Survivor

In this chapter, three lesson plans review the bare necessities of life for fish.

Fish Food

OBJECTIVES: Students will be able to:

- describe the dynamics of a simple food chain with three trophic levels
- explain that energy is lost as it travels up a food chain
- identify three classes of lakes, their relative nutrient abundance, and their ability to support life

METHOD: Students will complete a set of math problems in You do the Math in their booklets to show how energy is lost in a food chain. Students will play a population dynamics game and answer questions about their results.

MATERIALS:

1) One to three stopwatches* for each group of four students

2) One pair of scissors for each group unless you pre-cut the game pieces with a paper cutter prior to class—recommended.

* It may be easier for students to keep track of the different production rates if you expand the group size to six and assign a timekeeper with stopwatch for each trophic level.

● See Appendix D for Steady State? Game materials: Nutrient page (six copies per group on white paper), algae page (six copies per group on green paper), shiner page (six copies per group on yellow paper), bass page (six copies per group on purple paper).

SETTING: Indoors

DURATION: One to two 45-minute sessions, depending on whether math work and answers to game questions are done in class or at home. If having the students answer the game questions at home, make sure they have written their results down before they leave the classroom.

VOCABULARY: Ecosystem, ecology, trophic, primary producer, consumer, biomass, oligotrophic, limiting factor, mesotrophic, eutrophic, eutrophication, "Rule of 10" or "Ten Percent Law"

STANDARDS:
Science: F 8.8, 12.9, 12.10.
Environmental Education: B 8.1, 8.4, 8.8, 8.10, 12.1, 12.2, 12.3, 12.4, 12.6.

BACKGROUND: Ecosystems are intricate communities of interdependent plants and animals. Abiotic (non-living) elements provide support to the biotic (living) elements and include things like water, rocks, climate, and oxygen. Disturbance or limits to any part of an ecosystem creates ripple effects on other parts.

The interconnectivity of ecosystems is often demonstrated by using food chains. In a food chain, the organisms at each trophic level depend on an abundance of organisms at the trophic level beneath them. The population of a particular organism, however, is not determined solely by an abundance of food. The rates at which an organism grows, feeds, and reproduces are also important in understanding populations. In the activity used in this lesson, growth, feeding, and reproduction rates are all rolled into one "production rate" to simplify the game.

If this were a true population dynamics model, like models used by fisheries managers to understand how ecosystems function, students would consider the separate rates independently. More complex models would more accurately show how food choices and varying rates of consumption, growth, and reproduction at different life stages interact and affect other species in a food chain.

Limiting factors are also important in understanding food chains as they prevent the growth of an organism or population. The production rate of green algae, for example, is limited by the amount of nutrients in a body of water. If that limiting factor is removed (e.g. by dumping fertilizers into a lake, thereby providing an abundance of nutrients), the algae population would boom until another limiting factor controlled it (in this case, perhaps, lack of oxygen). An ecosystem in a steady (not stagnant) state is one in which each trophic level is producing at a slower rate than the level beneath it, resulting in a food pyramid.

Ecosystems always fluctuate to some degree, however, making the perfect "steady state ecosystem" more of an ideal than a reality.

OPENING: Have students read the **Fish Food** section in their booklets. Make sure that students understand the roles of primary producers, grazers, and predators in an ecosystem. If a demonstration would be helpful, use piled blocks or books to represent a trophic pyramid for the class. Discuss how ecosystems are controlled by the production rate at each level of the pyramid, which has its foundation in nutrients and sunlight. If something limits the abundance of nutrients or sunlight in an ecosystem, all levels of the pyramid are limited. Each trophic level in a pyramid depends on the level beneath it. Have students complete the math problem or use it as a take-home exercise.

MAIN ACTIVITY: Divide students into groups of four to six and pass the supplies to each group. Within each group, assign one person to each trophic level (algae, shiners, bass) and give one person the stopwatch to keep time or assign a timekeeper for each trophic level. Have students cut the colored copies into pieces, unless you've pre-cut them. Let them know that each square represents an abundance of organisms. For example, each yellow card represents enough shiners to keep one smallmouth bass alive. Have the students lay the six nutrient pages (game board) in front of them and read the rules of the game either from their booklets or go over them as a class. All students will do Round One. Assign a different Round Two (2A, 2B, or 2C) to each group. Depending on the size of the class you may have more than one group assigned to some of the rounds. (If there is time, they can all do all four rounds).

Each round will last exactly five minutes. Students will use the chart on their worksheets to determine the start time and production rates of their organisms. When the stopwatch begins, students will lay their cards on top of the organism they consume at the appropriate rate. For example, in Round One the time keeper will call out five second intervals. Algae will lay down one green card on top of the nutrient squares at a rate of one every five seconds. The shiner will begin after 10 seconds and will lay a yellow card on top of a green card at the rate of one every 10 seconds. The smallmouth bass will begin at 20 seconds and lay a purple card on a yellow card at a rate of one every 30 seconds. This will continue for a total of five minutes, but may require a practice round.

Going extinct: Each organism may only lay its cards on top of the organism it would consume. A purple card may not go on top of a green card, nor can a purple go on top of a purple. In Rounds Two A, Two B, and Two C, populations will crash because of lack of food. If all the cards in a trophic level have been covered up, they have all been eaten. They cannot reproduce or feed. That trophic level has been extirpated. If a trophic level cannot feed (lay down any more cards) because there are no more of its prey cards left uncovered, then that trophic level has crashed. Students will need to record the time that crashes happen and how many cards were left uncovered at the time of the crash. If other trophic levels can continue beyond the crash, let them do so until they, too, crash.

At the end of five minutes, students should record the number of cards left uncovered (still alive and feeding) at each trophic level and/or when the level crashed.

Have one student from each group write their results in a table on the board for their classmates to see. Students should record the results from each group in the table in their individual booklets. They will answer questions in their booklets using the results from all four rounds, not just the rounds they played.

CLOSING: Students can work individually or as a group to answer the questions in their booklets. Encourage students to use their new vocabulary in their answers.

ASSESSMENT QUESTIONS: What is the difference between an oligotrophic and a eutrophic lake? How does this difference affect the trophic structure of the lake? Give an example of a possible limiting factor in each type of lake.

ANSWERS: *The difference between the types of lakes is the amount of nutrients in each. Oligotrophic lakes are low in nutrients, infertile,* *and deep and clear. There are fewer primary producers in oligotrophic lakes, which limits the diversity of organisms that can survive. The limiting factors in oligotrophic lakes are soil and nutrients. Eutrophic lakes are high in nutrients, very fertile, shallow, warmer, and have an abundance of primary producers. The predominant limiting factor in eutrophic lakes is oxygen.*

EXTENSIONS:

Field: Head to a local stream or lake and conduct a survey of the various trophic levels you can find. How many different species of plants can students find and what is their relative abundance compared to the number of macroinvertebrates, small fish, or large fish you discover? Macroinvertebrate identification kits can be obtained on loan from Water Education Resource Centers across Wisconsin.

Art: Weave your own aquatic food web showing the connections between different trophic levels, air, land, and water.

If you have downloaded this booklet, please see the appendix that follows for additional materials.

Notes

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Survivor

Yellow perch and walleye, like all organisms, are adapted to certain habitats. Before stocking fish, a biologist needs to know the food, water, shelter, and space requirements of the species. If a waterbody does not have the components of habitat a fish needs, stocking it would be a waste of time and money. What would be the right habitat for a walleye? Is it the same as for a yellow perch? In this section you will learn what fish need in order to survive. We'll review some ecological principles, look at how the nature of water affects fish, and explore the different aquatic habitat types in Wisconsin.

INSTRUCTORS:
Underlined content is not provided in student manual.

Walleye

Fish Food

What fish eat and who they are eaten by plays a major role in the functioning of an aquatic ecosystem. There are predator and prey fish, just as there are predator and prey mammals. The wolf and the coyote are land versions of the salmon and the northern pike, while darters and shiners are the rabbits and mice. Having a healthy aquatic ecosystem means having the right balance of predators and prey in a body of water.

Walleye are generally found in large rivers and lakes, although they can be found in smaller lakes as well. They are found in all types of lakes, from oligotrophic to eutrophic. The same for yellow perch? Yes, in fact the yellow perch and walleye have an intricate predator-prey relationship where walleye feed on yellow perch, which feed on walleye fry.

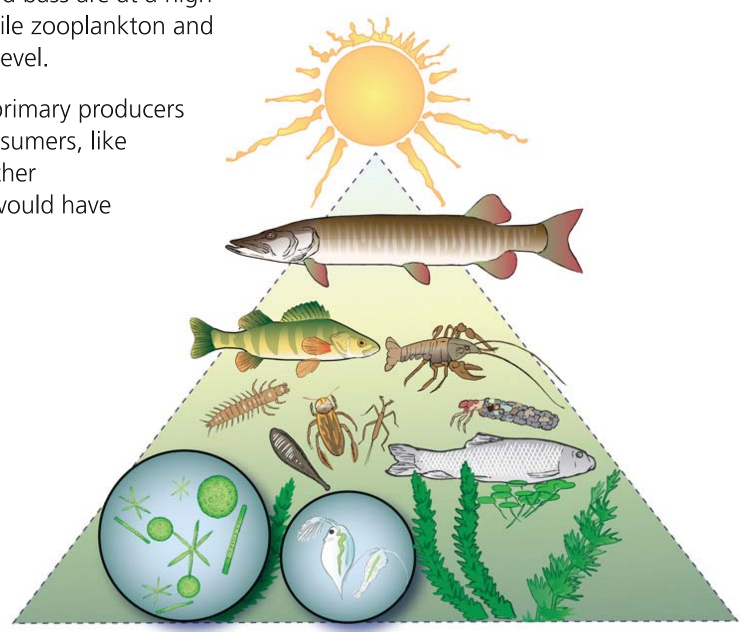
More than a Chain

If you think of the food web as a pyramid, the base of the pyramid would contain many small—even microscopic—plants and animals, while the top would include fewer, larger animals. Thousands of microscopic plants and animals are required to support a few predator fish. Musky and bass are at a high trophic level (feeding position) in the pyramid, while zooplankton and other microscopic organisms are at a low trophic level.

The lowest level on the pyramid is composed of primary producers (those who make their own food, like algae). Consumers, like the bass, feed on the primary producers and on other consumers. Can you think of any organisms that would have a higher trophic level than the musky or bass?

Losing Energy

Within any food web, there is a transfer of energy. When a trout eats a worm, some of the energy stored in that worm is transferred to the trout. Not all of the energy used at each level of the food web, however, is recoverable. As you move up the levels in the pyramid, there is less energy available at each higher level than at the level below.

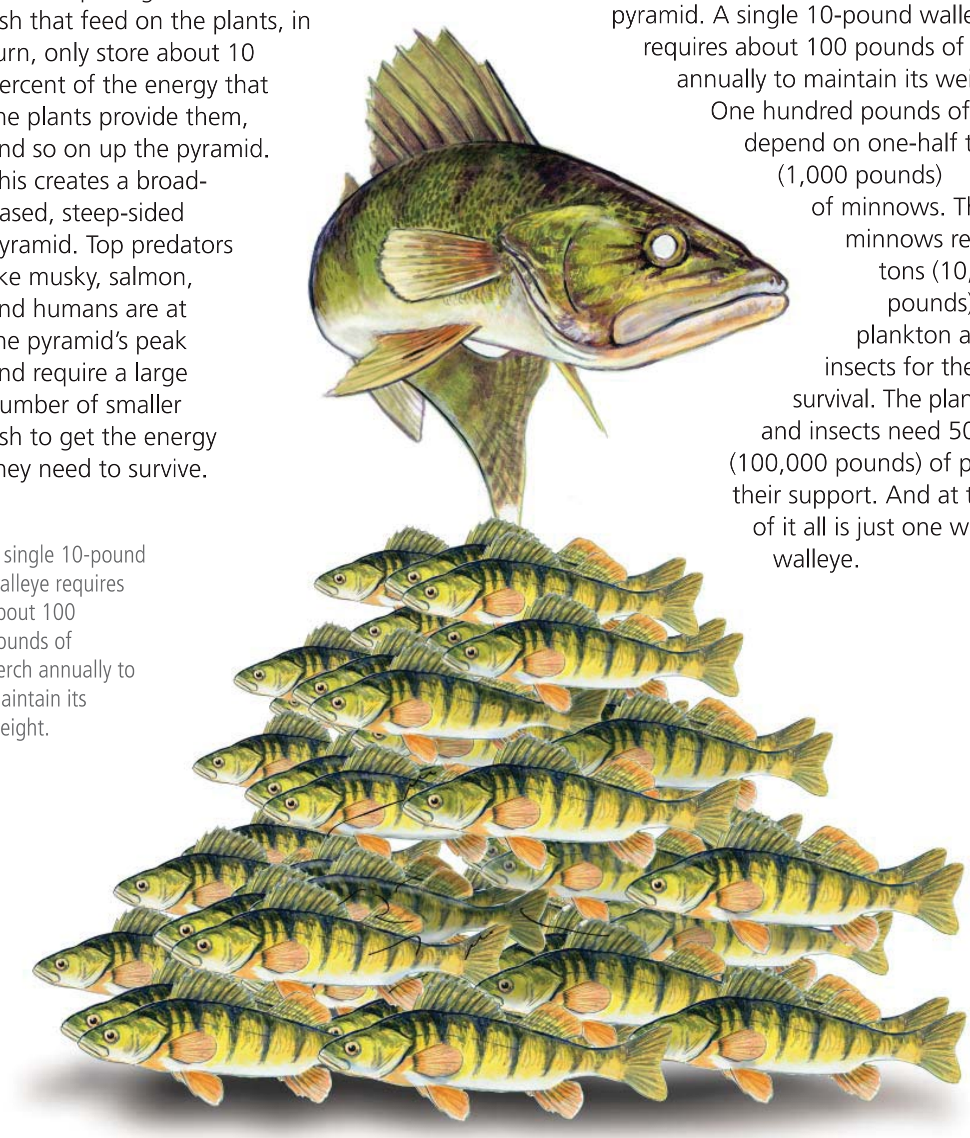


Energy Pyramid: Thousands of microscopic plants and animals are required to support a few predator fish.

Ecology

From Latin meaning "household" or Greek meaning, "house". When we study ecology, we are studying the relationships between organisms and their environments (homes).

Scientists often refer to this transfer and loss of energy as the "Rule of 10" or the "Ten Percent Law." The primary producers at the very bottom of the pyramid can only store about 10 percent of the radiant energy from the sun as sugars or carbohydrates in their tissues. The microscopic organisms and small fish that feed on the plants, in turn, only store about 10 percent of the energy that the plants provide them, and so on up the pyramid. This creates a broad-based, steep-sided pyramid. Top predators like musky, salmon, and humans are at the pyramid's peak and require a large number of smaller fish to get the energy they need to survive.



A single 10-pound walleye requires about 100 pounds of perch annually to maintain its weight.

Feed Me!

Walleye, for example, require a large amount of space in order to find enough prey to survive. There are fewer walleye in any lake or river compared to smaller fish, simply because a walleye is near the top of the trophic pyramid. A single 10-pound walleye requires about 100 pounds of perch annually to maintain its weight. One hundred pounds of perch depend on one-half ton (1,000 pounds) of minnows. Those minnows rely on five tons (10,000 pounds) of plankton and insects for their survival. The plankton and insects need 50 tons (100,000 pounds) of plants for their support. And at the top of it all is just one well-fed walleye.

Section A FISH KNOWLEDGE Ecology & Biology

You do the Math…

1. What is the total weight of biomass (living plants and animals) required to sustain that 10-pound walleye for a year? Show and label your work.

   100+1000+10,000+100,000=111,100 lbs of food

2. If 7,300 solar units are equal to the amount of energy required to sustain a pound of plants, how many solar units does it take to sustain a 10-pound walleye?

   100,000 lbs of plants x 7,300 solar units = 730,000,000 solar units

INSTRUCTORS: Underlined content is not provided in student manual.

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3. What factors influence the amount of energy a fish requires to maintain its weight or grow? In other words, what could cause that 10-pound walleye to starve?

   If any of the trophic levels below the walleye crash, the walleye will not survive. If there are not enough nutrients to support the plants, or if pollution blocks sunlight from getting to the plants, the walleye will crash. If the plankton and insects are damaged, the walleye will crash. If the perch are over-fished, the walleye will crash.

Oligotrophic lakes are usually formed by glacial scouring and have little soil on their bottoms.

Most of the lakes in the southern and central counties of Wisconsin are mesotrophic. These lakes were formed by glacial deposits and tend to be well-vegetated and fertile.

Eutrophic lakes are shallow, very fertile, and loaded with nutrients.

Illustrations by Chris Whalen, Courtesy of University of Wisconsin-Extension Lakes Program

This Lake's Got Class…

Lakes are classified into three trophic categories based on the amount of nutrients found in them and on water clarity.

Oligotrophic lakes have few nutrients and are generally found in the far north of Wisconsin. Lake Superior is a great example of an oligotrophic lake. These lakes were formed by glacial scouring which stripped away the soil. Lack of soil and other nutrients limited the growth of vegetation which allowed clear-water conditions to persist over the ages. Oligotrophic lakes tend to be deep with a high oxygen content that supports prized game fish like lake trout, perch and walleye.

Mesotrophic lakes have a medium amount of nutrients. Most of the lakes in the southern and central counties of Wisconsin are mesotrophic. These lakes were formed by glacial deposits and tend to be well-vegetated and fertile. Mesotrophic lakes are not as deep as oligotrophic lakes, but have a rich assortment of game fish like musky, northern pike, and bass.

Eutrophic lakes are low in oxygen, very fertile, and loaded with nutrients. They are typically shallow and found throughout Wisconsin where older lakes have filled in due to erosion or other factors. Eutrophic lakes will eventually become bogs or marshes. Younger eutrophic lakes host panfish and bass, but catfish, carp, and bullheads begin to dominate as the lake ages. Eutrophication is a natural aging process, but human activities can accelerate it by adding nutrients through erosion, polluted runoff, and leaky septic systems.

Steady State?

Use the worksheet below to fill in your population dynamics results as you participate in a simulated food chain with different limiting factors. Your teacher will provide you with a nutrient game board and cards representing algae, shiners, and smallmouth bass. At the end of a round, record the time that each population crashed and the number of uncovered cards of each color.

PLEASE SEE APPENDIX D
Steady State? Game Handouts

1. Each Round lasts exactly five minutes.
2. The Start Time is the time at which a trophic level begins growing (begin laying down cards).
3. The Production Rate is the time interval between laying cards down. It represents the combination of the feeding, growing, and reproducing rates for that trophic level. For example in Round 1, green algae lay down one card at the beginning (t=0) and lay down one card every 5 seconds for the entire 5 minutes. Shiners start after 10 seconds (t=10), and lay down one card every 10 seconds. Bass start after 20 seconds (t=20) and lay down one card every 30 seconds.
4. You may only place your cards on top of the species you consume. If there are no more cards for you to put yours on top of, your species dies of starvation.
5. At the end of five minutes, record the number of cards remaining uncovered (still alive and feeding) and/or when the trophic level crashed.

		ROUND 1		ROUND 2A		ROUND 2B		ROUND 2C	
TROPHIC LEVEL	CARD COLOR	START TIME	PRODUCTION RATE	START TIME	PRODUCTION RATE	START TIME	PRODUCTION RATE	START TIME	PRODUCTION RATE
Green Algae	Green	0	5	0	5	0	5	0	2
Common Shiner	Yellow	10	10	20	3	10	15	10	5
Small-mouth Bass	Purple	20	30	25	20	20	10	20	10

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INSTRUCTORS: Underlined content is not provided in student manual.

		ROUND 1		ROUND 2A		ROUND 2B		ROUND 2C	
TROPHIC LEVEL	CARD COLOR	CRASH TIME	NUMBER OF CARDS	CRASH TIME	NUMBER OF CARDS	CRASH TIME	NUMBER OF CARDS	CRASH TIME	NUMBER OF CARDS
Green Algae	Green	X	31	0:44	0	X	60	2:23	45
Common Shiner	Yellow	X	20	0:45	8	0:20	0	X	30
Small-mouth Bass	Purple	X	10	3:05	9	0:30	1	X	29

The results in this table provide answers that you should expect. Students will probably get close to, but not exactly, these answers, depending on how well they followed the rules.

1. Which round of the game does each of these phrases describe?

   Primary Producers are the limiting factor: Round 2A

   Predators are the limiting factor: Round 2B

   Nutrients are the limiting factor: Round 2C

   Steady State: Round 1

INSTRUCTORS: Underlined content is not provided in student manual.

2. Which of the rounds describes what can commonly happen in an oligotrophic lake? How would you change the model to reflect a eutrophic lake?

Round 2c is limited by nutrients. Nutrients are a limiting factor in oligotrophic lakes. To make a eutrophic lake, you could copy more nutrient pages so that the algae would never run out of a nutrient supply. (other answers possible)

3. What would happen in Round 1 if the round continued for another five minutes? Why?

If this round continued, the algae would crash first because they would run out of nutrients. The production rate of each level is slower than the one below it, so the shiner and bass wouldn't crash before the algae.

4. Why did all the trophic levels crash in Round 2A?

Shiners were eating faster than algae were growing, so the shiners ran out of food. After the shiners ran out of food, they died, so the bass ran out of food. The bass survived longer, because their production rate was so much slower than the other levels.

5. Name two ways a steady state could be restored for Round 2A:

If the algae rate were increased (e.g. maybe one card every 2 or 3 seconds) or if the shiner rate were decreased (e.g. maybe one card every 6 or 7 seconds) there would be a steady state until the algae ran out of nutrients.

6. What limits the growth of algae in Round 2C? Predict what would happen to the shiners and the smallmouth bass if this game were to run another five minutes.

The growth of algae in Round 2c is limited by nutrients. If the game continued, the shiners and bass would starve to death.

7. If you were planning to stock fish in a lake, what could you learn from these rounds?

You need to have enough biomass to support the fish you want to stock. Before you can put bass in a lake, you need to make sure there is an abundance of primary producers and grazers.

8. What are some of the assumptions and limitations of this food chain model?

It is assumed that feeding rate, reproduction rate, and growth rate are all one rate. In real life all of these rates are different. An animal might eat a lot, but reproduce slowly. In real life, an organism like the shiner doesn't just depend on algae to survive, so if algae disappeared, the animal could probably find another food source in order to survive. (other answers possible)