Lake Superior: Who lives there and what do they eat?

Lake Superior Food Chain

Grade Level: 3-5

Activity Duration: 60 minutes

Overview:

I. Lake Superior Fish Families
II. Lake Superior Food Chain Tag
III. Wrap-up and Review

Literacy Connections

Summary: Students begin the lesson by learning how fish are classified and trying their hand at organizing Lake Superior fish into families. Once students have a grasp on "who" lives in Lake Superior, they turn their attention towards what those fish eat and how energy is transferred between the interdependent organisms of an ecosystem. Students will assume various roles in a Lake Superior Food Chain Tag. In successive rounds of Food Chain Tag, new species are introduced and population ratios altered in an effort to balance the simulated ecosystem.

Topic: fish identification, food chain, food web, ecosystem, Lake Superior, producers, consumers, decomposers,

Theme: Lake Superior supports specific fish that can survive in oligotrophic lakes. These fish rely on a food web.

Goals: Students will know the major families of fish in Lakes Superior. Students will understand the concept of a food chain and how it applies to Lakes Superior.

Objectives:

1. Students will classify fish based on external characteristics.
2. Students will explain how a food chain works using Lake Superior organisms.
3. Students will define carrying capacity.
4. Students will explain why having a balance of prey and predator organisms is important to an ecosystem.
5. Students will explain how organisms in a food chain depend on one another for survival.

Lessons and Background Adapted From:

MN DNR MinnAqua Program. (2010). Fishing: Get in the Habitat! Leader's Guide. "Lesson 2.3 – Fish Families."

MN DNR MinnAqua Program. (2010). Fishing: Get in the Habitat! Leader's Guide. "Lesson1.2 – Food Chain Tag."

Suggested MN Science Standards:

3.4.1.1.1 Life Science – Structure and Function in Living Systems
Compare how the different structures of plants and animals serve various functions of growth, survival and reproduction.

3.4.1.1.2 Life Science – Structure and Function in Living Systems
Identify common groups of plants and animals using observable physical characteristics, structures and behaviors.

5.1.1.1.1 The Nature of Science and Engineering – The Practice of Science
Explain why evidence, clear communication, accurate record keeping, replication by others, and openness to scrutiny are essential parts of doing science.

5.1.1.1.4 The Nature of Science and Engineering – The Practice of Science
Understand that different models can be used to represent natural phenomena and these models have limitations about what they can explain.

5.1.1.2.2 The Nature of Science and Engineering – The Practice of Science
Identify and collect relevant evidence, make systematic observations and accurate measurements, and identify variables in a scientific investigation.

5.3.4.1.3 Earth and Space Science – Human Interactions with Earth Systems
Compare the impact of individual decisions on natural systems.

5.4.1.1.1 Life Science - Structure and Function in Living Systems
Describe how plant and animal structures and their functions provide an advantage for survival in a given natural system.

5.4.2.1.1 Life Science – Interdependence Among Living Systems
Describe a natural system in Minnesota, such as a wetland, prairie or garden, in terms of the relationships among its living and nonliving parts, as well as inputs and outputs.

5.4.2.1.2 Life Science – Interdependence Among Living Systems
Explain what would happen to a system such as a wetland, prairie or garden if one of its parts were changed.

Environmental Literacy Scope and Sequence

Benchmarks:

- Social and natural systems are made of parts. (K-2)
- When parts of social systems and natural systems are put together, they can do things they couldn't do by themselves. (K-2)
- In social systems that consist of many parts, the parts usually influence each one another. (3-5)
- Social and natural systems may not function as well if parts are missing, damaged, mismatched, or misconnected. (3-5)
- Social and natural systems can include processes as well as things. (6-8)
- The output from a social or natural system can become the input to other parts of social and natural systems. (6-8)
- Social and natural systems are connected to each other and to other larger and smaller systems. (6-8)
- Interaction between social and natural systems is defined by their boundaries, relation to other systems, and expected inputs and outputs. (9-adult)

Concepts addressed in this lesson: biotic factors, group, similarities and differences, cause and effect, cycles, ecosystem, patterns, predation, trophic level, energy and energy flow

For the full Environmental Literacy Scope and Sequence, see: www.seek.state.mn.us/eemn_c.cfm

Great Lakes Literacy Principles

1. The Great Lakes, bodies of fresh water with many features, are connected to each other and the world ocean.
2. Natural forces formed the Great Lakes; the lakes continue to shape the features of their watershed.
3. Water makes the Earth habitable; fresh water sustains life on land.
4. The Great Lakes support a diversity of life and ecosystems.
5. Much remains to be learned about the Great Lakes.
6. The Great Lakes are socially, economically, and environmentally significant to the region, the nation, and the planet.

For more information about and a complete listing of the Great Lakes Literacy Principles, visit: http://greatlakesliteracy.net/

Materials:

Lake Superior Fish Families:

- Various pictures of fish
- Laminated Lake Superior Fish Families Cards, one set per small group of four or five students
- Fish Characteristics Sheet, one per small group of four or five students

Lake Superior Food Chain Tag

- Aquatic Food Chain Sheet
- Aquatic Food Chain Cards
- Food Chain Identification Tags on clips
- 500 poker chips
- Plastic cups or plastic sandwich bags
- 2 five-foot ropes for shelter
- Masking tape
- 100" rope
- Whistle

Wrap-up

- Feltboard
- Cut outs of aquatic creatures with Velcro on one side.

Background:

Classifying Organisms by Groups[1]

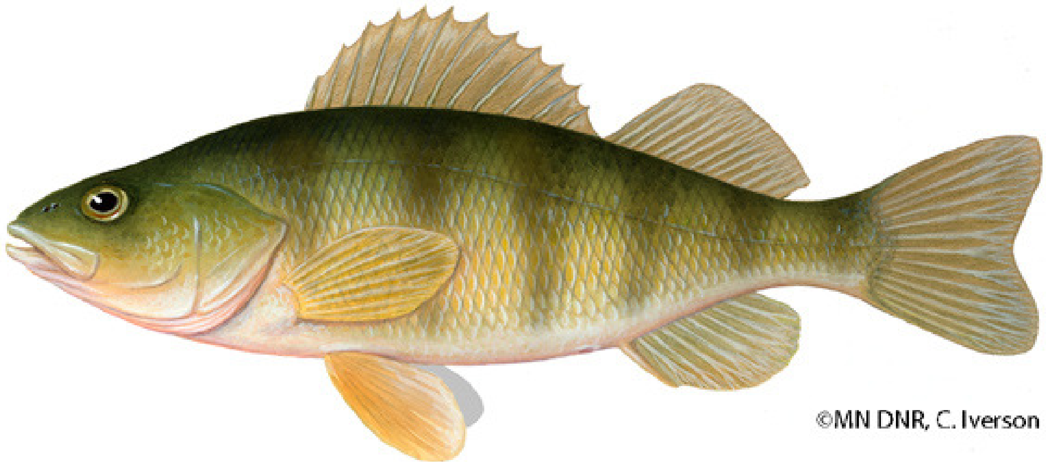
Classification is a method of identifying, naming, and grouping related organisms. In order to communicate with one another, scientists use a worldwide, standardized method of classification called taxonomy. By classifying organisms into groups related to shared physical traits, physiology, genetics, and evolutionary history, scientists hope to discover other similarities among the groups. Taxonomy uses a hierarchy of groups that starts with kingdoms. Kingdoms are divided into groups called phyla (phylum, in singular form), which are further divided into classes. Fish belong to the Kingdom Animalia and the Phylum Chordata, which includes all vertebrates.

Classifying Fish

Fish are often grouped into three main classes:
Class Agnatha: jawless fishes (Greek, *a* = without, *gnathos* = jaws)
Class Chondrichthyes: jawed fishes with cartilage skeletons (Greek, *chondros* = cartilage, *ichthyes* = fish)
Class Osteichthyes: jawed fishes with bony skeletons, also known as bony fish (Greek, *osteon* = bone, *ichthyes* = fish)

Fish from two of these classes inhabit Minnesota: the jawless (Agnatha) and bony fishes (Osteichthyes). Class Chondrichthyes contains mostly marine (saltwater) fish, none of which inhabit the fresh water of North America. Most Minnesota fish belong to the Osteichthyes class; only the lampreys belong to the Agnatha class. And although sturgeon, paddlefish, and bowfin skeletons are composed partially or entirely of cartilage, they're classified as primitive members of the class Osteichthyes.

Classes are further divided into groups called orders. Orders are subdivided into families, which are subdivided into genera (or genus, in singular form), which are further subdivided into species. As the classification system subdivides, individuals within groups become increasingly similar. The members of each progressive subdivision share more and more physical, physiological, behavioral, and genetic traits. Scientists identify unique fish types by their genus and species names. This scientific name is recognized worldwide, and remains constant, even though locally used common names may vary from place to place. The yellow perch, for example, is called lake perch or ringed perch in different parts of the country. These multiple common names would cause confusion if not for the scientific name for this species, *Perca flavescens*—genus name perca (Greek for perch) and species name *flavescens* (Latin for yellow).



Yellow Perch
Perca flavescens
Kingdom—Animalia Animal
Phylum—Chordata With backbone
Class—Osteichthyes With bony skeleton
Order—Perciformes With numerous short, fine-pointed teeth; prefer quiet waters
Family—Percidae Perches (walleye, yellow perch, and darters)
Genus—*Perca* Perch
Species—*flavescens* Yellow

Minnesota Fish Families

Minnesota has a diversity of water types, from cold, shallow streams to large, cool, or warm rivers, and from large, deep, cold lakes to small, warm-water ponds. This diversity, combined with the sheer quantity of lakes and fishable streams, accounts for the 160 fish species found in Minnesota.

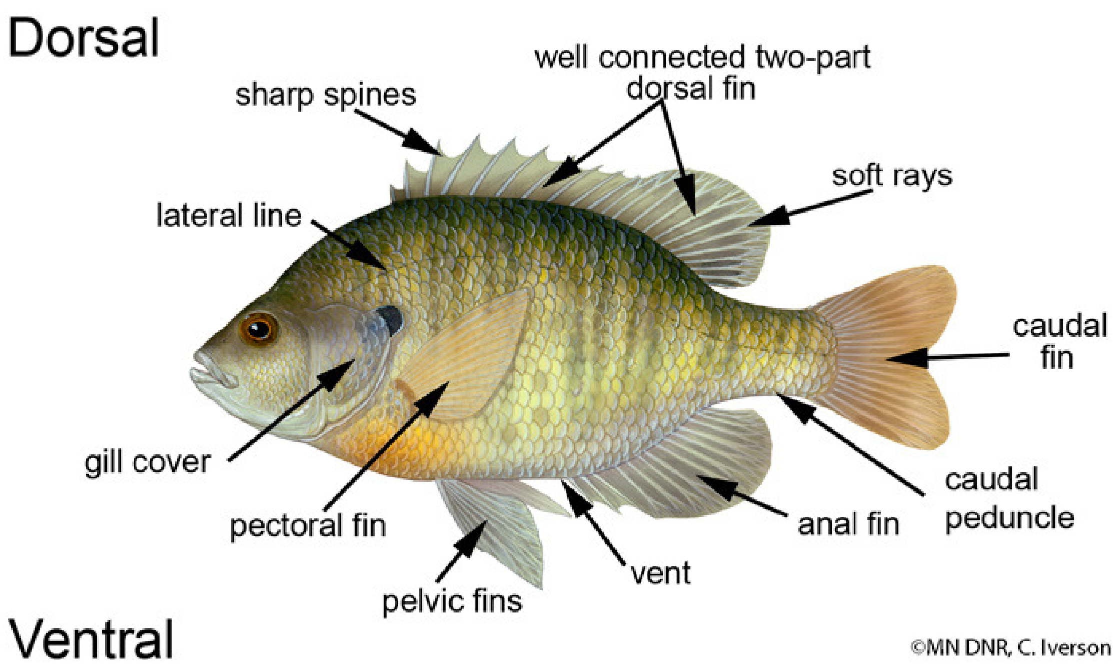
Five of Minnesota's fish families are considered game fish species—these are the fish most often sought by anglers:

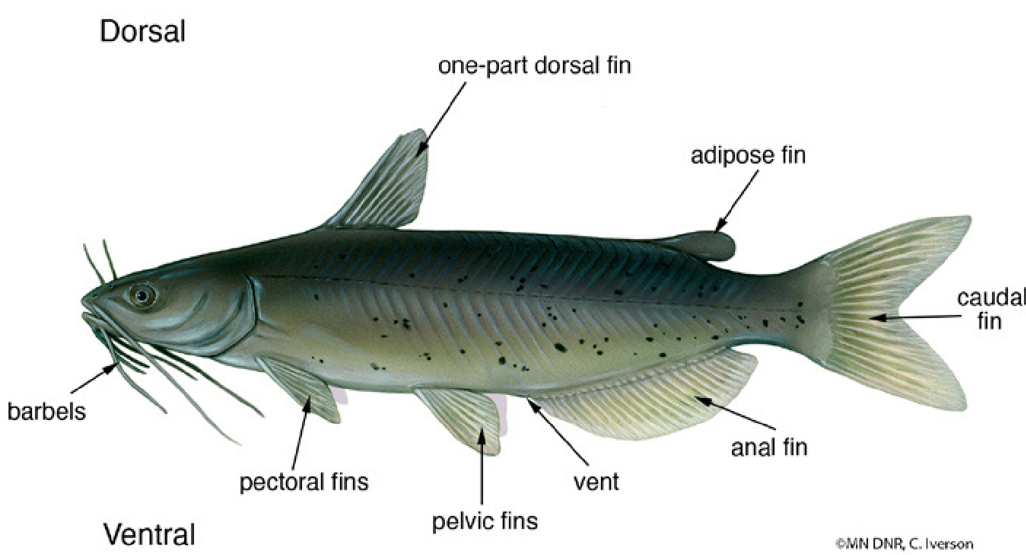
- Salmonidae: trout and salmon family
- Centrarchidae: sunfish family
- Esocidae: pike family
- Ictaluridae: catfish family
- Percidae: perch family

Physical Characteristics Classify Freshwater Fish

The appearance of external physical characteristics is one factor scientists consider in classifying fish. Scientists examine fins, rays and spines, scales, mouths, body shape, relative size and shape of body parts, and the presence or absence of structures such as barbels. Internal features and characteristic behaviors, physiology, genetics, and evolutionary history are also used to compare species and taxonomically classify fish. It's important to remember that size and color aren't always reliable features to use when classifying or identifying fish. These features can vary among individuals of the same species depending on age, sex,maturity, season, available food, and the water quality (minerals and nutrients) where they live.

Below are two diagrams labeling parts of a fish:



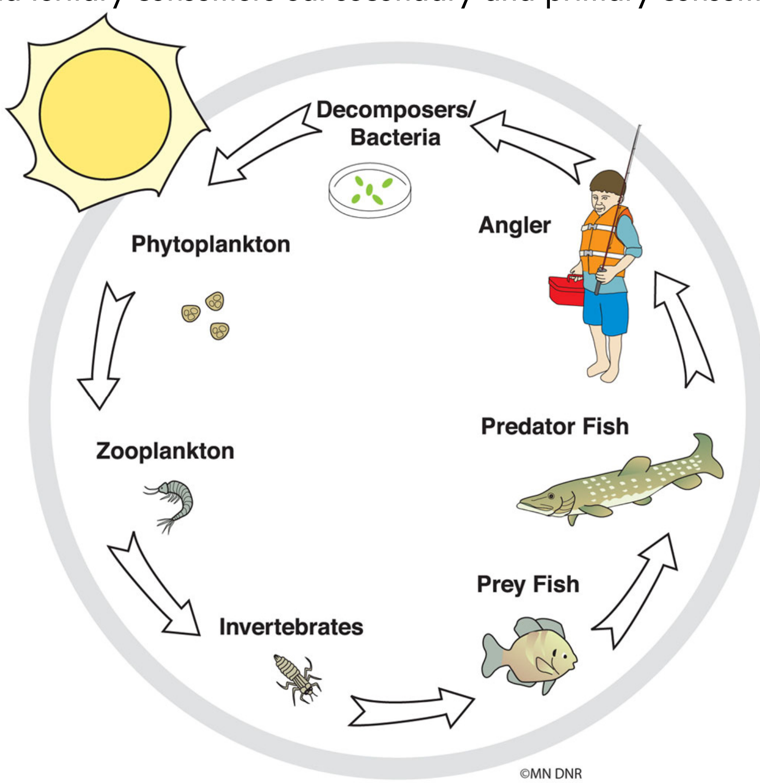


Ecosystem[2]

All things on the planet—both living and nonliving—interact. An **ecosystem** is defined as the set of elements, living and nonliving, that interact, over time, within a defined locale. A food chain demonstrates one way in which ecosystem elements interact in a systematic manner.

Food Chains

In an ecosystem, numerous interactions between organisms result in a flow of energy and cycling of matter. Food chains, the nitrogen cycle, and the carbon cycle are examples of these interactions. A **food chain** is the sequence of steps through which the process of energy transfer occurs in an ecosystem. All organisms need a continuous supply of energy. Energy flows through an ecosystem in one direction—through food chains. Food chains illustrate how energy flows through a sequence of organisms, and how nutrients are transferred from one organism to another. Food chains usually consist of producers, consumers, and decomposers. If a food chain has more than one consumer level, its consumers are defined as primary, secondary, or tertiary consumers. Primary consumers eat plants, secondary consumers eat primary consumers, and tertiary consumers eat secondary and primary consumers.

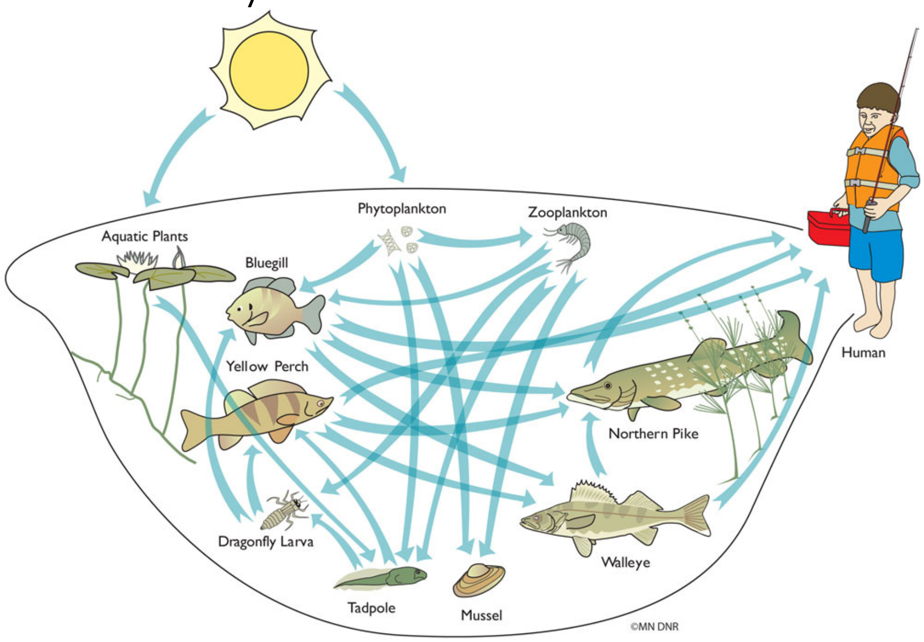


A food chain illustrates the movement of energy in an ecosystem.

The sun is the ultimate source of energy for all food chains. Through the process of photosynthesis, plants use light energy from the sun to make food energy. Energy flows, or is transferred through the system as one organism consumes another.

Food Webs

The concept of a food chain is an abstraction or generalization. Ecosystems are more complicated than a single food chain would indicate. Most aquatic ecosystems contain many more species than those in a single food chain, and all of these species interact and are interdependent. Like people, most aquatic organisms consume more than one type of food. A **food web** is a diagram of a complex, interacting set of food chains within an ecosystem.



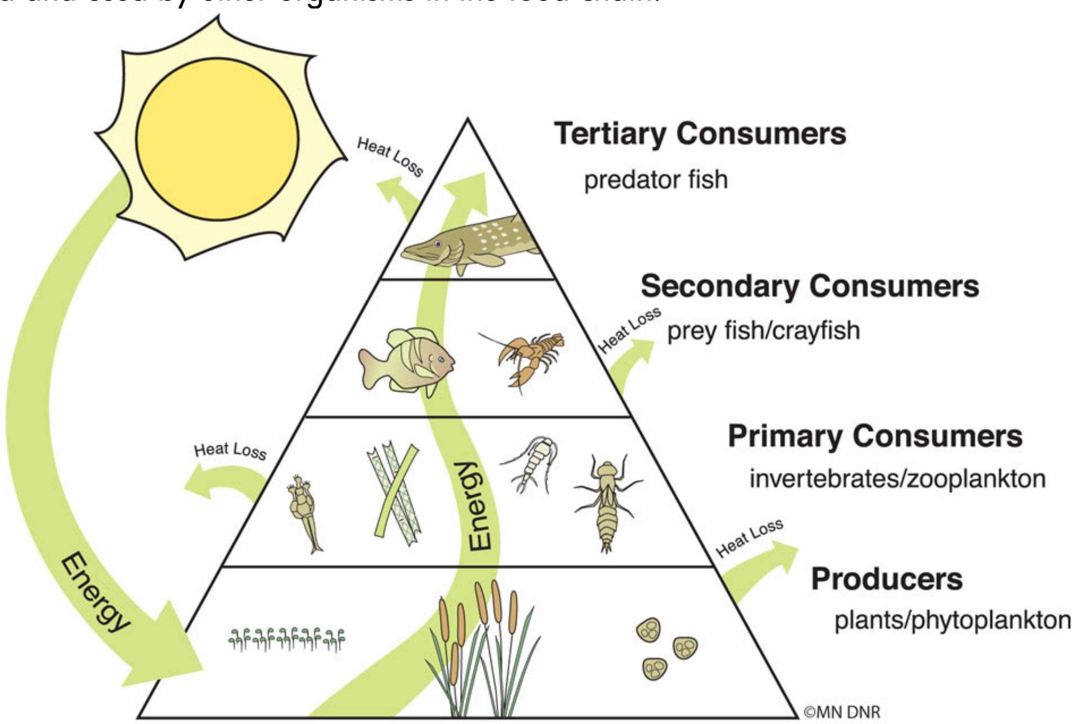
Parts of a Food Chain

A food chain includes the sun, plants, primary consumers, secondary consumers, and decomposers. The sun provides light energy (radiation), the ultimate energy source for all freshwater aquatic food chains. Plants are the next link in a food chain. **Plankton** are among the smallest living organisms in ponds, lakes, rivers, and streams. This group includes tiny free-floating plants, animals, and some forms of bacteria. They range in size from microscopic bacteria and single-celled organisms to larvae and invertebrates large enough to be visible to the unaided eye. With little or no swimming ability, most plankton floats freely with the currents in open water.

Phytoplankton are free-floating microscopic plants and bacteria suspended in the water that, like other plants, produce food energy directly from the sun's light energy. Plants (including phytoplankton) are called **producers** because they can produce simple nutrients and sugars (food energy) directly from the sun's light energy through the process of photosynthesis. As the base of food chains, phytoplankton populations are indicators of aquatic health. The food energy produced by phytoplankton supports much of the other life in the water.

Food energy transfers to microscopic aquatic animals, or **zooplankton**, as they consume phytoplankton. The zooplankton population in a lake or river can be a useful indicator of future fishery health because zooplankton are an important food for small fish (such as minnows) that are next in line in the food chain. Many larger fish, such as yellow perch, depend on a diet of smaller fish.

A **consumer** is an organism that obtains energy from eating other plants or animals. A relatively large quantity of plant material is required to support primary consumers. Animals that eat only plants (or phytoplankton) are primary consumers, or herbivores. Primary consumers, in turn, support a relatively smaller number of secondary consumers, or carnivores—animals that eat other animals. In food chains, most of the food energy consumed by organisms fuels growth and other functions. As an organism uses energy, food energy is converted to heat energy, which is lost from the system. Some food energy is stored in the tissues of organisms, and is, in turn, consumed and used by other organisms in the food chain.



This aquatic food pyramid illustrates energy transfer and relative biomass (defined below) in an aquatic ecosystem. Producers make up the greatest biomass in the system, and support all other life forms. Producers convert light energy from the sun into food energy. This food energy is transferred through the levels of the food pyramid, or trophic levels, as one organism consumes another. At each level in the food pyramid, energy is lost to the surrounding environment as heat as the organisms use food energy to feed, respire, grow, and reproduce. For this reason, each trophic level can only support or provide energy for a smaller biomass of organisms. Energy is also lost as heat on each level as organisms eat, move, grow, and reproduce. The sun continually replaces the energy in the system. Because energy is lost at each level, most food pyramids contain, at most, four trophic levels.

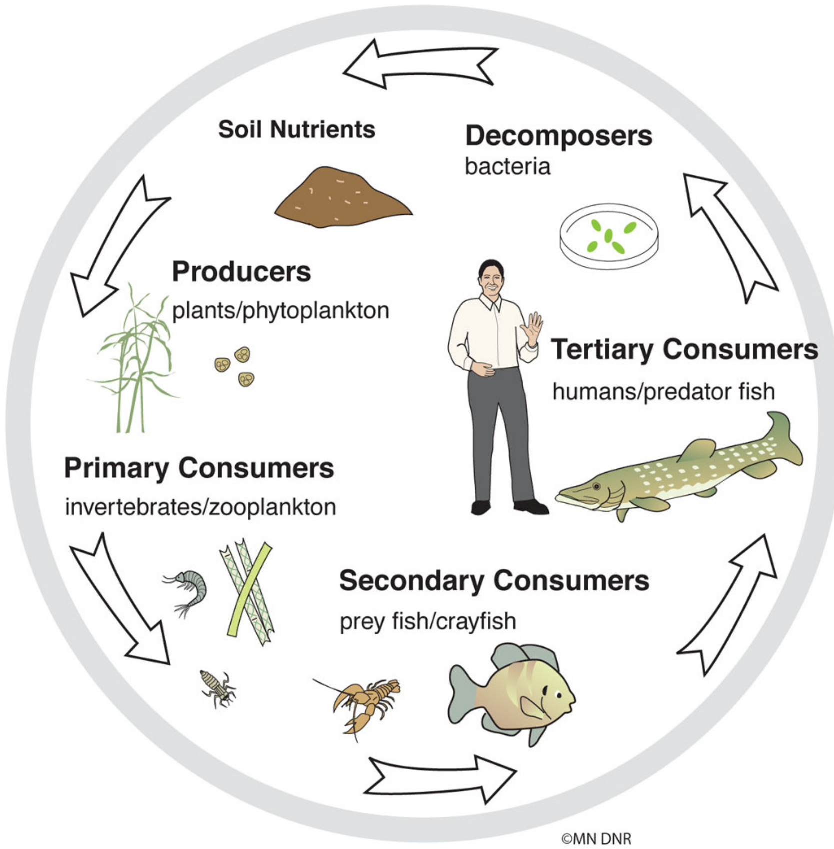
Biomass describes any organic plant or animal material available in an ecosystem on a renewable basis. A large biomass of producers at the bottom of the food pyramid supports a relatively smaller biomass of consumers, which support an even smaller biomass of secondary consumers. Energy flows from one level to the next as the organisms use it. An animal that hunts, captures, and consumes other animals is a **predator**. Northern pike and eagles are predators, for example. An animal consumed by a predator is described as **prey**.

Decomposers, such as bacteria and fungi, complete the food chain by consuming dead plants and animals and breaking them into nutrients. One nutrient by-product of decomposition is carbon dioxide, a simple substance that producers need to create food energy. Decomposers are the crucial last link in a food chain—they put nutrients back into the ecosystem. They also keep the landscape tidy—imagine what it would be like if decomposers didn't break down dead plants and animals!

Food Energy and the Nutrient Cycle

Nutrients are continually recycled in all ecosystems, but energy flows one way. Nutrients are the materials required for life, and they build and renew organisms as they cycle through food chains. For example, carbon dioxide and water (which contains carbon, hydrogen, and oxygen), which plants use to convert the sun's energy into carbohydrates, also cycle through consumers as the consumers eat plants. (They also cycle through other consumers.) When consumers die, bacteria and fungi decompose them, releasing these and other nutrients (phosphorous, nitrogen, and sulfur) into the soil, water, and air. These nutrients are available to plants again, which use them to convert the sun's energy into carbohydrates.

Decomposers are often referred to as **nutrient recyclers** because they break down dead material to provide the nutrients producers need to continue the cycle. Each plant, animal, and person is composed of nutrients that have been—and will be—used by other organisms in a continuous cycle. This sharing and recycling of nutrients is known as the **nutrient cycle.**



Producers, primary consumers, secondary consumers, and decomposers are connected and interdependent by means of habitat needs and simple food chains. Loss or damage to just one link in a food chain eventually affects all organisms in the food chain system.

A food web is a larger, more complex system. But, as in food chains, loss or damage to a single strand in the food web impacts the entire system.

The food chain system is composed of parts, including the sun, plants, herbivores (plant-eaters or primary consumers), carnivores (animaleaters or secondary consumers) and decomposers. A food chain illustrates how the various parts of a natural system have *functional* as well as *structural relationships*. Two main processes occur in this energy transfer system. One involves the movement of energy—in the form of light energy or radiation from the sun—to plants through photosynthesis. The second involves the movement of energy, in the form of organic molecules or food energy, from plants to herbivores to carnivores through consumption of biomass, as illustrated in the food pyramid model.

The parts of a food chain work together efficiently and demonstrate integration. Through the process of evolving together over time, present-day species of plants, herbivores, carnivores, and decomposers have developed ecological relationships. These relationships—of one species to another and between each species and its environment— maintain population levels and balance within ecosystems.

Carrying Capacity

The maximum number of individuals or inhabitants that an environment can support without detrimental effects on the habitat or to the organisms over time is referred to as **carrying capacity.** Aquatic habitats contain limited amounts of necessary food, water, cover, space, and other resources. The quantity and quality of these resources influence the carrying capacity of a habitat. Because resources are limited, the population growth of a given species slows as its population approaches the habitat's carrying capacity. At times, a population may exceed carrying capacity but it will decrease eventually. Population numbers tend to fluctuate over time, depending on seasons and changes in weather, climate, and other environmental shifts. Other influences include excessive predation, the introduction of exotic species, disease, pollution, over-harvesting, poaching, development, agriculture, and recreation. If a fish population grows dramatically, becoming larger than the carrying capacity of the lake ecosystem, the fish consume resources much faster than they can be naturally replenished. Eventually, this can result in serious habitat degradation and a reduced carrying capacity. Because all organisms are interconnected and depend on one other for survival, other populations of organisms are impacted, too. Excessive numbers of one type of fish competing for food and other resources will eventually lead to the death of many individuals if balance isn't restored. Fish sometimes **emigrate** (leave an area) and the size of the population in the habitat decreases. This, in turn, affects the predators that normally depend on that type of fish for food. This eventually impacts the entire food chain.

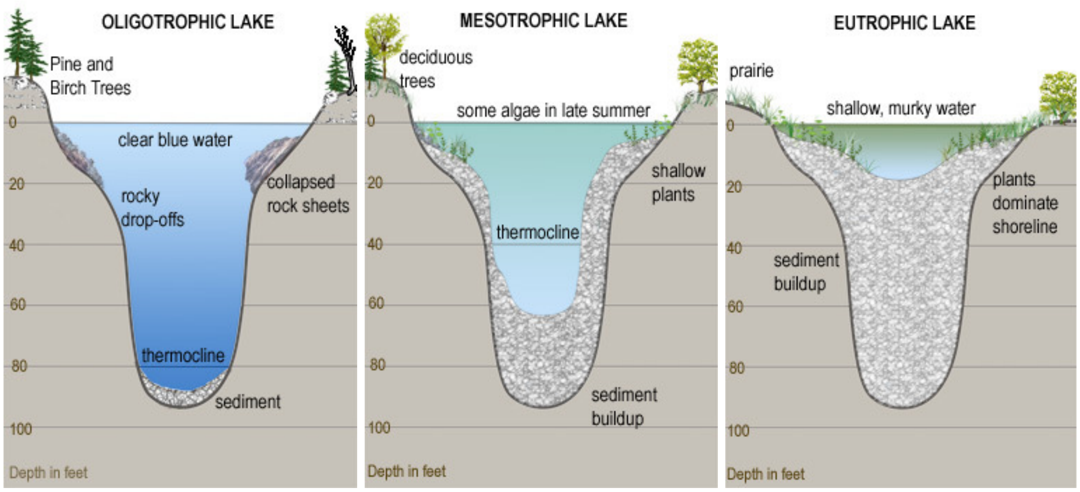
Balance

An ecosystem that can sustain itself over time through the interrelationships of its living and nonliving components is said to be in **balance.** Food chains are one type of interaction among organisms, and are part of a larger system of cycles, checks, and balances that maintain stable ecosystems—those that function continuously and remain viable over time. An ecosystem in balance is sustainable.

Life in Lake Superior[3]

Lake Superior is considered to be an ultra-oligotrophic lake; the water is very clear, and there is relatively little life relative to the size and volume of the lake. Why is the lake so sterile? The amount of aquatic life depends mostly on temperature and nutrients. The open lake is low on both. The temperature averages around 40 F (4C) annually (getting up to around 58 F (14.5 C) at the warmest time in August)

, and because of the lake's small watershed area (again relative to size) and other factors, the amount of essential nutrients like nitrogen and phosphorus enterting the lake is also very low. Trophic status gives an indication of the amount of nutrients present, but is not synonymous with water quality. The EPA defines trophic status as "The level of growth or productivity of a lake as measured by phosphorus content, algae abundance, and depth of light penetration." The result is a fairly simply food chain in the open Lake Superior. The clear, cold water supports very little phytoplankton, such as alage. These few phytoplankton feed even fewer zooplankton, such as water fleas and copepods. Macroinvertebrates like mysis or forage fish like kiyi eat the copepod, lake trout eat the kiyi.



Images from: http://www.rmbel.info/reports/Static/trophicstates.aspx

Only fish that can survive in cold and nutrient poor environments are successful in the open lake. These fish include: trout, salmon, lake whitefish, lake herring, burbot, and sculpins. There are approximately 48 native fish species in Lake Superior. Anglers will identify the river mouths along the shores of Lake Superior as prime fishing ground. Fish gather at these places to spawn and feed. Near shore waters contains fish species that wouldn't survive in the open water of the lake; these species include: suckers, rainbow smelt, round whitefish, sticklebacks, and members of the minnow family.

Vocabulary[2]:

Oligotrophic – a lake that has very low productivity as a result of having few nutrients; as such, oligotrophic lakes cannot support as many fish as lakes with more nutrients

Producer – an organism that produces simple nutrients and sugars (food energy) directly from the sun's light energy through the process of photosynthesis

Consumer – an organism that obtains energy from eating other plants or animals

Decomposer – an organism that completes the food chain by consuming dead plants and animals and breaking them into nutrients

Food web – a diagram of a complex, interacting set of food chains within an ecosystem

Food chain – the sequence of steps through which the process of energy transfer occurs in an ecosystem

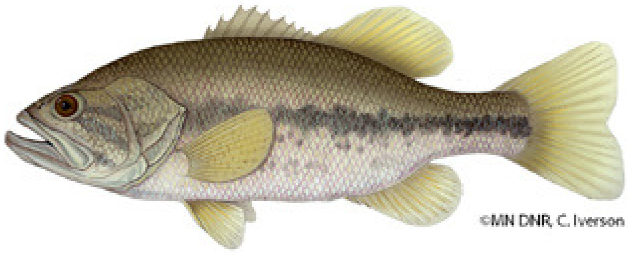
Ecosystem – the set of elements, living and nonliving, that interact, over time, within a defined locale

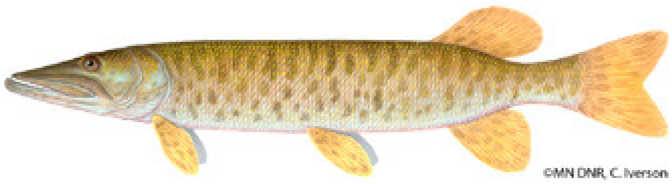
Carrying Capacity – the maximum number of individuals or inhabitants that an environment can support without detrimental effects on the habitat or to the organisms over time

Procedure:

Lake Superior Fish Families[1]

1. Introduce that you are going to become fish classifiers!
2. Discuss with students how the world's scientists use a universal classification system to communicate more precisely about organisms. Ask students to think about how difficult it would be to discuss fish characteristics if everyone didn't use the same classification system. For example, if one person's system classified fish according only to behaviors, instead of physical characteristics, muskellunge and largemouth bass could be grouped in the same family because they're both predators. Do these two fish look alike?





3. Divide the class into groups of four or five. Give each group a **Fish Families Sheet** and a set of **Fish Families Cards**.
4. Discuss the **Fish Families Sheet**. The five important game fish families in Minnesota are listed along with identifying characteristics. Minnesota has 27 fish families with 160 species, but this classification lesson is limited to the five families of game fish found in Minnesota. These game fish families are well-known to anglers.
5. Have each group sort the pictures into the five family groups based on the characteristics listed. Ask students to write the names of each fish under the appropriate heading on the worksheet.
6. After each group is finished, ask the groups to explain why they sorted the fish as they did. Compare and discuss the different grouping systems. In which group did students place Minnesota's state fish?
7. Ask students to choose a fish from the **Fish Families Sheet**, and, as a class, identify the family into which most scientists have classified that fish.
8. Continue working through the **Fish Families Sheet** as a class by identifying the family group of each fish on the sheet.

Lake Superior Food Chain Tag[2]

1. When the students settle down and you have their attention, ask them where they get all that energy! (We get our energy from the food we eat. All food energy can be traced back to the sun.) Ask the students what they ate for dinner last night. You may wish to have them draw pictures of the foods on a paper plate. Ask them to diagram the flow of food energy from their dinner back to the sun. Did anyone have fish for dinner?
2. Ask students to think about how fish get the energy they need to swim around, and to grow. What do fish eat?

3. Choose six volunteers to come to the front of the class. 4 Give each volunteer one Aquatic Food Chain Card.
4. Ask the volunteers to try to line up in the order of a food chain (without talking). How did they do?
   a. Explain food chains, food webs, and predator-prey relationships.
   b. SUN and SPIROGYRA: Explain that light energy from the sun helps tiny green plants called phytoplankton (producers) grow and produce food energy in a lake.
   c. COPEPOD and MAYFLY LARVA and CISCO: Zooplankton and aquatic invertebrates (water insects, bugs and crustaceans) and small fish, like minnows (primary consumers), eat the phytoplankton.
   d. LAKE TROUT: Larger fish, like perch (secondary consumers), eat the smaller fish.
   e. ANGLER: Finally, an eagle or an angler might catch a perch or northern and eat if for dinner. The steps through which food energy flows and is transferred is called a food chain.
   f. SPIRILLA: What parts don't get eaten or otherwise removed from the water will be broken down by bacteria.
5. Ask the students the following questions. Which organisms in our food chain are predators? Which animals are prey species? Can an animal be both predator and prey? (The perch is one example of a species that is both predator and prey. Perch eat minnows, and are also eaten by larger fish such as northern pike.)
6. **FOOD CHAIN TAG:** To begin the game, identify the boundaries of your lake ecosystem (an area approximately half the size of a basketball court) and conduct the activity within this space. Use a rope or field cones to mark the boundary.
   a. Define ecosystem for the students.
   b. Scatter plankton (poker chips) randomly around the lake, reserving approximately 100 poker chips for use in Round Three.
   c. **Round One: Primary consumers**—15-36 fairy shrimp
      i. Distribute a minnow identification tag to each student.
      ii. Hand students a "stomach" (plastic cup or sandwich bag) in which to put their "plankton" (poker chips) – you can mention that the plankton could be the spirogyra or copepods – YUM! Put all the "fairy shrimp"(students) in the lake. When the activity starts, the fairy shrimp will try to fill their stomachs, one poker chip at a time, with as much "plankton" as they can.

Ecosystem

The set of elements, living and nonliving, that interact, over time, within a defined locale

iii. Tell the students the rules of the lake:
    1. To avoid collisions, tell the students that they may not run! Repeat this, if necessary, throughout the activity. The instructor may wish to assume the role of an eagle—whose eagle eyes see every fish in the lake. The eagle is a predator and will make a quick lunch of any fish that runs!
    2. Everyone must stop "feeding" (putting poker chips in their plastic cup or bag) promptly at the sound of the signal. Demonstrate the signal on the whistle or other noisemaker.
    3. Everyone must remain within the lake boundary.

iv. Let the feeding continue until the minnows have eaten all the plankton.

v. When the plankton are gone, give the signal to stop feeding. Ask the students how many fairy shrimp filled their stomachs with fifteen or more poker chips (plankton)? Those fairy shrimp survived! What happened to all the food in the lake?

vi. Introduce the term carrying capacity. What will happen in our lake now that all the food is gone?

vii. Thinking about the food chain, how could we balance the lake?

viii. Have students return plankton to the lake.

> **Carrying Capacity**
>
> The maximum number of individuals or inhabitants that an environment can support without detrimental effects on the habitat or to the organisms over time

d. **Round Two: Secondary consumers—four to twelve cisco (depending on class size)**

i. Put two circles made with rope into the lake. Tell the students the rope circles represent cover and are safe places for prey. Only one student at a time may hide in a rope circle, and only for five seconds at a time. Tell students that they can't stand next to the cover and go in and out. They must move to other areas of the lake before they can return to cover.

ii. Add another layer of consumers to the lake. Exchange several students' fairy shrimp identification tags for cisco identification tags. The number of cisco will depend on the size of your class. If your group size is about fifteen, you may wish to start with four cisco. If your group size is closer to 35, try starting with eight or nine cisco.

iii. Tell students the cisco can eat plankton in the lake, just as the fairy shrimp do. But, perch are predators and can also eat minnows. Predators catch their prey by tagging them. When tagged, the minnow, or prey, must empty the contents of its stomach into the stomach of the predator, which is the cisco. The tagged fish is now "dead" and must sit down at the edge of the lake.
iv. Begin the feeding and continue until most of the plankton has been eaten before giving the signal to stop feeding.
v. How many fairy shrimp have plankton in their stomachs? Those fairy shrimp survived! How many minnows survived? How many cisco survived? A cisco has survived if it has food in its stomach.
vi. What would happen to the food if we kept playing? Is anything missing from our lake?
vii. Have students return plankton back to the lake.

e. **Round Three: Decomposers—one to four bacteria**
i. Select one or two of the fairy shrimp to portray bacteria.
ii. Tell students that the bacteria break down the dead plants and animals into nutrients and they're called decomposers. In this round, when the fairy shrimp are tagged, they must sit down and wait to be decomposed by the bacteria. The bacteria will take them to the edge of the lake. To prevent students from feeling frustrated at having been tagged and sitting out the rest of the round, demonstrate that it can be fun to "decompose" on the edge of the lake! (Be dramatic.)
iii. Give the 100 reserved poker chips to the bacteria. The bacteria toss a few poker chips back into the lake when they take a tagged fairy shrimp to the edge of the lake. This represents the nutrients the bacteria release, which provide new phytoplankton growth in the lake. The phytoplankton, in turn, provides food for zooplankton and other consumers.
iv. Start the game again. You may wish to periodically add a few fairy shrimp (the ones that get tagged) back into the game as this round progresses, to show reproduction of fairy shrimp.
v. Let the feeding occur until most of the plankton are consumed, or after several minutes of your aquatic ecosystem functioning in balance.
vi. How many fairy shrimp survived? How did the bacteria affect the lake ecosystem? Is our ecosystem balanced? What does our ecosystem need? (You may need to adjust the ratio of fairy shrimp, cisco, and bacteria to better balance the system).

vii. Ask students if anything else could be missing from the lake. Can they think of another predator to add to the lake?
viii. Have students return the plankton to the lake.

f. **Round Four: Predators—one to four lake trout, depending on class size**
   i. Add lake trout to the lake. Exchange up to three fairy shrimp identification tags from the remaining fairy shrimp for lake trout identification tags, depending on the size of your class. You may also wish to have some fairy shrimp and cisco trade roles, giving more students opportunities to be predators. The lake trout are predators that feed on the cisco. When a cisco gets tagged, the student must empty half the contents of its stomach into the stomach of the lake trout and sit down to wait for the bacteria to take them to the edge of the lake. Then they give their remaining poker chips (food energy) to the bacteria to scatter back into the lake as phytoplankton. (The lake trout can eat cisco or fairy shrimp. But remind the students that lake trout usually go after the cisco because they're larger and give them more food energy for less work. Cisco still eat both fairy shrimp and plankton. Fairy shrimp eat only plankton.)
   ii. Both fairy shrimp and cisco may hide in the cover (hula-hoops), but the same rules apply: only one fish in a rope circle at a time, and for only five seconds. They must then move around the lake.
   iii. Restart the game. When much of the plankton is gone, or when the system has been operating in balance for several minutes, stop the game. Determine how many survivors remain in the lake. Are there fairy shrimp left? How many cisco are left? Did the lake trout survive? A lake trout has survived if it has food (poker chips) in its stomach. A healthy, balanced lake will have more prey individuals than predators. How could you adjust the numbers so this occurs? (An approximate ratio of 6 (fairy shrimp): 3 (cisco): 1(lake trout) balances this simulated lake.
   iv. Students should begin to understand that energy flows through ecosystems and is constantly being replenished by the sun as nutrients cycle or circulate through the ecosystem. Tell students that an ecosystem is defined as all living and nonliving things interacting within a defined place. One way that living and nonliving things interact is by means of a food chain.
   v. Have students return the plankton to the lake.

g. **Round Five: Top predators—one or two anglers**

i. Discuss with students how people are part of the ecosystem, and how they might impact it.
ii. Select one or two of the fairy shrimp to be anglers. Give each an angler identification tag to wear. Explain that anglers must first find bait— by tagging one fairy shrimp—before they can fish. While linking arms, the fairy shrimp and angler must then try to catch a cisco or lake trout by having the cisco ("bait") tag that fish. (Only one fish can be caught at a time.) The angler will then take the fish's food energy and escort this "caught" fish to the edge of the lake. Ask students what happens to the food energy (poker chips) from the fish the angler catches. Remind students that the fish can still use the cover to hide from predators and anglers.
iii. When most of the plankton is gone, stop the game. Determine which species survived. If the lake ecosystem is in balance, there should be more fairy shrimp than cisco, and more cisco than lake trout.
iv. Have students discuss the results of this round. Is the lake balanced or is it headed for trouble? How did anglers affect the lake ecosystem? If the impact was dramatic, what could be done to limit the anglers' impact on the lake? (Examples include creating regulations such as designating fishing seasons for certain species or establishing catch limits.) What would happen if the number of lake trout exceeded the carrying capacity? (Eventually, they could be the sole remaining fish and have no more food to eat.) Could the lake trout survive this situation?
v. If time permits, try to balance the lake by varying the ratios of different fish species in the lake, then play more rounds and discuss what happens. Have the students determine what adjustments after each round to balance the ecosystem. Try adding more anglers and introduce fishing regulations to maintain a balanced ecosystem.

Putting the Picture Together – Lake Superior Food Web Review

1. Explain to students that you will now review what you know about the Lake Superior Food Web. In the Lake Superior Food Chain game, students became one tiny part of the larger food web.
2. Pull out the feltboard and the folder of aquatic creatures and arrows.
3. Ask students what fish live in Lake Superior. As students list off fish, place the fish on the feltboard.

4. Add in a few more
5. Ask students what those fish eat. Help them with terms like phytoplankton and zooplankton.
6. Ask a student to come place an arrow between a predator and prey organism with the arrow pointing toward the creature that would eat the smaller creature.
7. Continue to ask students to add arrows between prey and predator species to create a food web.
8. The board may look pretty cluttered at this point. Explain to students that in Lake Superior, this many fish typically would not be found in the same place. Lake Superior is so cold and nutrient poor that it just can't support a lot of fish.

References:

1. MN DNR MinnAqua Program. (2010). Fishing: Get in the Habitat! Leader's Guide. "Lesson 2.3 – Fish Families."
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