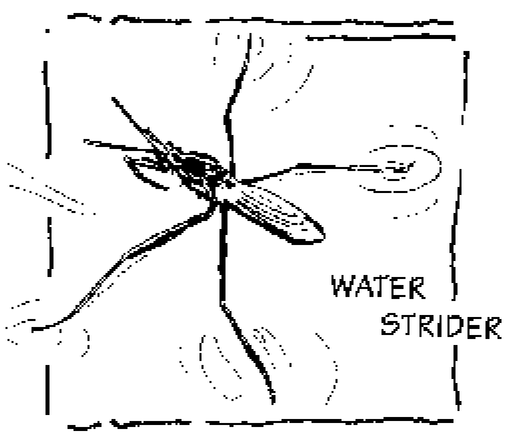
LAKES, PONDS, RESERVOIRS

This lesson and its corresponding activities are targeted to grades 5-9 and subject areas English language arts, mathematics, science, social science and fine arts,. Most of the activities and the following background information may be adapted to other grade levels.

More than 2,900 lakes, 84,000 ponds and 3 large reservoirs are found across Illinois. Lakes are generally considered to



be nonfree-flowing (lentic) bodies of water 20 or more acres in size, while ponds are nonfree-flowing bodies of water smaller than lakes (IDNR 1988). Illinois contains a variety of lake types. Northern Illinois is home to glacial lakes which were created thousands of years ago as glaciers advanced and receded. Oxbow lakes are formed when a meandering stream cuts a new and straighter channel. The old bend in the stream, now cut off from the main channel, becomes a lake. Impoundments and reservoirs are created by obstructing the flow of a river with a dam or berm. These water bodies are often used for public water supplies. Ponds and stormwater detention basins are built by excavation or by expansion of an existing lowland area.

Lake ecosystems are complex and varied. Oligotrophic lakes tend to be unproductive in terms of organisms present, have high levels of dissolved oxygen and contain very clear water. Lakes that have many particulates present, low dissolved oxygen and are highly productive with large populations of plants, animals and plankton are eutrophic. Mesotrophic lakes fall between the two extremes found in oligotrophic and eutrophic lakes. Within the lake there are specifically adapted organisms. Bottom dwellers are known as benthic organisms. Free-swimming organisms are called nekton. Plankton are small, free-floating organisms. Neuston are organisms that live on the surface film of water, like water striders, duckweeds, mosquito larvae and whirligig beetles. Those lakes with the greatest diversity of species tend to be the most stable. However, changing or disturbing even one component of the ecosystem affects all of the other components. Although the effects may not be seen immediately, they will occur.

Lakes are the least permanent and probably the most fragile part of Illinois’ surface water system. All lakes are considered to be temporary because over time they fill in through the process of eutrophication. Because water moves much more slowly through a lake than it does through a stream, lakes act as settling basins. Inflowing solid and dissolved substances, natural and synthetic, may drop out of the water and build up on the bottom. Seepage lakes are fed primarily by groundwater, while drainage lakes are fed by surface runoff and tributary streams. Drainage lakes tend to show immediate responses to dramatic precipitation changes. However, seepage lakes may show little change in water levels during prolonged dry periods because the groundwater supplying them tends to remain fairly constant. If a seepage lake is affected by a severe drought, it may take several years for water levels to return to normal. Changes in the watershed may also affect the lake’s water balance. Undeveloped land tends to absorb rainfall and release it slowly. Yet when land is covered with impervious structures like roads and parking lots, precipitation runs off quickly and may change water levels in lakes drastically.

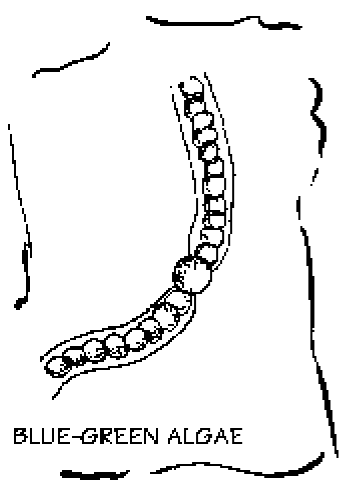
Physical Properties

Many Illinois lakes are deep enough to stratify, or form layers of water with different temperatures. Stratification occurs because water’s density changes with its temperature. Water is densest at 39EF. Above and below that point, water becomes lighter. In very shallow lakes, stratification does not occur because wind and wave action keep the water molecules mixed throughout.

In the fall, air temperatures cool the surface waters of a lake to 39EF. When the water reaches this point, it sinks (fall turnover). As the lake continues to cool, the colder water (32EF) is pushed to the top and may form ice. When spring arrives, the surface waters begin to warm. As they reach 39EF they sink and mix with the deeper water (spring turnover). As the season progresses, the temperature differences between the upper and lower regions of the lake increase. In lakes deeper than about 10 to 12 feet, the lake stratifies into three layers. The upper layer, or epilimnion, extends down about 8 to 15 feet from the surface and is the warmest layer. The middle layer, also know as the metalimnion or thermocline, is narrow and exhibits falling temperatures with increasing depth. Below the thermocline to the lake bottom exists the hypolimnion which has the coolest lake waters.

Temperature is one of the key factors that regulates the kind of species that can live in our lakes. The amount of dissolved gases that water holds varies with the temperature. Warm water, for instance, holds much less oxygen than cold water. Temperature also affects feeding, growth and reproduction of many aquatic organisms.

Biological Properties
Lakes may be divided into three biological zones. The littoral zone extends into the lake from the shoreline. Macroinvertebrates, bacteria, rooted aquatic plants, algae, aquatic vertebrates and other organisms are numerous here. Wetlands often border at least part of the lake's shore. Light may penetrate to the bottom of this zone.



The open water part of a lake is the limnetic zone. Phytoplankton, zooplankton and fish are found here. Since photosynthesis can only occur where light is present, the transparency of the limnetic zone affects the productivity of the phytoplankton and therefore the amount of oxygen produced.

Deep lakes may have a profundal zone. This zone receives little or no sunlight. Bacteria, fungi and other decomposing organisms thrive on the organic matter that falls from the upper layers of the lake. Large amounts of oxygen are used in decomposition, and the profundal zone is known for being deficient in oxygen.

Chemical Properties and Water Quality Testing
Dissolved Oxygen (DO)
The amount of oxygen dissolved in a lake's water has a dramatic effect on the organisms present. Under normal conditions water contains 30 times less oxygen per given volume than air. Oxygen may enter a lake by diffusion from the atmosphere and by photosynthesis. Factors affecting dissolved oxygen levels include photosynthetic activity, wind and wave action, the amount of decomposing organic matter, time of day, salinity, atmospheric pressure, volume of water and temperature. Winter can be particularly stressful for a lake's aquatic life. Ice may seal off atmospheric oxygen. A layer of snow may block sunlight penetration through the ice. If these conditions persist for a lengthy period, oxygen-producing organisms may die while decomposition and respiration for other organisms continues. Oxygen levels may fall so low that a winter kill occurs.

Testing for DO is done with kits that may be purchased from scientific supply houses. DO is usually expressed as milligrams per liter (mg/l) or parts per million (ppm).

Biochemical Oxygen Demand (BOD)
Biochemical oxygen demand measures the amount of oxygen used by microscopic organisms as they decompose organic materials. Increased quantities of plant life in a water body usually lead to increased levels of BOD. Increased levels of organic wastes also lead to increased BOD. Sources include natural waste material, such as leaves, factories/processing plants, agricultural runoff and wastewater treatment plants. Test kits may be purchased from scientific supply houses.

In water bodies with high BOD levels, most of the available oxygen is used in the process of decomposition. Aquatic life must be tolerant of low oxygen levels, move or die. When this condition occurs, organisms that thrive in low oxygen may flourish.

Total Solids
Total solids includes both dissolved solids (pass through a filter) and suspended solids (trapped by a filter). The category includes living and nonliving items. Typical inorganic components are the result of weathering and soil erosion in the watershed and resuspension of sediments. Suspended solids may contain excess nutrients, pesticides and toxins. Organic suspended solids are mainly algae and decaying organic matter. High concentrations of total solids may lead to the following problems: a laxative effect in drinking water; an unpleasant taste in drinking water; reduced water clarity; decreased photosynthesis; and an increase in water temperature. Low concentrations of total solids may limit growth of aquatic life. Test kits may be

purchased from scientific supply houses.

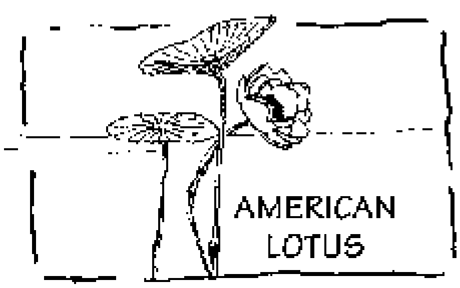
Turbidity

Turbidity (cloudiness) measures the clarity of water. The more suspended solids in the water, the higher the turbidity. Some turbidity is normal from dissolved organic matter, sediment and minerals. Increases above normal levels may be caused by soil erosion, waste discharge, runoff and other factors. High turbidity leads to warmer water, lower oxygen levels and less photosynthesis. It can clog fish gills, reduce growth, reduce disease resistance, cover eggs and larvae and eliminate habitat. Turbidity is often measured with a Secchi disk.

Total Phosphorus

In many lakes the amount of phosphorus present controls the amount of plants present. This essential nutrient can also cause problems if it is present in significant quantities. Phosphorus added from sewage treatment plants, lawn and farm fertilizers, poor septic systems or other sources leads to increased growth of algae and aquatic plants, sometimes to detrimental effect. Lakes are referred to as "young," middle aged" or "old." High levels of phosphorus continually being added to a lake, or phosphorus loading, can cause eutrophication, in which the lake ages before its time.

Phosphorus is measured in parts per billion (PPB). To give you an idea of the dimensions of this measurement, one part per billion would be like one pinch of salt for every 10 tons of potato chips or one second in 32 years or one drop of water in 500 barrels of soft drink.



Nitrogen

Nitrogen is used by organisms to build proteins. It is very abundant in its molecular form, but most organisms cannot use it in this form. Some species of blue-green algae are able to use nitrogen directly from the atmosphere. They also convert it into forms that aquatic plants can use, namely ammonia and nitrate. Nitrogen is then passed to aquatic animals as they eat the plants or organisms that have eaten the plants. Decomposition of organic matter and excretions of aquatic animals may contribute large amounts of nitrogen compounds into the water which can lead to eutrophication. Ammonia, a nitrogen compound formed during organic decomposition, can be toxic to aquatic life in significant quantities.

Test kits may be purchased from scientific supply houses, generally for nitrates. Nitrate test results are usually expressed as the level of nitrate-nitrogen, which means nitrogen in the form of nitrate. Levels below one part per million (ppm) indicate unpolluted water. Concentrations of 0.03 ppm or above lead to increased plant growth. Levels above 0.10 ppm may contribute to such increased plant growth that oxygen is depleted.

pH

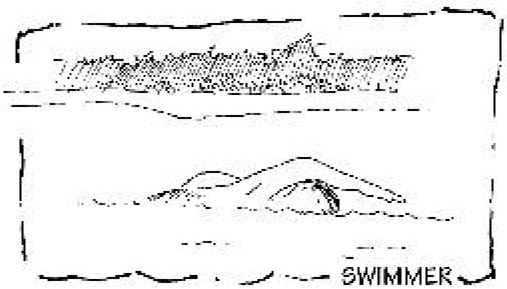
This test measures the hydrogen ion concentration of substances. The pH scale ranges from 0-14. Neutral solutions have equal amounts of hydrogen ions and hydroxide ions. Their pH is 7. If a substance has more hydrogen ions than hydroxide ions, its pH is between 0 and 7 and is considered acidic. If a substance has more hydroxide ions than hydrogen ions, its pH is between 7 and 14, and it is considered basic. For every one unit change in pH, there is a ten-fold change in the acidic or basic content of the sample. Many factors can affect pH, including acid rain or snow and the types of rocks and minerals found in the area. Testing is done with a pH meter or pH paper.

Under normal conditions most Illinois lakes have a pH between 6.5 and 9. Although rainwater in Illinois is slightly acidic (about 4.4), most lakes are able to offset this acidity by naturally occurring buffering compounds in the water. A pH reading of below 5 is considered critical and damage to the gills of aquatic organisms may occur. Readings of 5 to 6 are rated as endangering because this level of acidity is toxic to some organisms. Readings between 6 and 8 are considered satisfactory.

Fecal Coliform

Fecal coliform bacteria are found in the solid wastes of humans and other warm-blooded animals. These bacteria can enter water bodies through direct release by animals, from runoff carrying animal wastes and from human sewage. Fecal coliform bacteria naturally occur in the digestive tracts of warm-blooded animals. Pathogenic bacteria may be present along with the fecal coliform bacteria. If fecal coliform counts are high for an area, there is an increased chance that pathogenic organisms are present, too. Pathogenic organisms are usually not sampled directly because they are few in number and difficult to count. Fecal coliform results are stated as number of colony forming units (CFU) per 100 ml of water. Test kits may be purchased from scientific supply houses.

No fecal coliforms should be present in drinking water. A range of 200-1,000 CFU per 100 ml of water is safe for swimming, although people often swallow water when swimming and chances of infection are great. CFU readings of 1,000-5,000 per 100 ml of water are considered safe for activities like boating and fishing. Ear infections, dysentery



and hepatitis may be contracted in areas with high fecal coliform counts.

Temperature

Temperature of the water directly affects the amount of dissolved oxygen present, chemical concentrations, rate of photosynthesis, metabolic rate of aquatic organisms and sensitivity to diseases and parasites. Water has a high heat capacity and resists temperature change. Cool water holds more oxygen than warm water. Thermal pollution occurs when warm water is added to a natural body of water, generally by industries, dams and runoff. Actions such as clearing shoreline vegetation may cause an increase in water temperature. Soil erosion contributes to warmer water because the suspended soil particles absorb heat. Temperature is measured with a thermometer.

Most aquatic species are acclimated to specific ranges of water temperatures. As the temperature changes, those species that are adapted to one range of temperatures will be replaced by those that are tolerant of the new temperature. At temperatures greater than 68EF, many plants and fish diseases thrive, as do most bass, crappie, bluegill, carp, catfish and caddisflies. Temperatures in the range of 55-68EF support some plants and some fish diseases along with salmon, trout, stoneflies, mayflies, caddisflies and water beetles. Water temperatures below 55EF are habitable for trout, caddisflies, stoneflies and mayflies. Rapidly changing water temperatures can cause thermal stress to aquatic organisms.

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See related CD-ROM components: *Illinois Aquatic Species Fact Sheets; Illinois Aquatic Exotics Fact Sheets; Illinois Rivers and Lakes Fact Sheets; WILD Math: How Many Fish are in This Lake?*

UNIT 2, LESSON 2
ACTIVITY 2

RESERVOIR ACTIVITY

SUGGESTED GRADE LEVELS: 7-9
SUBJECTS: English language arts, mathematics, social science, fine arts
SKILLS: analysis, computation, drawing, generalization, inference, research, small group work, writing
CORRELATION TO ILLINOIS LEARNING STANDARDS: English language arts 1C, 3C, 4A, 4B, 5A, 5C; mathematics 6B, 6C, 10A; social science 17C; fine arts 26B

OBJECTIVES
Students will 1) realize the economic importance of the three major reservoirs in Illinois; and 2) consider the impact of these reservoirs on the counties in which they are located.

METHOD
Students will use data presented to calculate tourism facts about the three major reservoirs. Students will manage a budget and create advertisements to increase tourism at one of the lakes.

BACKGROUND
Carlyle Lake, Rend Lake and Lake Shelbyville are the three Illinois reservoirs constructed and managed by the U.S. Army Corps of Engineers. Carlyle Lake is a part of Bond, Clinton and Fayette counties. It is the largest inland lake in Illinois. Rend Lake is surrounded by Jefferson and Franklin counties. It is the second largest inland lake in the state. Lake Shelbyville, third largest inland lake in Illinois, is bordered by Shelby and Moultrie counties. For more specific information about each lake, consult the *Illinois Rivers and Lakes Fact Sheets* found in this education kit.

The lakes serve a variety of purposes. Flood control, water quality control, public water supplies, area redevelopment, recreation, tourism, commercial fishing and fish and wildlife conservation are just some of the uses for these sites. Since their construction, the lakes have also had profound impacts on the communities adjacent to them. Illinois tourism is a $16 billion annual business and the second largest tax revenue producing industry in Illinois. These lakes are well-known tourist attractions. The following activity will help students visualize how economically important a water body can be.

MATERIALS
for each group: copy of “Reservoir Facts,” “Student Record Sheets” and *Illinois Rivers and Lakes Fact Sheets* for Carlyle Lake, Lake Shelbyville and Rend Lake; writing materials; calculator; Illinois road map (available from the Secretary of State’s offices); U.S. highway map or atlas; paper or graph paper; ruler

PROCEDURE
1. Divide the class into cooperative groups of two to four students. Give one copy of the “Reservoir Facts,” “Student Record Sheets” and water body facts for Carlyle Lake, Lake Shelbyville and Rend Lake to each group. Be sure that each group has writing materials, a calculator and access to Illinois and U.S. road maps.

2. Ask students to fill in the answers to the questions on the “Student Record Sheets.”

3. Conduct a general discussion regarding the facts about these lakes. Were the students impressed by any particular features?

4. Assign each group one of the counties listed. More than one group can be assigned the same county. Give each group a “budget” of $200,000 to increase tourism in their county by promoting the lake. What would they spend the money on? Students should compile an actual budget with expenditures listed. They should develop a 12-month budget. Students may need to do some independent research such as contacting radio and television stations about the cost of advertisements, hotels about convention costs or other items dependent upon their budget. For those selecting advertisements, they should actually write the advertisement, write and/or videotape the television commercial, design the poster, develop the brochure or complete other appropriate items (buttons, bumper stickers, etc.).

EXTENSIONS

1. Take students to visit one of these reservoirs. Have them look for evidences of tourism.
2. Contact the tourism director in your county or community. Arrange for that person to speak to the class about his or her job and water-related tourism in the community.
3. Bring in a speaker from one of the communities bordering a reservoir who remembers when the lake wasn't there. Ask him or her to talk about changes to the community.
4. Complete the *WILD Math: How Many Fish are in This Lake?* activity in this kit.

EVALUATIONS

1. Student groups should turn in the student record sheet for evaluation.
2. Student groups should be evaluated on the tourism budget and support materials that they develop. Groups could also be evaluated on a short presentation of this material to the class.
3. Students should write a short summary paper about the importance of these lakes to the counties hosting them and to the Illinois economy.

RESERVOIR FACTS

AVERAGE NUMBER OF VISITORS PER YEAR
data obtained from U.S. Army Corps of Engineers

Carlyle Lake - 2.4 million
Lake Shelbyville - 2.5 million
Rend Lake - 2.4 million

TOURISM DOLLARS SPENT
figures obtained from Illinois Department of Commerce and Community Affairs and represent 1995 expenditures for domestic leisure travel expenses only

Carlyle Lake

Clinton County	$16.48 million
Bond County	$ 5.16 million
Fayette County	$ 7.03 million

Lake Shelbyville

Moultrie County	$ 4.15 million
Shelby County	$ 5.05 million

Rend Lake

Franklin County	$14.48 million
Jefferson County	$28.63 million

REND LAKE VISITATION DATA
data obtained from the U.S. Army Corps of Engineers Activity Use Survey at the lake - averages for three-year period

hunting - 39%	fishing - 38%
sightseeing - 35%	boating - 35%
picnicking - 26%	camping - 24%
swimming - 17%	skiing - 9%

CARLYLE LAKE Monthly Visitation Report - Total Visits per Month
data obtained from U.S. Army Corps of Engineers

October 1995 - 250,902	February 1996 - 40,099	June 1996 - 424,062
November 1995 - 93,914	March 1996 - 42,331	July 1996 - 373,389
December 1995 - 37,990	April 1996 - 36,920	August 1996 - 346,189
January 1996 - 25,569	May 1996 - 294,666	September 1996 - 328,315

Group Camping Report

Visitors from the following 22 states camped at Carlyle Lake during the period October 1995-September 1996: Alabama, Arizona, California, Florida, Illinois, Indiana, Kentucky, Maine, Massachusetts, Michigan, Missouri, New York, North Dakota, Ohio, Oklahoma, Oregon, Pennsylvania, Tennessee, Texas, Utah, Washington, Wisconsin

Visitors from 52 Illinois counties camped at Carlyle Lake during the period October 1995-September 1996. Listed below are the top ten counties represented in order of their ranking (most frequent visits to fewer visits).
Madison, St. Clair, Clinton, Macoupin, Marion, Washington, Montgomery, Monroe, Bond, Randolph

STUDENT RECORD SHEET

Group member names:____

1. Why and when were these lakes built?

	Why	When
Carlyle Lake	____________________________	__________
Lake Shelbyville	____________________________	__________
Rend Lake	____________________________	__________

2. Find the total tourism dollars spent for each lake. Place your answer in the blanks below. Write the numbers out (5,500,000 instead of 5.5 million, for example).

Carlyle Lake ________________________

Lake Shelbyville________________________

Rend Lake ________________________

3. What is the average amount of money spent by each tourist at these reservoirs?

Carlyle Lake ________________________

Lake Shelbyville________________________

Rend Lake ________________________

4. Lake Shelbyville hosts more tourists annually than the other two reservoirs yet receives the least money per person from them. List some possible explanations for this situation.

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5. If each tourist at Lake Shelbyville were to spend the same average amount as a tourist at Rend Lake, how much more income would have been generated for Moultrie and Shelby counties in one year? Show your work.

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6. If you were the tourism director for a county bordering one of these lakes what could you do to increase tourism to your county?

____

____

____

7. Using the Rend Lake visitation data, which months of the year would you say are the busiest for the employees at the lake? Why?

____

____

8. On a separate piece of paper, graph the number of visitors per month at Carlyle Lake.

What are the four busiest months at Carlyle Lake?_______________________

What would you hypothesize are the top three activities at the lake during these months?

____

If you were the park manager at Carlyle Lake, what could you do to increase park attendance during the slower months?

____

____

9. Visitors from what state traveled the farthest to reach Carlyle Lake? (Base your distances on travel from the capitol of each state in the most direct route by highway.)

____

How many miles did these visitors travel to reach the lake (one way)? (Assume that they came from the capitol of this state by the most direct highway route.)

____

10. Calculate the average distance traveled by visitors from the 10 Illinois counties that most frequently camped at Carlyle Lake. Use the distance from the county seat to Carlyle, taking the most direct highway route.

____

What do you notice about the location of these 10 counties in relation to the lake?

____

If you were in charge of tourism for the city of Carlyle, would you want to spend more money advertising the lake in southern Illinois or northern Illinois? Why?

____

____

11. List three positive and three negative aspects of having a large reservoir in your county.

Positive	Negative
____________________	____________________
____________________	____________________
____________________	____________________

UNIT 2, LESSON 2
ACTIVITY 3

GREAT LAKES FOOD WEB

SUGGESTED GRADE LEVELS: 7-9
SUBJECTS: English language arts, science, social science
SKILLS: analysis, classification, discussion, generalization, inference, reading
CORRELATION TO ILLINOIS LEARNING STANDARDS: English language arts 1C, 3C, 4A, 4B; science 12B, 13B; social science 17C

OBJECTIVES
Students will: 1) identify important species and components of Great Lakes food webs; and 2) understand that environmental changes, introduction of exotic species, over harvest and social/technological changes have influenced Great Lakes fisheries over time.

METHODS
Students will represent parts of the food web in an interconnected activity.

BACKGROUND
The Great Lakes are a relatively young system compared with the world's oceans. The lakes were formed between 14,000 and 4,000 years ago, leaving a relatively short time for fishes to evolve or move into the region since the last glaciers retreated. In addition, they have areas that are cold, deep and low in nutrients and the northern climate where they are found has a short growing season.

In spite of their harsh surroundings, the Great Lakes are a productive system for a variety of life forms. They compose one of the largest surface freshwater systems in the world, and their sheer size means that they can support an abundance of life. Together, the Great Lakes cover more than 94,000 square miles of surface area, an area larger than the states of New York, New Jersey, Connecticut, Rhode Island, Massachusetts, Vermont and New Hampshire combined! They contain six quadrillion gallons of fresh water, one-fifth of the world's supply of fresh surface water. For specific information about Lake Michigan, see the *Illinois Rivers and Lakes Fact Sheets* in this kit. Another Lake Michigan activity may be found in Unit 3, Lesson 2.

The Great Lakes provide a variety of habitats, areas where fishes can find their life requirements such as food, shelter and space. The littoral zones are those nearshore areas shallow enough for light to penetrate the water and reach the lake bottom. Like coastal wetlands, the littoral zones are very valuable for Great Lakes fisheries because they provide areas for spawning and feeding. In protected areas, rooted plants provide cover for fishes and other life. The pelagic zone is the rest of the open-water area of a lake. Some adult fishes, such as salmon, prefer to spend a large part of their time in this zone. The benthic zone is at the bottom of the lakes. Bacteria, detritivores (eat decaying organisms) and some fishes, like burbot and lake sturgeon, live here.

A food chain is a group of organisms which feed on each other and through which energy is passed from one organism to another. Producers form the base of the Great Lakes food chain. They convert and store the sun's energy and available nutrients into living biomass. In the Great Lakes, most of these producers are microscopic, floating organisms called phytoplankton. Examples are diatoms (algae), green algae, blue-green algae and dinoflagellates (algae with two flagella and a cellulose cell wall).

The next level of the chain is made up of another group of tiny floating organisms called zooplankton. These are the first consumers. They eat other organisms. Typical zooplankton include copepods (small crustaceans), protozoans, cladocerans (crustaceans called water fleas), amphipods (small crustaceans) and rotifers.

Macroinvertebrates form the third level of the chain. Deepwater macroinvertebrates include *Diporeia* spp. (an amphipod), opossum shrimp, freshwater worms and midges. Shallow water dwellers include leeches, clams, snails and insect larvae.

strain particles out of the water using their gill rakers. Water passes around these hard projections from the gills, which look much like a rake or comb. Solid particles are trapped in the mouth and may be swallowed. Other fishes, like lake trout, feed on plankton, macroinvertebrates and fishes. Generally, juveniles of large or medium-sized fishes, like salmon and yellow perch, feed mainly on plankton and macroinvertebrates until they grow large enough to eat small fishes. Small fishes provide much of the food for larger fishes. These small fishes, such as bloaters, lake herring, sculpins, shiners, alewife and smelt, are called forage fishes.

Besides the fishes noted above, consumers of fishes include birds and mammals. As organisms in the lakes die, decomposers such as bacteria and fungi begin the break down of these organic materials into nutrients that become available for the producers.

The lakes can support only a limited amount of life forms. The carrying capacity (maximum population size an area can support) and productivity of a part of any lake is determined by a variety of factors. The number and bulk of top level consumers an area can support is always less than the amount of organisms under that level. At each level, some energy is used by the organisms for growth, reproduction or movement, and some energy is lost as heat. In reality, life in the Great Lakes does not exist as a simple food chain. Many organisms feed on more than one type of food. A better picture of lake ecology is shown by a food web. The food web in these lakes is complex and ever changing.

MATERIALS

copies of “Species Profile Cards” (one card per student); glue (optional); scissors; index cards or stiff paper; string; overheads (from masters): “Great Lakes Ecology and Food Web” and “ Pyramid of Biomass and Biomagnification in the Great Lakes”

PROCEDURE

1. Copy and cut out the “Species Profile Cards.” You may want to glue the cards on index cards or heavy paper to facilitate their use in future classes. Lamination is also recommended. The “Species Profile Card” for forage fishes may be divided into five separate cards to represent each of the fishes listed. Make an additional card for each of the following: sunlight; nonliving nutrients; and humans. If you have enough students, make and distribute multiple copies of the following cards: phytoplankton; zooplankton; benthos; and forage fishes.

2. Using the overhead masters provided, lead a discussion about different life forms found in the Great Lakes. Note the different areas of the lake, types of organisms present and point out the pyramid of biomass (the mass of all organisms shown at each trophic level). Do not be too specific with information, but allow the students to get a general idea of what is present in the lakes. Be sure to review the vocabulary associated with different habitat zones in the lake.

3. Give one species profile card to each student.

4. By stretching the string between students, first connect the producers (phytoplankton) with sunlight and nonliving nutrients. Next, connect the first level consumers, zooplankton and benthos, to the phytoplankton and to each other. Next, connect the forage fishes into the food web. As you connect each group of organisms, have the students read the life history information on their cards and discuss the food web relationships as you go.

5. Now tell the students that they will be adding the predator fishes found in the Great Lakes originally (prior to the 1920s). Have the remaining students look at their cards. Which are “native?” Which species were introduced/exotic and arrived later? Add to the food web: lake trout; walleye; yellow perch; and lake whitefish. Add humans to the food web.

6. Consider what happened to the fisheries over time. Set the stage by telling students that it is the 1920s. The Great Lakes fisheries have started to decline due to logging, dams, growth of cities and over harvest. The arrival of exotic species in the Great Lakes creates new challenges. Have each student read his/her card. Add the smelt. Add the sea lamprey. Add the alewife. With each addition, add the organism, then let the added species gently pluck or strum his/her string connection to the food web. When the other organisms already in the web feel the motion, have them gently pluck or strum their connections. Watch the effects of each introduction eventually spread throughout the entire food web.

7. Tell the students it is the 1960s, and alewife have become a terrible problem in some areas in the Great Lakes. As fisheries managers, you decide to introduce a predator to help solve the alewife problem. Add Pacific salmon to the web (read card).

Watch the effects throughout the web.

8. Now a new problem is becoming obvious. Pollution has led to eutrophication of some areas in the lakes (particularly in shallow bays). It leads to tremendous growth of algae (phytoplankton) which are less beneficial to the small organisms that depend on algae for food. As this growth dies and decays, valuable oxygen is used up in the lakes. What are the effects up the food chain?

9. Now we are in the present. Cleanup efforts have improved Great Lakes water quality. What effects occur in the food web? Two new invaders have just arrived in the Lakes. Add the *Bythotrephes cedarstroemi* ("Bc," a water flea) and the zebra mussel (one by one) to the food web (read cards). Have the students hypothesize what will be the effects of these additions.

EXTENSIONS

1. Research in detail the life history of a Great Lakes organism. Make a display, write a play or read a technical article in a scientific journal.
2. Seine a shallow water area for fishes. A seine is a net stretched between two poles with floats at the top of the net and weights along the bottom of the net. It may be purchased at sporting goods stores. (Note: in order to catch or possess fishes, a fishing license and other permits may be required. Check with the Illinois Department of Natural Resources, Division of Fisheries Resources, One Natural Resources Way, Springfield, IL 62702-1271, phone 217/782-6424, for regulations.) Identify fishes. Keep field notes.
3. Find or draw a picture of each organism described in the food chain. Glue the picture on one side of a notecard. Write the species facts on the other side of the card. Use the cards to learn species identification and facts.
4. Construct a large cross section of Lake Michigan as a mural. Assign one type of organism to each student. Have the student find a picture of the organism or prepare and color a drawing of the organism. Let each student use the fact card in the activity to learn where the organism lives in the lake. Place the photograph/drawing in the proper location of the lake. Discuss the variety of organisms found and the diversity of habitat types available.

EVALUATIONS

1. Have each student answer the following questions in one or two paragraphs. Can we restore the biological conditions of the Great Lakes to the way they existed in the past? Why or why not?
2. Have each student relate a typical Great Lakes food chain, with specific organisms named. Ask the students to delete one link in the chain and explain the results on all the other organisms in the chain. Why would a food web be a better representation of the processes occurring in the lakes than a food chain? Diagram both situations.

Adapted with permission from: Michigan State University and Michigan Sea Grant Extension, *The life of the lakes: a guide to Great Lakes fishery education materials* (East Lansing, Michigan. 1994).

FORAGE FISHES

DESCRIPTION: small fishes which serve as food for larger fishes

EXAMPLES:

sculpins - 7 inches or less; large head, stout body; large and fanlike pectoral fins (fins directly behind the head of a fish); pelvic fins (usually with one spine) under pectoral fins
bloater - 8-10 inches; long, deep-bodied fish with adipose (fat) fin
lake herring - 8-12 inches; similar to bloater but with more gill rakers (food strainers)
sticklebacks - 2-4 inches; small, thin fish; dorsal spines unconnected by fin tissues
emerald shiner - 2-3 inches; silvery, iridescent body

ADULT DIET: mostly plankton, insect larvae, some benthos; larger species may take smaller fishes

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

sculpins - benthic and littoral; some spawn in spring, others in late summer or early fall;
Mottled and slimy sculpins establish nests under rocks or other debris and deposit eggs on the ceiling of the nest. Deepwater sculpins eat mainly midge larvae and *Diporeia* spp. Spoonhead sculpins eat planktonic crustaceans in deep-water areas and aquatic insect larvae inshore. Other sculpins eat mainly aquatic insect larvae and crayfish.
bloater - pelagic and benthic; spawn in February through March; eat mainly zooplankton
lake herring - pelagic; gather in large schools to spawn in late November or early December; mainly a plankton feeder
sticklebacks - littoral and benthic; spawn in spring or summer; some build nest of sticks or weeds; eat aquatic insects, planktonic crustaceans
emerald shiner - mainly pelagic; spawn in summer; form schools offshore in summer, move in shore in fall and in spring; spend days in deep water and move to surface at night; feed mainly on plankton and algae and eat some midge larvae

ALEWIFE *exotic

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

ADULT DIET: planktivore (plankton-eating); may also eat small fishes and fish eggs

HABITAT/BEHAVIOR: mainly pelagic, but also inshore; spawns in shallows in late spring, early summer; strains plankton from water through structures called gill rakers (hard, comb-like structures on gills, allow strained food to be deposited in mouth); schools move inshore to feed at night; die-offs may occur in spring and summer; not native to Great Lakes--invaded from Atlantic Ocean through Erie Canal into Great Lakes

SPECIES PROFILE CARDS

WALLEYE

DESCRIPTION: usually 13-20 inches, 1-3 pounds but can grow much larger; dorsal (back) fin with hard-rayed and soft-rayed sections; large eyes and white tip on tail

ADULT DIET: piscivore (fish-eating)

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

SPECIES PROFILE CARDS

YELLOW PERCH

DESCRIPTION: usually 4-10 inches; yellow belly and dark vertical bars on sides

ADULT DIET: forage fishes, aquatic insects

HABITAT/BEHAVIOR: benthic and inshore; spawn in late April through early May near aquatic plants

LAKE WHITEFISH

DESCRIPTION: usually 17-22 inches, 1.5-4 pounds; silvery with pale green-brown back

ADULT DIET: planktivore (plankton-eating), also some small fish and fish eggs

HABITAT/BEHAVIOR: benthic; spawn in November and December usually in shallows; found in schools; found in hypolimnion in summer and move to shoals (shallow areas) in spring

SPECIES PROFILE CARDS

ZEBRA MUSSEL *exotic

DESCRIPTION: thumbnail-sized mussel with light and dark bands

ADULT DIET: filter-feeder on small particles and organisms in water

HABITAT/BEHAVIOR: adults are benthic and attach to hard surfaces; usually found in clusters; larvae are planktonic (free-swimming, microscopic); not native to Great Lakes--arrived in Great Lakes in ballast water of international cargo vessel(s) which had been to an inland Russian port

SPECIES PROFILE CARDS

SPINY WATER FLEA *exotic

DESCRIPTION: slightly larger than 1/4 inch; spiny tail; large, single eye

ADULT DIET: predatory, pierces and shreds smaller zooplankton

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

BROWN TROUT *exotic

DESCRIPTION: usually 20-22 inches but can grow much longer; 4-5 pounds; dark crosses or checks on silvery body, tail with occasional dark spots, 10-12 anal rays (support structures in anal fin)

ADULT DIET: smelt, alewife, other forage fishes

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

SPECIES PROFILE CARDS

RAINBOW TROUT OR STEELHEAD *exotic

DESCRIPTION: usually 20-30 inches and 6-10 pounds; light body with dark spots, side has pinkish band

ADULT DIET: invertebrates, plankton, forage fishes

HABITAT/BEHAVIOR: pelagic (open water); spawn in rivers, streams which they enter in late October through early May; most spawning occurs in the spring; do not die after spawning; not native to the region--introduced from the Pacific northwest

SPECIES PROFILE CARDS

LAKE TROUT

DESCRIPTION: often about 31 inches and 10 pounds; scattered light spots on dark body; forked tail

ADULT DIET: forage fishes such as chubs (ciscoes), lake herring, sticklebacks, alewife, smelt, sculpins

HABITAT/BEHAVIOR: mainly benthic (lake bottom), but may be found at various depths (pelagic and inshore); spawn on rocky reefs during November and December

PACIFIC SALMON - CHINOOK SALMON, COHO SALMON *exotic

DESCRIPTION: **chinook**--adults about 36 inches, 18 pounds; black mouth and inner gums, anal fin with 15-17 rays, black spots all over tail **coho**--can reach about 27 inches, 6.5 pounds; gray gums, anal fin with 13-15 rays, black spots on back and upper half of tail

ADULT DIET: alewife, smelt, other forage fishes

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

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SPECIES PROFILE CARDS

SEA LAMPREY *exotic

DESCRIPTION: can grow up to 34 inches; lacks jaws; has circular mouth with rasping teeth; no paired fins

ADULT DIET: fluids and tissues of large fish, particularly salmon and trout which have small scales

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

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SPECIES PROFILE CARDS

RAINBOW SMELT *exotic

DESCRIPTION: 7-8 inches and less than 0.25-1 pound; long silvery body with rainbow-like iridescent color on sides; adipose fin

ADULT DIET: planktivore (plankton-eating)

HABITAT/BEHAVIOR: mainly pelagic; spawns in streams, rivers; spawn in spring

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BENTHIC LIFE IN THE GREAT LAKES

DESCRIPTION: microscopic to small animals which live on the lake bottom; includes animals from the following groups

oligochaetes (aquatic worms, leeches)--members of segmented worm group

crustaceans--decapods (crayfish) with heavy shell, claws and 5 pairs of walking legs and amphipods (including *Diporeia* spp.), sometimes called freshwater shrimp, with no shell, gills at the base of the legs and a body slightly flattened side-to-side

aquatic insects--chironomids (midge larvae) with a long cylindrical body and *Hexagenia* (mayfly larvae) with a long body, feather-like gills along the abdomen and three tails at the posterior end

ADULT DIET: scavengers/omnivores--decaying plant and animal debris (detritus), bacteria, algae; some feed on crustaceans or insect larvae; crayfish and midge larvae are mainly herbivorous, but also feed on detritus

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

PHYTOPLANKTON

DESCRIPTION: (diatoms, green algae, blue-green bacteria, protists) microscopic to visible free-swimming plants

ADULT DIET: photosynthetic organisms (produce their own food)

HABITAT/BEHAVIOR: found to depths where light can penetrate water; movement mainly controlled by water movement

ZOOPLANKTON

DESCRIPTION: microscopic to visible animals which are free-swimming; includes a variety of animal types

crustaceans

- **water fleas** (cladocerans)--body has a hard shell; branched swimming antennae; large eye
- **copepods** (e.g., *Cyclops*)--cylinder-shaped body; long, segmented, swimming antennae
- **opossum shrimp** (mysids)--10 pair of jointed legs; looks like miniature crayfish; stalked eyes

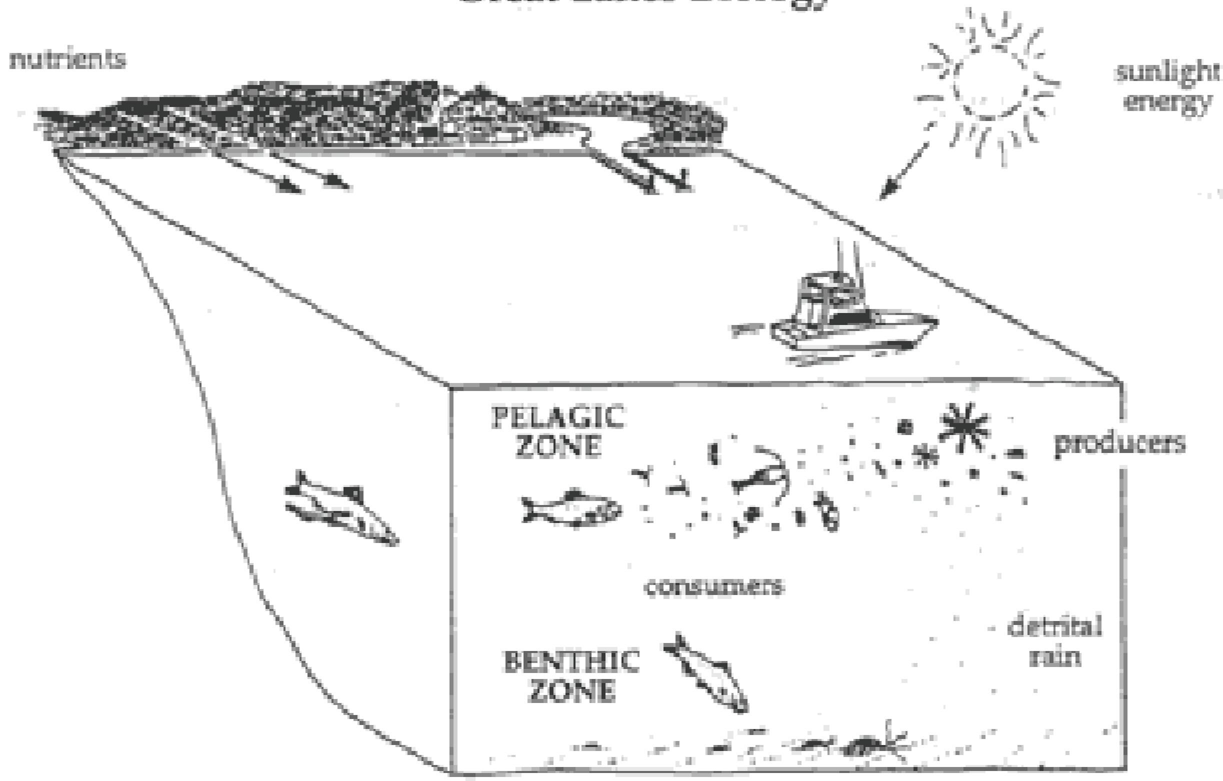
rotifers--rotating hairlike cilia at front of body

protozoans--single-celled animals such as amoebas, paramecia

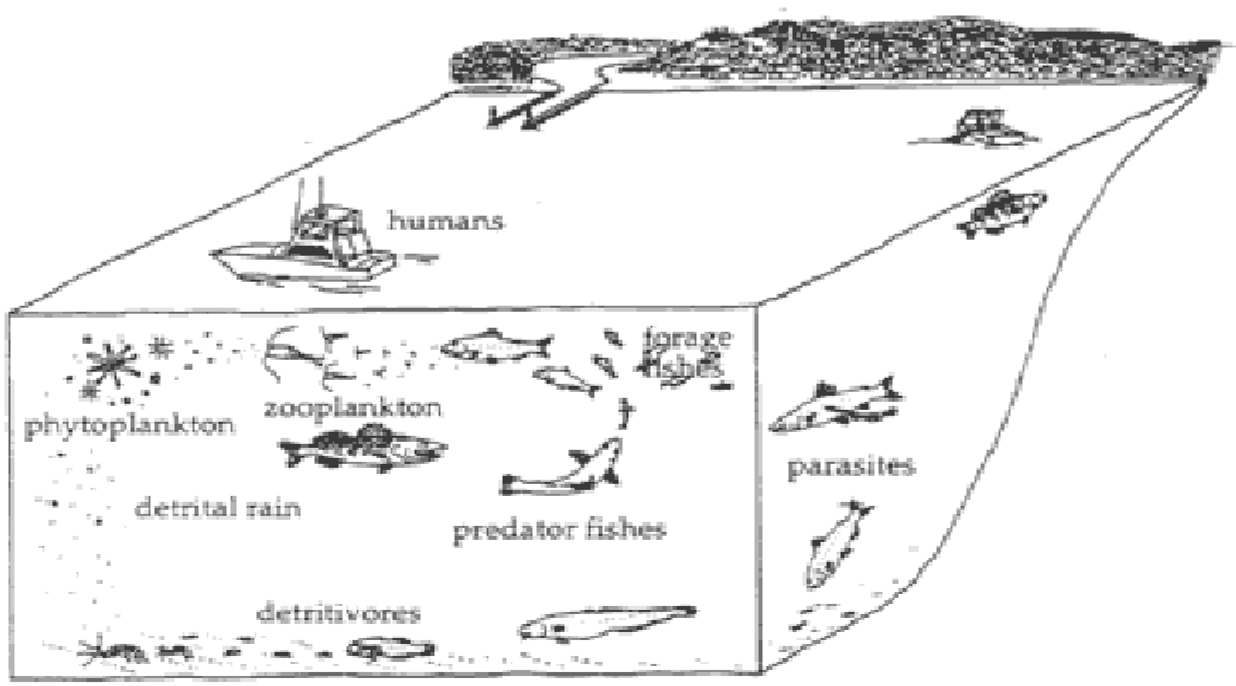
ADULT DIET: mostly omnivorous, eating algae, detritus (decaying organisms), rotifers, protozoa and other crustaceans; *Cyclops* and *Leptodora* (a type of water flea) are predators that grasp their prey; opossum shrimp, daphnia (a water flea) and rotifers sweep food to their mouths and strain it from the water

HABITAT/BEHAVIOR: mostly pelagic; make vertical migrations daily which vary with light levels, season, and age and sex of the individual; most migrate up as darkness sets in and return to deep water at dawn; some species do reverse migration or twilight migration; opossum shrimp are an important food source for trout, whitefish and chub.

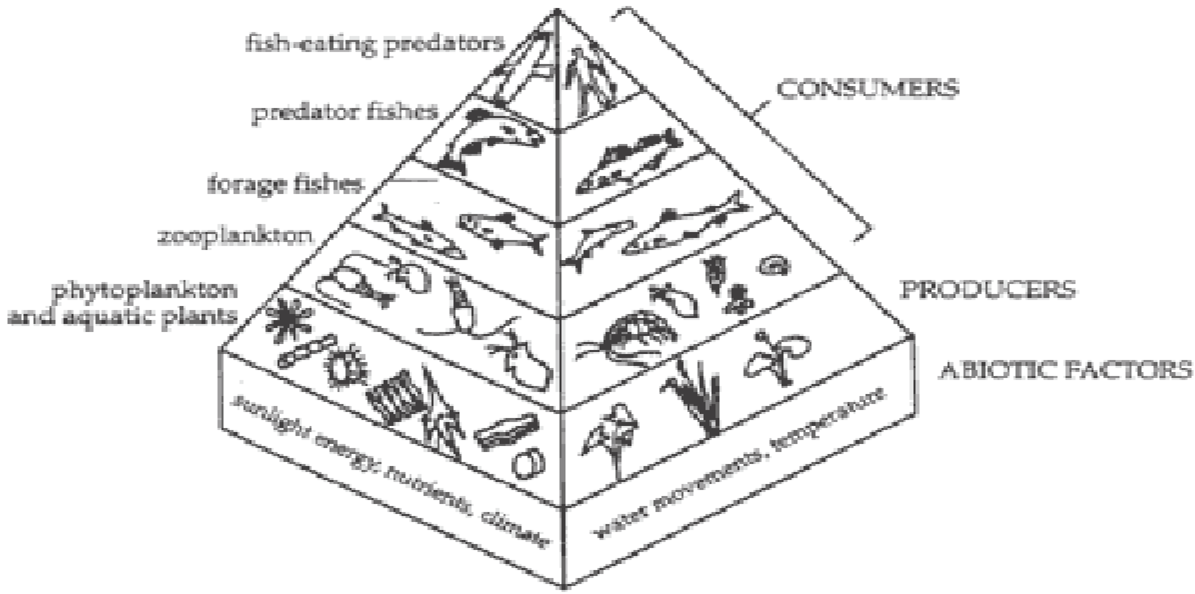
Great Lakes Ecology



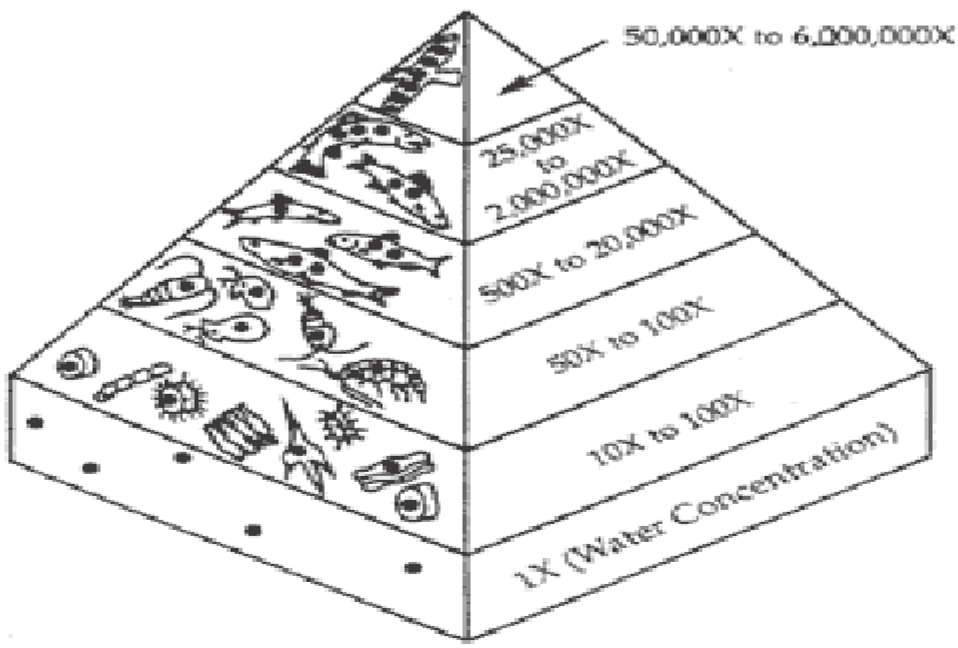
Great Lakes Food Web



Pyramid of Biomass



Biomagnification in the Great Lakes



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