten by other fish. Muddy water would reduce the ability of sight-feeding fish to find food. If larvae remained, their food supply would probably be reduced because of plankton loss. Shore birds would probably have more trouble catching small fish, and the nest sites for the birds could be destroyed.

G2. Plants could be killed. Plant plankton would probably increase in number up to a certain water temperature. Zooplankton would probably be killed. Fish that depend on warmer water temperatures to determine their spawning time might spawn earlier than usual. If the temperature got too high, some fish would not enter the estuary at all. Fish larvae might have more algae to eat, but excess heat could kill both eggs and larvae. The food supply would be affected.

G3. Removal of bottom sediments would cause destruction of the water plants rooted there. Fish, shore birds and other animals that depended on the plants for breeding areas, food or shelter would no longer enter the estuary. Plankton would be washed out into the lake. (No water plants would be available to hold them back.)

G4. Nobody wants a marsh as a back yard. We can assume that the water edges are bordered by seawalls or sand beaches in front of the homes. The character of the estuary would be completely changed. Few rooted plants could survive and there would be few plankton. Adult fish would move further inland to spawn, or spawning may be prevented, thus no eggs would be produced to continue the species in that area. Food supply would decrease, so animals would need to find other feeding grounds. Few plants would remain so that there would be no nest sites. Students will probably have interesting ideas on what changes would be involved. All possibilities should be discussed.

3. The estuary is dredged out so that boats can go up the creek. The mouth of the estuary is deepened and probably protected by a sea wall. A portion to be used as a marina is deepened as well to a depth of 2 to 3 meters.

4. The estuary is filled in on the sides so that new homes can be built near the water.

REVIEW QUESTIONS

1. Explain what is meant by population sampling.

2. Describe a sampling method for a microscopic community.

3. What types of organisms might be found in an estuary plankton sample? Do you think having a diversity of organisms in an estuary is important? Why or why not?

4. Explain how a temperature increase could affect the number of plankton in a lake. Select another human induced change discussed in the activity and explain its potential effect on the microscopic community. How will these changes affect fish and other animal species in the food chain?

5. Why are estuaries considered to be "endangered environments?"

EXTENSION

Have the students create their own "plankton sample." Place a handful of straw in a container of water in the sun. Using a microscope, examine changes in the number and types of organisms in the water over several days.

REFERENCES

Eisenhower National Clearinghouse has online information about wetland resources (http://www.enc.org). Toll-free number: 1-800-621-5785.

The E.P.A. has educational resources available for the classroom. Contact the Wetlands Information Hotline 1-800-832-7828 for printed material, posters, and other resources.

Some state agencies may provide field trips for students. They also could have manuals available regarding wetlands in your area. Contact your state's natural resource agencies for more information.

Figure 2. Estuary Plankton Sample, May (water temperature 13°C).

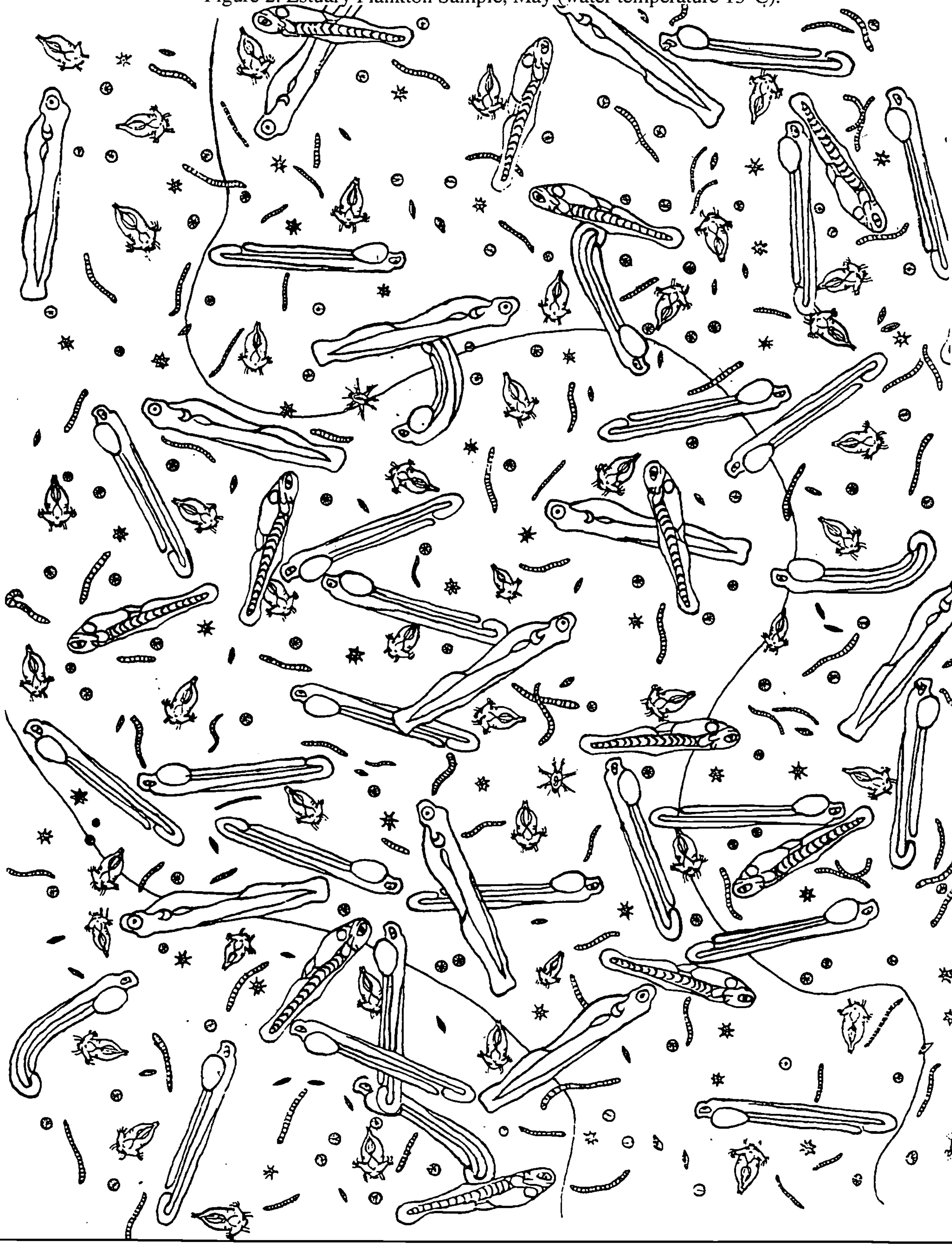


Figure 3. Estuary Plankton Sample, August (water temperature 21°C).

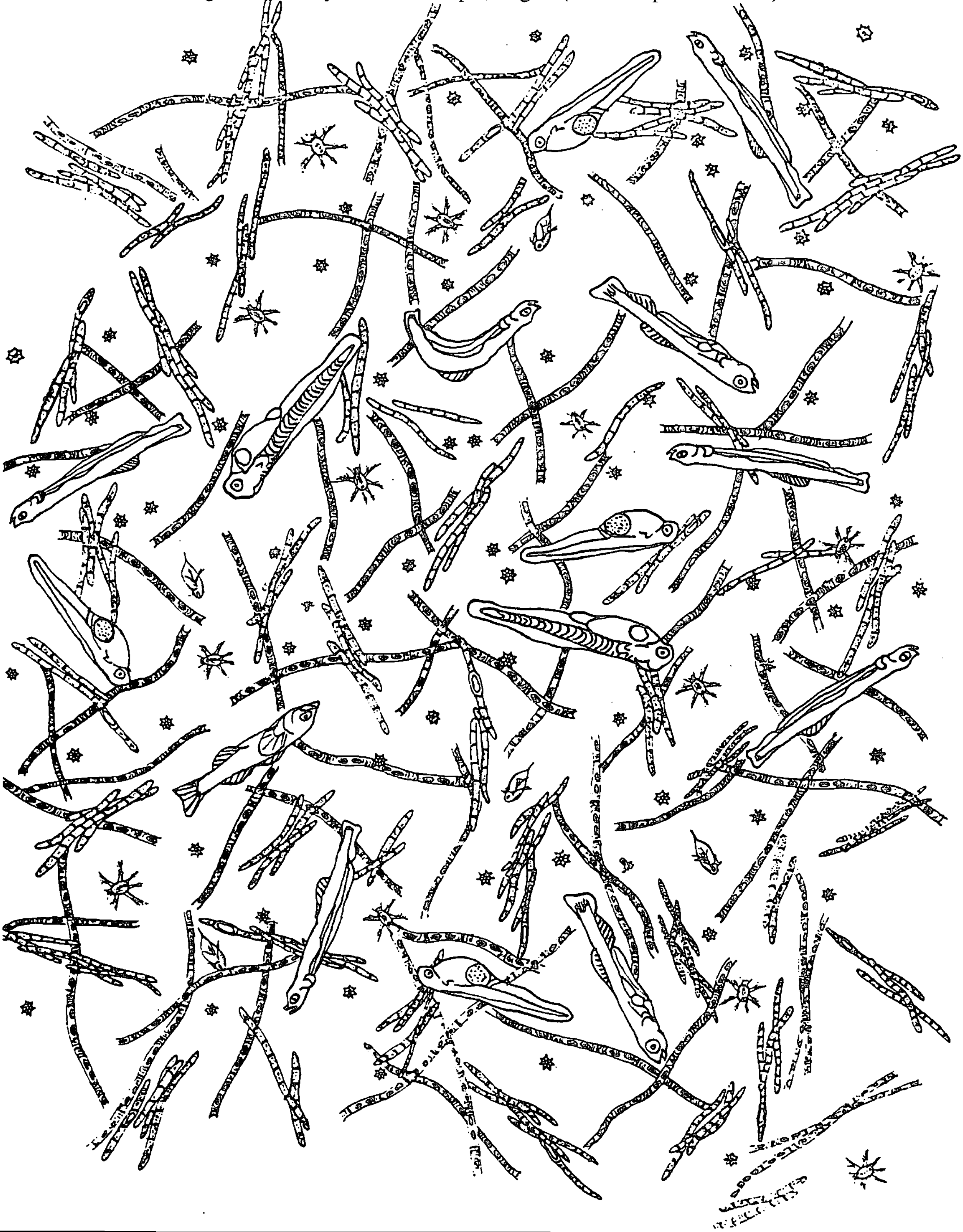
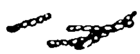
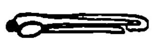
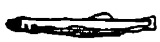


Figure 4. Worksheet for Estuary Plankton Sample.

PLANKTON SAMPLE

Organism	May Sample (Fig. 6) 1	2	3	Ave.	Total Pop.	Aug. Sample (Fig. 7) 1	2	3	Ave.	Total Pop.
Algae:										
Diatoms 										
Green 										
Blue-green 										
Zooplankton:										
Cladocerans 										
Copepods 										
Protozoans 										
Rotifers 										
Fish Larvae:										
Yellow Perch  Yolk-sac larva										
 Regular larva										
Gizzard Shad  Yolk-sac larva										
 Regular larva										
White Bass  Yolk-sac larva										
 Regular larva										
Sheepshead (freshwater drum)  Yolk-sac larva										
 Regular larva										
Emerald Shiner  Yolk-sac larva										
 Regular larva										

*Yolk–sac larvae have just emerged from eggs. A yolk-sac larva is younger than a regular larva.

Extending Your Knowledge

Wetlands can also be thought of as nurseries for birds because many species of birds build nests in the watery environments to raise their offspring. Migratory birds may depend on specific wetland sites as resting stops during their journeys.

Table 1 illustrates the percentage population changes for some wetland species during 1989-1990 and 1990-1991 and the overall trend from 1966-1991. In the contiguous 48 states, wetlands represent approximately 5 percent of the land area. Combined with deep water habitats (e.g. lakes), this figure increases to 9.3% for the conterminous U.S. Any decrease in this small number could have dramatic impacts. During the mid-1970s to the mid-1980s wetlands decreased in area by 2.5%, representing a loss of over 2.5 million acres. Including deep water habitats these figures are altered to a percentage loss of 1.2% and an area loss of 2.3 million acres.

Some scientists use *proxy data* as indicators of changes in habitat for specific species, such as wetland species. One example is the use of bird data. Table 1 lists data from the Breeding Bird Survey (BBS). What do the data suggest about wetland changes, that is, could species changes be attributed to wetland loss? From what you have learned in this activity set, what human induced changes could result in the loss of wetland environments? What do you think is the value of using this kind of data for detecting changes in wetlands?

1. Is it possible to compare the 1966-1991 bird survey figures with the wetland loss figures over the period of the mid-1970s to the mid-1980s?

2. Using the list of the birds included, examine the long-term population trends of selected waterfowl species. For example, examine the figures for Wood Ducks and Mallards over the 25-year period. Many people would think that mallard population trends would have exhibited an increase because of their adaptability to urban environments. Does the data set reveal this type of trend?

   Examine the trend for Canada Geese. Where are most of these geese located now – rural or urban environments?

Source

Adapted from "How do we learn about wildlife population changes?" Produced by Tony P. Murphy for the Ohio Sea Grant Education Program, the Great Lakes Protection Fund, and the George Gund Foundation.

Answers

1. Even though the time periods do not correlate exactly, it is possible to get an idea of the possible impact of wetland loss on waterfowl populations.

2. To answer these questions, it is necessary that the students select a variety of waterfowl in addition to those mentioned. They may wish to do additional research on a specific species that they observe locally or suspect to have changed.

   Mallards appear to have declined in numbers over the twenty five year period.

   Canada Geese seem to be adaptable to both rural and urban environments. In urban areas geese are protected from predators, which tends to promote their visiting those sites. Flocks may become an issue for housing developments or parks built next to lakes and ponds.

Table 1. Two year changes (1989-1990 and 1990-1991) and long term (1966-1991) population trends for selected wetland species which were seen on 50 or more BBS routes in either two-year period. For the 3 intervals, percentage change per year (%/Year) is presented. Sample size (in N [number of routes]) is shown for each of the 2-year changes. For the third interval, the relative abundance is presented (R.A.). This is defined as the mean count on BBS routes over the 1966-1991 interval.

	1989 - 1990		1990 - 1991		1966 - 1991	
Species	%/Year	N	%/Year	N	%/Year	R.A.
Common Loon	3.9	103	23.5	121	2.2	0.74
Pied-billed Grebe	8.5	106	9.5	95	-1.6	0.21
Double-crested Cormorant	-24.5	137	12.7	138	6.5	0.61
American Bittern	27.9	132	-10.3	131	-1.6	0.41
Great Blue Heron	-0.35	741	3.3	748	1.5	0.77
Great Egret	-36.7	185	-32.4	170	1.1	1.41
Snowy Egret	-43.6	75	-28.1	61	6.9	0.81
Little Blue Heron	-13.8	131	17.1	124	-1.3	1.69
Cattle Egret	-27.6	182	20.1	188	2.4	12.56
Green-backed Heron	4.7	524	11	545	0	0.74
Black-crowned Night-Heron	-15.3	78	-32.8	84	-0.5	0.18
White Ibis	-36.7	59	183.4	51	2.2	4.36
Canada Goose	-2.1	352	15.2	379	7	2.51
Wood Duck	33.8	342	2	368	2.9	0.26
American Green-winged Teal	250.8	72	-43.5	80	-0.2	0.32
American Black Duck	158.9	65	-49	58	-0.7	0.27
Mallard	7.2	728	13.8	749	-4.1	5.06
Northern Pintail	52.3	114	-33.5	108	-15	1.85
Blue-winged Teal	15.4	192	-6.7	189	-1	1.53
Cinnamon Teal	-21.2	68	25.4	73	7.2	0.47
Northern Shoveler	23.2	82	10.8	88	0.5	1.04
American Wigeon	-21.4	86	2.8	87	0.3	0.95
Lesser Scaup	20.6	73	9.4	73	2.7	1.41
Common Merganser	-10.7	99	13.6	103	1.6	0.27
Ruddy Duck	19	57	49	62	2.4	0.68
Osprey	19.7	117	-2.6	119	2.6	0.12
American Kestrel	-0.2	738	4.5	724	0.6	0.92
Sora	71.3	132	5.2	140	-3.3	0.62
American Coot	-0.3	144	27.7	135	0.3	1.81
Killdeer	-8.9	1177	-5.7	1210	-0.1	5.57
American Avocet	4.5	68	-10	77	0.1	0.8
Spotted Sandpiper	-1.3	236	9.5	255	0	0.42
Upland Sandpiper	-1.9	188	16.3	195	3.6	1.9
Long-billed Curlew	-4.6	70	-2.9	71	-0.5	1.48
Marbled Godwit	22.1	69	-31.7	68	1	2.08
Common Snipe	-3.6	308	-9.1	303	0.4	2.08
Belted Kingfisher	-18.4	504	5.5	476	-1	0.38
Nashville Warbler	-7.5	226	0	217	1.7	4.94
Cerulean Warbler	24.2	70	-19.2	76	-2.7	0.21
Prothonotary Warbler	3.4	350	-11	373	1.1	1.31
Northern Waterthrush	-11.5	166	7.8	152	0.8	1.56
Wilson's Warbler	-8.1	130	4.1	135	0.9	1.34
Swamp Sparrow	-1	245	-17.2	245	0.4	1.07
Red-winged Blackbird	-0.4	1307	1.1	1325	-1	55.24
Yellow-headed Blackbird	0.6	218	-16	230	3	7.8

2. (Continued) Rates of change for cormorants could differ based on the weather, disease, and competition for nesting sites and food supply that varied during each year. Allow students to discuss their ideas about what could have caused the different rates of change.

   Students may respond in several ways. Data suggest that rates of change were more positive in the latter two years. Some may argue that lower number of prey species could have been present in the prior years which could have contributed to a decrease in herons sighted, thus the latter two years would have shown more prey. Others may suggest that prey species could have been more abundant in the earlier years because they were less threatened with predation, and in the latter two years their numbers would have shown a decline. Discuss possibilities that students suggest.

3. Various factors are responsible. Not all waterfowl depend on the same type of habitat – some live in wetlands, while others prefer deep water habitats. In fact, deep water habitats have increased slightly over the ten year period discussed. Also, some species adapt more readily to expanding urban habitats.

Teacher's Note

You may want to have students create a picture of their perception of what a plot would look like.

Note the two year changes for the Double-crested Cormorant. What reasons would you suggest for the different rates among years?

Investigate the species data for the Great Blue Heron, Little Blue Heron, and Green-backed Heron. In which two year period did the rates of change seem more positive?

Make a prediction about changes likely with prey species as the number of herons changed over time. In which two year period do you think the prey species would likely have been more abundant?

3. Would the loss of wetlands and deep water habitats have an equivalent impact on all waterfowl species? Why do some waterfowl population trends exhibit an increase and others a decline?

4. As a wildlife manager in one of the states or provinces surrounding the Great Lakes, you have to put forward a management plan for waterfowl. Base your waterfowl plan on the data from the population trends. How would you manage the various species? On which species would you increase/decrease the hunting "bag" limit? Why? Are there any additional aspects of your plan that could influence population trends? What are they and why have you used them?

Researchers gather the bird data using a type of census technique. Spot or territory mapping is used to describe the habitat examined. Various criteria were developed to establish the plots in the census: a "minimum plot size of 40-100 hectares (100-250 acres) in an open habitat, or 10-30 hectares (25-75 acres) in a closed habitat" (*Audubon Field Notes*, 1970, 724).

Instructions to BBS personnel include the following. Single uniform habitats should be selected as the study areas, if possible. For example, birch marsh, sand dunes, upland deciduous forest, upland coniferous forest, grassy field, etc. Plots should be square if possible. A detailed description of the plot should include: latitude and longitude from an official topographic map, general characteristics of the plot and surrounding landscape e.g., bog with scattered pines, farmland, etc., size in hectares and acres, altitude in meters and feet, soil type and/or bedrock, general topography e.g., mountains, valleys, peaks, hills, roads, etc., a large scale map showing the main vegetation types, their distribution and the location of the plot with its boundaries marked on the map, and any other relevant information. A grid system may be used to show the locations of birds and census takers, if reference to physical locations is not possible.

A minimum of 10 visits should be made to a closed habitat and eight to an open habitat during the breeding seasons of the majority of the birds in the plot. These visits should be spaced as evenly as possible during breeding. In addition, visits should be concentrated in the morning when most of the bird song activity occurs. If this same plot is surveyed in later years, the same pattern should be utilized if possible. All the details concerning each trip to the plot should be recorded – weather conditions, hours spent there, birds seen and heard, etc.

The following method was used in the bird census. "The bird population of any given habitat should be based on the number of territorial males rather than the number of pairs. The reason for this is that ordinarily the number of breeding females cannot be accurately determined without a great deal of extensive study involving much more time than is generally spent in conducting the census" (Hall, 1964, 414). Currently, the organizers (Cornell Laboratory of Ornithology) instruct people to mark the approximate position (and sex when possible) of birds as they are encountered (visually and/or aurally). Record all birds using the plot. Birds simply flying over the plot should not be included.

REVIEW QUESTIONS

1. What methodology is followed in the BBS to survey areas for birds? Discuss any limitations to the method that could threaten its accuracy.

2. What possible link is there between waterfowl population trends and the loss of wetland/deep water habitats?

EVALUATION

1. Using waterfowl population trends as a central point, have the students create a poster (concept map) which illustrates all possible factors that impact this trend.

2. Have students write a report on the use of BBS data as proxy data. Does it really inform us of the overall health of the environment? Answers should be supported with evidence.

Online Resources

Have the class find information about the Breeding Bird Survey on the Internet using http://www.mbr.nbs.gov/bbs/bbs.html which is part of the National Biological Service's network of web pages. Students can learn more about NBS projects at the Patuxent Wildlife Research Center, from the Migratory Bird Research and Monitoring Page http://www.mbr.nbs.gov/.

Additional information is found on the NBS page – Bird Monitoring in North America, http://www.im.nbs.gov/birds.html.

Have the class do an Internet search for information about birds that spend part or all of their time in the wetlands of the Great Lakes region. Each person can find something interesting about a species to share with other class members, or people can look for a specific fact about migratory birds and explore various options for finding the information.

EXTENSIONS

1. In your examination you have observed three methods used by scientists to sample wetland plant and animal species: (1) transect, (2) random sampling technique, and (3) census or survey method. Critique the three methods presented. What are their strengths? What are their weaknesses? If you were conducting research on a wetland near your home or school, would you adopt similar sampling techniques or would you add other methods to your study. What do you think would be the best way to achieve species counts and measure biodiversity in a wetland area? You may want to do library research to support your answer.

2. Create your own project to demonstrate how a change in one plant or animal species, such as a bird or plankton type, could affect other species in an estuary. Use a poem, drawing, or an idea of your own to show the interrelationships between organisms in a wetland. Where might the role of humans be incorporated? Note that you could explore the effects of both the increase and decrease in abundance of the individual species you choose. (Hint: See the food web song included with the walleye activities.)

Hint for Extension

1. Point out to students that while a random sampling technique, as in the plankton sample, counts a number of organisms as representative of an entire area, a census method tries to achieve an exact count for a specified geographic area. Each type of count has value in different situations.

REFERENCES

Breeding Bird Survey. 1990. *Instructions for Conducting the Breeding Bird Survey*. Laurel, Maryland 20708: U.S. Fish and Wildlife Service.

Hall, George A. 1964. "Breeding-Bird Censuses – Why and How." *Audubon Field Notes*. 18 (3): 413-416. New York: National Audubon Society.

Dahl, T. E. 1990. *Wetlands losses in the United States 1780's to 1980's*. U.S. Department of the Interior, Fish and Wildlife Service, Washington, D.C.

Dahl, T. E. and C. E. Johnson. 1991. *Status and Trends of Wetlands in the Conterminous United States, Mid-1970's to Mid-1980's*. U.S. Department of the Interior, Fish and Wildlife Service, Washington, D.C.

Robbins, Chandler S. 1970. "Recommendations for an International Standard for a Mapping Method in Bird Census Work." *Audubon Field Notes*. 24 (6): 723-26. New York: National Audubon Society.

Source of Breeding Bird Survey data

U.S. Fish and Wildlife Service, Office of Migratory Bird Management, Laurel, MD 20708.

Framework for Earth Systems Education

UNDERSTANDING #1: Earth is unique, a planet of rare beauty and great value.

- The beauty and value of Earth are expressed by and for people of all cultures through literature and the arts.
- Human appreciation of Earth is enhanced by a better understanding of its subsystems.
- Humans manifest their appreciation of Earth through their responsible behavior and stewardship of its subsystems.

UNDERSTANDING #2: Human activities, collective and individual, conscious and inadvertent, affect Earth systems.

- Earth is vulnerable, and its resources are limited and susceptible to overuse or misuse.
- Continued population growth accelerates the depletion of natural resources and destruction of the environment, including other species.
- When considering the use of natural resources, humans first need to rethink their lifestyle, then reduce consumption, then reuse and recycle.
- Byproducts of industrialization pollute the air, land, and water, and the effects may be global as well as near the source.
- The better we understand Earth, the better we can manage our resources and reduce our impact on the environment worldwide.

UNDERSTANDING #3: The development of scientific thinking and technology increases our ability to understand and utilize Earth and space.

- Biologists, chemists, and physicists, as well as scientists from the Earth and space science disciplines, use a variety of methods in their study of Earth systems.
- Direct observation, simple tools, and modern technology are used to create, test, and modify models and theories that represent, explain, and predict changes in the Earth system.
- Historical, descriptive, and empirical studies are important methods of learning about Earth and space.
- Scientific study may lead to technological advances.
- Regardless of sophistication, technology cannot be expected to solve all of our problems.
- The use of technology may have benefits as well as unintended side effects.

UNDERSTANDING #4: The Earth system is composed of the interacting subsystems of water, rock, ice, air, and life.

- The subsystems are continually changing through natural processes and cycles.
- Forces, motions, and energy transformations drive the interactions within and between the subsystems.
- The Sun is the major external source of energy that drives most system and subsystem interactions at or near the Earth's surface.
- Each component of the Earth's system has characteristic properties, structure, and composition, which may be changed by interactions of subsystems.
- Plate tectonics is a theory that explains how internal forces and energy cause continual changes within Earth and on its surface.
- Weathering, erosion, and deposition continuously reshape the surface of the Earth.
- The presence of life affects the characteristics of other systems.

UNDERSTANDING #5: Earth is more than 4 billion years old, and its subsystems are continually evolving.

- Earth's cycles and natural processes take place over time intervals ranging from fractions of seconds to billions of years.
- Materials making up Earth have been recycled many times.
- Fossils provide the evidence that life has evolved interactively with Earth through geologic time.
- Evolution is a theory that explains how life has changed through time.

UNDERSTANDING #6: Earth is a small subsystem of a Solar system within the vast and ancient universe.

- All material in the universe, including living organisms, appears to be composed of the same elements and to behave according to the same physical principles.
- All bodies in space, including Earth, are influenced by forces acting throughout the solar system and the universe.
- Nine planets, including Earth, revolve around the Sun in nearly circular orbits.
- Earth is a small planet, third from the Sun in the only system of planets definitely known to exist.
- The position and motions of Earth with respect to the Sun and Moon determine seasons, climates, and tidal changes.
- The rotation of Earth on its axis determines day and night.

UNDERSTANDING #7: There are many people with careers and interests that involve study of Earth's origin, processes, and evolution.

- Teachers, scientists, and technicians who study Earth are employed by businesses, industries, government agencies, public and private institutions, and as independent contractors.
- Careers in the sciences that study Earth may include sample and data collection in the field and analyses and experiments in the laboratory.
- Scientists from many cultures throughout the world cooperate and collaborate using oral, written, and electronic means of communication.
- Some scientists and technicians who study Earth use their specialized understanding to locate resources or predict changes in Earth systems.
- Many people pursue avocations related to planet Earth processes and materials.

The development of this framework started in 1988 with a conference of educators and scientists and culminated in the Program for Leadership in Earth Systems Education. It is intended for use in the development of integrated science curricula. The framework represents the efforts of some 200 teachers and scientists. Support was received from the National Science Foundation, The Ohio State University, and the University of Northern Colorado.

For further information on Earth Systems Education, contact the Earth Systems Education Program Office, 2021 Coffey Road, The Ohio State University, Columbus, OH 43210.

http://www.ag.ohio-state.edu/~earthsys/

Sample Rubric

The rubric was developed by an Earth Systems teacher for use in evaluating individual student research projects.

Research Time Utilization	The student needed continual reminders to get back to work. Work may be inappropriate to the project.	The student was usually on task, but needed an occasional reminder to get back to work. All work is appropriate.	The student was always on task and did not need reminders to get back to work.
Participation in Project	The student does not add an equitable amount of work to the project and does not meet all requirements for the length of presentation.	The student adds an equitable amount of work to the project, but may not meet all requirements for the length of the presentation.	The student adds an equitable amount of work to the project and meets all requirements for the length of the project.
Accuracy of Information During Presentation	The student's information was lacking in content and was not factually correct in many places. Information may not be pertinent to the presentation.	The students' information is for the most part factually correct. Information may not be pertinent to the presentation.	The student's information is factually correct and pertinent to the presentation.
Clarity of Presentation	The student's work is not well planned. The student was confused by much of the information presented. The student was not clear in explaining topics.	The student's work is well planned. There seemed to be some confusion or misinterpretation of information.	The student's work is well planned and clearly explained. The student showed a clear command of the information presented.
Visual Aid Worksheet, or Simple Demonstration	The device used by the student was not used at a timely place in the presentation, had little bearing on the presentation, or was absent from the presentation.	The device used by the student was appropriate for the presentation. It may have been used in a more appropriate manner. The design of the device may not have maximized the learning.	The use of the device was timely and appropriate. The design of the device was constructed to maximize learning.

Source: Mayer, V.J. and R.W. Fortner, 1995. *Science is a Study of Earth: A resource guide for science curriculum restructure*. Columbus, OH: Earth Systems Education Program, The Ohio State University.

Ohio Sea Grant Education Program

The Ohio Sea Grant Education Program has focused on the development of curriculum materials to enhance the quality of science education, the infusion of these materials into the classroom, and teacher training. Materials developed emphasize real-world issues including, most recently, the impact of global climate change on the region.

Earth Systems -
Education Activities for Great Lakes Schools (ES-EAGLS)

ES-EAGLS are designed to take a concept or idea from the existing school curriculum and develop it in a Great Lakes context, using teaching approaches and materials appropriate for students in middle and high school. The activities are characterized by subject matter compatibility with existing curriculum topics, short activities lasting from one to three classes, minimal preparation time, minimal equipment needs, standard page size for easy duplication, suggested extension activities for further information or creative expression, teachability demonstrated by use in classrooms, and content accuracy assured by critical reviewers.

Each title costs $8.00

Land & Water Interactions in the Great Lakes EP-082
Great Lakes Climate & Water Movement................EP-083
Great Lakes Shipping EP-084
Life in the Great Lakes EP-085
Great Lakes Environmental Issues EP-086

The Great Lakes Solution Seeker

This compact disk will help educators teach their students about the Great Lakes by providing online or simulated Internet connections to comprehensive data sources, resources, graphics, and activities. The data and activities work best on Macintosh system 7.0 or higher. Most sections are also usable with Windows 95. EP-081 *$10.00*

Global Change in the Great Lakes

Ten scenarios (2-4 pp. each) and an introduction explain climate models and are packaged in a file folder. The scenarios describe the scientific community's prevailing interpretations of what may happen to the Great Lakes region in the face of global warming but are written in terms the general public can understand. The scenarios explore water resources, biological diversity, shipping, agriculture, airborne circulation of toxins, estuaries, eutrophication, recreation, fisheries, and forests. EP-078 *$6.00*

Great Lakes instructional material for the changing earth system. Provides integrative activities on global change to educators and decision-makers and must be purchased with EP-078 (above). Printing donated by Brunswick Marine. Cost includes EP-078 and additional postage charge. EP-080 *$9.00*

Summary of the global change scenarios (above) for the Great Lakes region. 2 pp. FS-057 *free*

Oceanic Education Activities for Great Lakes Schools (OEAGLS)

OEAGLS (pronounced "eagles") were developed from 1985 to 1991 for students in middle school grades. The ES-EAGLS (see above) are modifications of OEAGLS. Refer to that series description. Each OEAGLS title consists of a student workbook and a teacher guide.

Each title costs $3.00

Yellow Perch in Lake Erie EP-009
Shipping on the Great Lakes EP-013
Geography of The Great Lakes EP-014
Ohio Canals EP-015
The Great Lakes Triangle EP-017
Knowing the Ropes EP-018
We have Met the Enemy..EP-021
It's Everyone's Sea: Or is it? EP-022
A Great Lakes Vacation EP-024
Storm Surges EP-025

OEAGLets

Three activities provide students in primary grades with activities relevant to Lake Erie. The activities apply to all primary subject areas. *Each title costs $5.00*

Lake Erie - Take a Bow EP-031
Build a Fish to Scale EP-032
A Day in the Life of a Fish EP-033

Additional Educational Materials

Holling C. Holling's *Paddle-to-the-Sea* published by Houghton Mifflin Company. 28 pp. EP-076/B *$10.00*

Supplemental curriculum activities to accompany Holling C. Holling's Paddle-to-the-Sea. 168 pp. of activities for grades 3-6: science, social studies. EP-076 *$10.00*

The great Lake Erie. Sixteen experts present different facets of the importance of the Great Lakes to North America and the world. Written in 1987 and reprinted by Ohio Sea Grant in 1993. 148 pp. EP-079 *$10.00*

The Ohio Sea Grant Education Program: Development, Implementation, Evaluation. EP-075 *$8.00*

Abstracts of research in marine and aquatic education: 1975-1990. Brief review of the topics addressed in marine and aquatic education research, including knowledge and attitude testing of various groups, models of program evaluation, and comparisons of impact of education techniques. 24 pp. EP-077 *$2.00*

Costs cover publication, postage, and handling.
Make payment payable to The Ohio State University in U.S. dollars. Mail your request and payment to:
Ohio Sea Grant Publications, The Ohio State University, 1314 Kinnear Road, Columbus, OH 43212-1194.
[Pho]ne 614/292-8949 or e-mail (cruickshank.3@osu.edu) if you have any questions or would like to place a large order.

Other ES-EAGLS

Great Lakes Climate and Water Movement

Water Movement

- How does water move in the Great Lakes basin?
- How long does it take water to flow through the Great Lakes?

Temperature and Climate

- What happens to heat energy reaching the Great Lakes?
- What causes the land-sea breeze?
- How do the Great Lakes affect temperature?
- How is weather influenced by the Great Lakes?

Lake Levels and Storms

What causes storm surges?

- How do storm surges affect water levels on Lake Erie?
- How do the levels of the Great Lakes change?
- What would be the result of regulating the level of one of the Great Lakes?

Seasons on the Great Lakes

- How do the Great Lakes change through the seasons?
- How does stratification affect water quality?
- What factors impact ice coverage on the Great Lakes?

Land & Water Interactions in the Great Lakes

Geography and Technology

- How well do you know the Great Lakes?
- What can GLIN tell us about land and water interactions?

History of Land and Water Interactions

- When did the rocks in the Great Lakes basin form?
- How were sedimentary rocks in the Great Lakes basin formed?
- How did rocks and rivers shape the Great Lakes?
- What evidence of glaciation exists in the Great Lakes region?
- What evidence of glaciation and geologic processes can be found on Great Lakes beaches?

Land and Water Interaction Today

- What causes the shoreline to erode?
- Can erosion be stopped?
- How fast can a shoreline change?
- How much land has been lost?
- What natural wonders of the Great Lakes relate to land and water interactions?
- [illegible] n a concept map represent land and [illegible] nteractions?

Great Lakes Shipping

Great Lakes Shipping

- What products are carried on the Great Lakes?
- What is the most economical form of transportation?
- Which transportation method uses the least energy?

World Connection

- Where go the boats?
- How do ships go from one lake to another

Language

- How have ships and sailing influenced our language?

Great Lakes Triangle

- What is the Great Lakes Triangle?
- How can disappearances within the Triangle be explained?
- What happened aboard the *Edmund Fitzgerald*?

Canals

- How were early canal routes determined?
- How did the canals affect Ohio?

Great Lakes Environmental Issues

Resources and Reactions

- How big is a crowd?
- Who owns the resources of the Great Lakes?
- How (environmentally) insulting can we get?
- How skillfully can you read science articles?

Toxins in the Great Lakes?

- How much is one part per million?
- Which fish can we eat?
- How should the public heath be protected?
- How do toxins move through the food chain?
- How big is the problem of airborne toxins?
- Where do all the toxins go? (internal view)
- Where do all the toxins go? (external view)
- Could we live without chlorine in the Great Lakes?

Watershed and Basins Issues

- What can we learn about water quality in a river?
- What happens when nutrients enter a lake?
- What is the status of the Great Lakes Areas of Concern?

Oil Pollution

- Where does oil pollution come from?
- How can an oil spill be cleaned up?
- How does an oil spill affect living things?
- What if . . .? (a Great Lakes investigation)

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