2

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.

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.

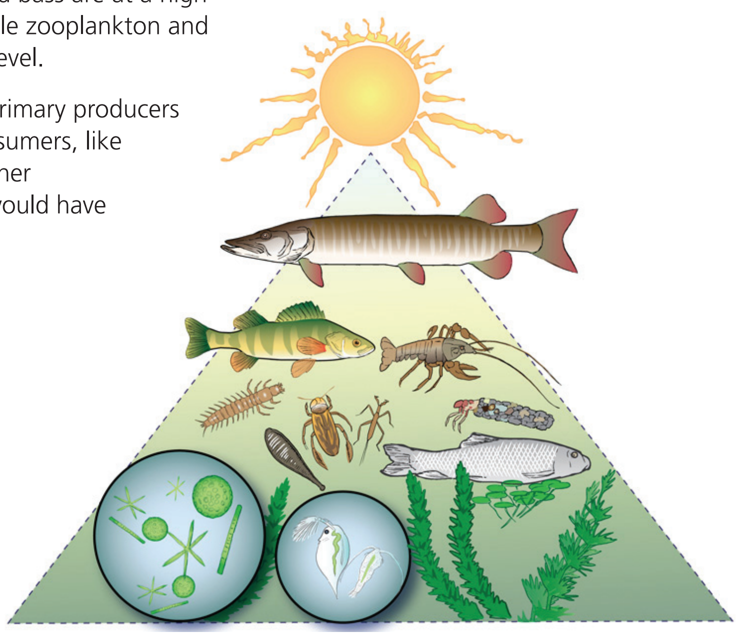
More than a Chain

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.

2

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.

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.

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

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.

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?

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?

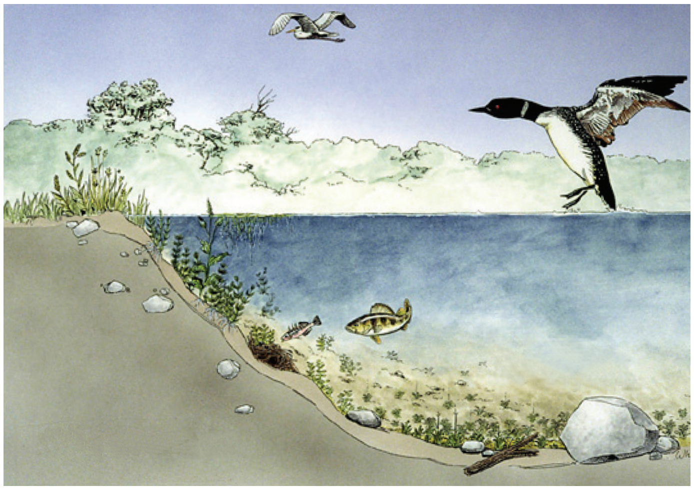
This Lake's Got Class…

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.



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

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.

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

		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								
Common Shiner	Yellow								
Small-mouth Bass	Purple								

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

   Primary Producers are the limiting factor: ______________________

   Predators are the limiting factor: ______________________

   Nutrients are the limiting factor: ______________________

   Steady State: ______________________

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?

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

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

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

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.

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

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

Water of Life

All organisms require water to live. Humans need it to quench thirst, carry boats, and grow food. Fish, of course, rely on clean water simply to breathe and function. Knowing what sort of water conditions a fish requires will help you find the best fishing holes for the species you seek to catch.

"Breathing" Water

Each water molecule is composed of two atoms of hydrogen and one of oxygen. As long as those molecules are bound together, the oxygen molecule is not available to the fish. Fish get the oxygen they need to "breathe" from microscopic bubbles of dissolved oxygen.

Dissolved oxygen comes primarily from air mixed into the water through wind and wave action. In a stream, moving water tumbling over rocks picks up oxygen from the air and carries it along. Plants and algae also contribute oxygen to the underwater world through photosynthesis during daylight hours.

While plants add oxygen to the water during the day, respiration by and decomposition of dead plants and animals remove it.

Polluted runoff also reduces the dissolved oxygen content of a waterbody by adding nutrients that use up oxygen.

Biological Thermostats

Dissolved oxygen content is also tied to water temperature and other factors. Cold water can hold more oxygen than warm water. As weather or thermal pollution warm the water, dissolved oxygen levels drop and fish must work harder to breathe. Thick snow cover on frozen lakes blocks photosynthesis, necessary for the production of oxygen and can lead to "winterkill" conditions. Dissolved oxygen concentrations in a certain stream may be higher in early morning or in mid-winter than they are in the mid-afternoon or summer.

Dry weather can decrease the amount of water in a stream, causing it to move slower and, therefore, pick up less oxygen. Rain, on the other hand, can mix with oxygen on its way down to earth, bringing the oxygen with it when it lands in a body of water.

Most fish require a dissolved oxygen concentration of seven to nine milligrams per liter (mg/l) . Cold-loving trout prefer higher levels of seven mg/l, while bass are adapted to five mg/l. The majority of fish cannot survive at levels below three mg/l. Can you think of some fish that, based on their habitat, might be tolerant of lower levels of oxygen?

Prime Real Estate

Which of the following environments would most likely have good trout habitat based on dissolved oxygen? Which of these could host a catfish?

1. A fast-moving, unpolluted stream ______________________________
2. A small pond with lots of vegetation ______________________________
3. A large slow-moving, muddy river ______________________________
4. Lake Michigan ______________________________
5. Lake Superior ______________________________

Temperature Tolerances of Common Fish

FISH SPECIES	PREFERRED TEMPERATURE °F										
	40	45	50	55	60	65	70	75	80	85	90
Catfish										XX	??
Bullhead								XX	XX	XX	
Sunfish							XX	XX	XX		
Largemouth Bass						XX	XX	XX			
Muskellunge					XX	XX	XX	XX			
Chinook Salmon		XX	XX	XX							
Lake Trout	XX	XX	XX								

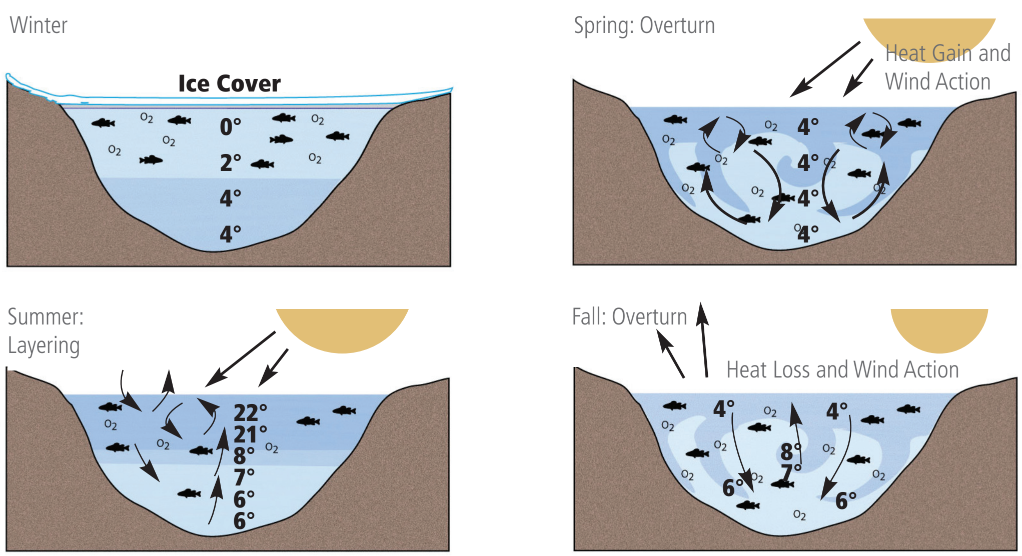
Comfort Zones

Water temperature is perhaps the single most important factor in determining where fish will be and how they will behave. Each species has its own comfort and tolerance level. Fish tend to seek the most comfortable environment, assuming that there is sufficient oxygen, and will migrate from shallow to deep water to find their optimal temperatures.

Like Oil and Vinegar

What sensations do you feel when you dive into a lake during summer? The cool, deep water is often a shock compared to the warmer surface water. Warm and cool water becomes **stratified** (layered) just like the layers of vinegar and oil in a bottle of salad dressing. This is because different temperatures of water have different densities. Warm water is less dense than cold water. The heat of the summer sun warms the **epilimnion** (surface water) until it becomes so warm and light that it cannot mix with the heavier, colder **thermocline** and **hypolimnion** below. The thermocline (also called the **metalimnion** for "middle layer") marks a rapid change in temperature with a small change in depth.

When surface water cools in fall, it sinks until it reaches its maximum density at 4°C (39°F), just above the freezing point. As it continues to cool, it gets lighter and freezes on the surface, indicating that the ice fishing season is just around the corner. If water did not behave this way, lakes would freeze from the bottom up, killing everything in them. Anglers know that as water temperatures shift throughout the seasons, dissolved oxygen, nutrients, and fish distribution shift as well.



By late fall, overturn is complete and temperature is a uniform 4°C* throughout.

*C=Celsius

Coming Up for Air

Watch the demonstration of the layers in a summer lake and then answer the following questions:

1) Where does most of the heating occur in a lake? ______________________________

2) What is the effect of wind on a summer lake? ______________________________

____

3) How does layering affect fish living in the lake?______________________________

____

____

4) Given all that you have learned about temperature and oxygen, what could climate change mean for aquatic species? For anglers?

____

____

5) Design a 10-year experiment that would allow you to determine the layering in your own local lake and whether or not it is changing as a result of climate change. What type of equipment would you need? Where would you take measurements and when? How would you know if you were getting a good sample of the lake? ______________________________

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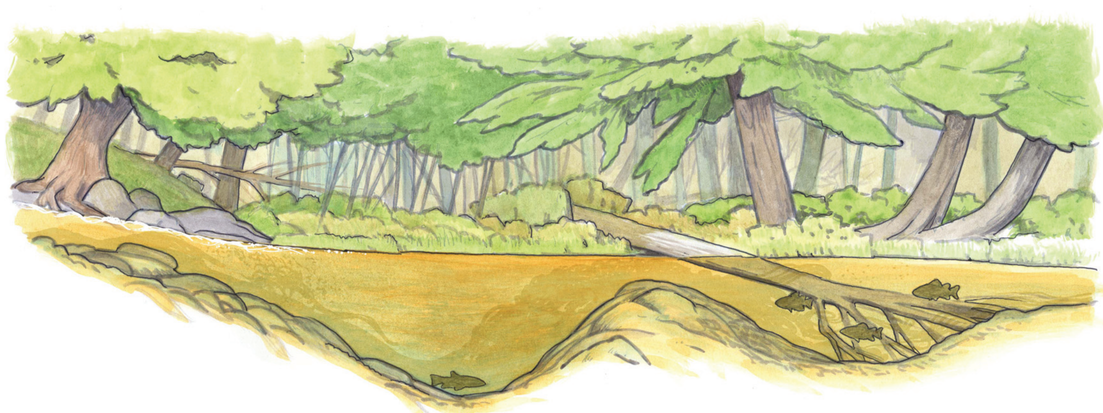
Home Sweet Home

Why do certain fish live deep in lakes, while others can be found in shallow streams, and still others dart in and out of a reedy marsh? Think back to the past two lessons in this section. Fish need to live in waterbodies that can supply enough energy (a small pond cannot support 10-pound walleye) and that will meet their temperature and dissolved oxygen requirements. But fish have more needs than just food and water; they also need places to hide—either to surprise prey or take cover from predators—and places to **spawn** (lay their eggs). A great diversity of aquatic habitats makes for a great diversity of fish species. Woody cover (like fallen logs), aquatic vegetation, rock piles, and overhanging riverbanks are all components of different ideal fish habitats.

Spawn
Lay eggs

Go with the Flow: Rivers and Streams

Rivers and streams provide fish with **dynamic** habitat. Streams dramatically change in depth and flow with the weather, the seasons, and the climate. A flood, for example, can quickly destroy spawning habitat by washing out bottom material. Floods can also make new spawning habitat instantly by felling a log, creating a shady deep pool. Streams are also different from one section to the next—the temperature and current that you find at the **headwaters** of a stream will be different from the temperature and current at the **mouth** of that same stream, and will vary considerably along the stream's entire length from rapids to riffles to pools. Fish travel into, out of, and within stream systems to find the conditions perfect for their food, protection, or spawning needs. As with other habitat types, rivers and streams will warm as our climate changes, which may make them uninhabitable to temperature-sensitive species like trout.



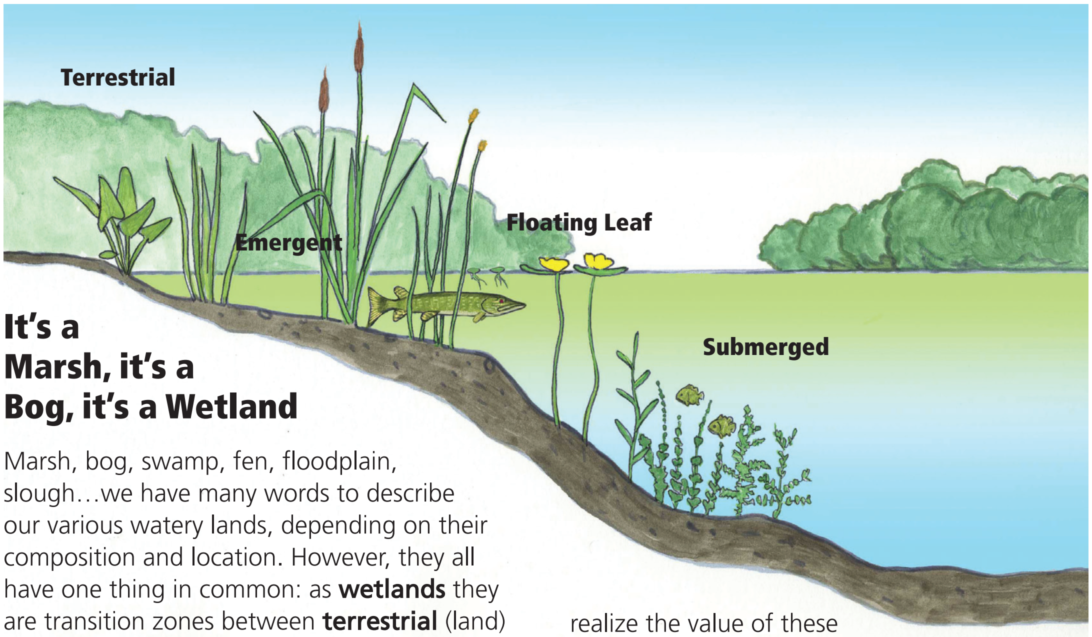
Fish travel into, out of, and within stream systems to find the perfect conditions for their food, protection, or spawning needs.

Wanted

Large, oligotrophic lake with plenty of minnows and other small fish. Cold depths required. Silty bottom preferred. Access to littoral zone a must. Call or email. - A. Sauger

Math Quiz

Wisconsin once had 10 million acres of wetlands and now has only 5.3 million acres. What percent of Wisconsin's wetlands have been lost? Wisconsin was once 28% wetland. What is it today?



A diversity of native aquatic plants are vital to fish habitat and are rooted in the littoral zone of a lake.

It's a Marsh, it's a Bog, it's a Wetland

Marsh, bog, swamp, fen, floodplain, slough…we have many words to describe our various watery lands, depending on their composition and location. However, they all have one thing in common: as **wetlands** they are transition zones between **terrestrial** (land) and aquatic ecosystems. The plants and soils of a wetland are generally saturated with water for at least one season during the year. Like streams, wetlands are very dynamic and change with the weather. During dry spells water might not even soak a wetland's soil. However, during rainy periods wetlands are quick to fill and the water may be over your head. Some fish spend their entire lives in wetlands, while others come only to feed or spawn. Marshes, which are usually wet year-round and filled with shelter-providing grasses, tend to be the most hospitable wetlands for fish. Bogs are typically too acidic for fish.

Wetlands provide important functions available nowhere else on earth. Beyond providing habitat for fish, they are also wildlife nurseries for birds, amphibians, reptiles, and insects. Wetlands also act as great sponges, sopping up floodwaters and filtering out contaminants before they reach groundwater and surface waters. Wetlands keep the effects of erosion in check by holding back silt and preventing it from clogging spawning beds in rivers and streams. Wetlands used to cover 10 million acres or 28% of Wisconsin. Today roughly 5.3 million acres remain. Long after the damage was done, many people came to realize the value of these wetlands and now work to protect and restore them.

In the Zone: Inland Lakes

Lakes have distinct habitat zones that vary in nutrients, oxygen content, temperature and cover. Fish inhabit lake zones when and where the conditions match their needs. The most commonly recognized habitat zones in a lake are the **littoral** (shallow), **limnetic** (open water), **profundal** (deep water), **benthic** (bottom), and **wetland**. The littoral zone extends from the shoreline out as far as emergent, floating, and submerged rooted plants can grow, which is generally about 15 feet, depending on water clarity and lake depth. It is an important zone for females to spawn and for young fish to hide because of the protection underwater plants and fallen trees offer. The limnetic zone (sometimes called the pelagic zone, particularly in ocean environments) begins where water is too deep for rooted plants to get established, but an abundance of sunshine photosynthesizes phytoplankton (microscopic floating plants).

Large, cold-loving fish can be found in the limnetic zone, feeding on free-swimming

Littoral
shallow

Limnetic
open water

Profundal
deep water

Benthic
bottom

Wetland
land-water transition area

Watery Wisconsin

Trace the history of our abundant aquatic resources and you'll be led back about 15,000 years to the ice age. Mountains of glacial ice channeled out many of Wisconsin's 44,000 miles of rivers and streams. Footprints of the glaciers became the Great Lakes as well as most of the 15,081 inland lakes that are splashed across the state.

Many of Wisconsin's wetlands were created where chunks of ice left depressions. The southwest part of Wisconsin, known as the "driftless area," was not glaciated during the last glacial period. Streams in this region have been at work for thousands of years, cutting deep valleys into the soft layers of limestone and sandstone deposited by ancient inland seas. There are few natural lakes and wetlands in this area.

zooplankton like crustaceans and rotifers. The deep, dark profundal zone lies below the limnetic zone and oxygen levels start to drop. The benthic zone is a very low-oxygen environment where decomposers and scavengers roam.

Wetland habitats associated with lakes are marshy transition areas from the water to upland areas. It is common for the littoral zone to also be called a "wetland" in lakes.

Fingerlings
Young fish

Substrate
Bottom material

Superior Habitat: Great Lakes

Wisconsin's eastern and northern borders are nestled against two of the largest freshwater lakes in the world, Lake Michigan and Lake Superior. The extreme depths and cold temperatures of the Great Lakes provide habitat for many of Wisconsin's big game fish. Near-shore rocky reefs attract chinook salmon, coho salmon, and brown trout, while rainbow trout (or "steelhead") live near the surface in open water, often many miles from shore. Lake trout require the coldest waters and generally live in 50 to 200 feet of water, depending on the season. Extensive wetlands and **tributaries** along Lake Superior provide spawning habitat for brown trout, steelhead, chinook and coho, while northern pike head to Chequamegon Bay at spawning time.

Nursery Needs

Wetlands and littoral zones are host to many aquatic plants that serve as protection for fish eggs, **fry** (newly hatched fish), and **fingerlings** (young fish). This makes them a popular site for spawning—but plenty of fish go elsewhere to raise their young. Protection is one consideration for parent fish, but **substrate** (bottom material) is another. Many fish create **redds** (nests) out of a certain bottom material. If that material is not available, the fish will go elsewhere. Other fish deposit their eggs directly on the bottom of a lake or river, while still other fish have eggs that float or that attach to vegetation. Some fish, like salmon, return to the site where they were spawned when it is time to lay their own eggs. Temperature, dissolved oxygen, and food availability are also important indicators of where a fish will spawn.

Follow Your Nose

When salmon are very young, they "imprint" on the stream in which they are stocked or hatched. In spring, the young salmon migrate to the Great Lakes. At spawning time, the salmon are drawn by their strong sense of smell back to their "home" stream.

Spa(wning) Resort

Research the spawning habitat requirements for a fish in order to determine the ideal habitat for the fish's needs. Then design a travel brochure using images and text to lure the fish to your Spa (wning) Resort. As you develop your travel brochure, keep the following questions in mind:

1) What temperature and dissolved oxygen content do the eggs and fingerlings of the species require?

2) What types of protection do the eggs need? Do they need to be camouflaged or placed under a structure? Do the parent fish create a redd?

3) Who will prey on the eggs or fry? What can the fish parent do to prevent this? What other threats might the eggs and fry encounter?

4) What will the fingerlings eat when they hatch? Is it available nearby?

5) How far will the fingerlings have to travel to reach the area where they live in maturity?