Chapter 3 • Lesson 2

The Function of Aquatic Plants

Imagine an underwater forest teeming with life!

Explore the world of aquatic plants and find out how they create healthy lake and stream habitats for fish and other aquatic animals.

© 2010 Minnesota DNR • MinnAqua • USFWS Sport Fish Restoration

Minnesota Department of Natural Resources

MinnAqua
Fishing: Get in the Habitat!

Table of Contents

Chapter 3 • Lesson 2

Please note: Academic Standards are updated regularly and our alignments will be updated on the DNR Academic Standards Website at: www.mndnr.gov/education/teachers/edstandards_intro.html

The Function of Aquatic Plants

Minnesota Academic Standards

◒ Lesson *introduces* this Benchmark.
◒ Lesson *partially* addresses this Benchmark.
● Lesson *fully* addresses this Benchmark.

Language Arts

Grade 3
I. Reading and Literature B. Vocabulary Expansion:
Benchmark 1—The student will acquire, understand and use new vocabulary through explicit instruction and independent reading. ●
III. Speaking, Listening and Viewing
A. Speaking and Listening:
Benchmark 2—The student will demonstrate active listening and comprehension. ●
Benchmark 3—The student will follow multi-step oral directions. ●
Benchmark 4—The student will give oral presentations to different audiences for different purposes. ●

Grade 4
I. Reading and Literature B. Vocabulary Expansion:
Benchmark 1—The student will acquire, understand and use new vocabulary through explicit instruction and independent reading. ●
III. Speaking, Listening, and Viewing
A. Speaking and Listening:
Benchmark 2—The student will demonstrate active listening and comprehension. ●
Benchmark 3—The student will participate in and follow agreed-upon rules for conversation and formal discussions in large and small groups. ●

Grade 5
I. Reading and Literature B. Vocabulary Expansion:
Benchmark 1—The student will acquire, understand and use new vocabulary through explicit instruction as well as independent reading. ●
II. Writing D. Research:
Benchmark 2—The student will formulate research questions and collect relevant information or perform observations that address such questions. ●
III. Speaking, Listening and Viewing
A. Speaking and Listening:
Benchmark 2—The student will demonstrate active listening and comprehension. ●
Benchmark 4—The students will give oral presentations to various audiences for different purposes. ●

History and Social Studies

Grades 4-8
II. Minnesota History
G. Post-World War II to the Present:
Benchmark 4 - Students will identify and describe significant land use changes in Minnesota, issues related to land use, and analyze the impacts of those changes and issues. ●
V. Geography D. Interconnections:
Benchmark 1—Students will recognize changes over time in nearby landscapes, resulting from human occupation. ●

Science

Grade 3
I. History and Nature of Science
A. Scientific World View
Benchmark 1—The student will explore the use of science as a tool that can help investigate and answer questions about the environment. ●
B. Scientific Inquiry
Benchmark 2—The student will participate in a scientific investigation using appropriate tools. ●
Benchmark 3—The student will know that scientists use different kinds of investigations depending on the questions they are trying to answer. ●

IV. Life Science
B. Diversity of Organisms:
Benchmark 1—The student will describe the structures that serve different functions in growth, survival and reproduction for plants and animals.
Benchmark 2—The student will know that plants have different structures from animals that serve the same necessary functions in growth, survival and reproduction.
C. Interdependence of Life:
Benchmark 1—The student will know that organisms interact with one another in various ways besides providing food.
Benchmark 2**—**The student will know that changes in a habitat can be beneficial or harmful to an organism.

Grade 4
I. History and Nature of Science
B. Scientific Inquiry:
Benchmark 2—The student will collect, organize, analyze and present data from controlled experiments.
Benchmark 3—The student will recognize that evidence and logic are necessary to support scientific understandings.
III. Earth and Space Science
A. Earth Structures and Processes:
Benchmark 1—The student will identify and investigate environmental issues and potential solutions.
IV. Life Science
B. Diversity of Organisms:
Benchmark 1—The student will classify plants and animals according to their physical characteristics.
Benchmark 2—The student will learn that the characteristics used for grouping depend on the purpose of the grouping.

Grade 5
I. History and Nature of Science
B. Scientific Inquiry:
Benchmark 1—The student will perform a controlled experiment using a specific step-by-step procedure and present conclusions supported by the evidence.
Benchmark 2—The student will observe that when a science investigation or experiment is repeated, a similar result is expected.

IV. Life Science
F. Flow of Matter and Energy:
Benchmark 1—The student will recognize that organisms need energy to stay alive and grow, and that this energy originates from the sun.

Environmental Literacy Scope and Sequence

Benchmarks

- Social and natural systems are made of parts. (PreK-2)
- Social and natural systems may not continue to function if some of their parts are missing. (PreK-2)
- When the parts of social and natural systems are put together, they can do things they couldn't do by themselves. (PreK-2)
- In social and natural systems that consist of many parts, the parts usually influence one another. (3-5)
- Social and natural systems may not function as well if parts are missing, damaged, mismatched or misconnected. (3-5)

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

Chapter 3 • Lesson 2

The Function of Aquatic Plants

Grade Level: 3-5
Activity Duration: Part 1: 60 minutes
Part 2: 30 minutes to set up, plus daily observations for seven to fourteen days
Part 3: 30 minutes to set up, plus fifteen minutes to record results (48 hours later)
Group Size: 30 (maximum)
Subject Areas: Language Arts, Science, Social Studies, Expressive Arts
Academic Skills: communication, comparison, drawing, drawing conclusions, identification, inquiry, observation, public speaking, prediction, recording data, reporting, small group work
Setting: indoor or outdoor gathering area with tables
Vocabulary: algae, crucial habitat, emergent plants, erosion, floating-leaf plants, limnetic zone, littoral zone, nitrogen, phosphorus, submerged plants, surface runoff, xylem
Internet Search Words: bonfires, phosphorus, phosphorus-free dishwasher detergent, phosphorus-free fertilizer, bonfires, road salt, streams; on the Minnesota DNR website: lakescaping for wildlife, Restore Your Shore, water quality

Instructor's Background Information

Like terrestrial plants, aquatic plants need sunlight, water, carbon dioxide, and nutrients to grow. A houseplant will die if submerged in water for long, but aquatic plants thrive in wet conditions.

Aquatic plants and algae are usually green because of the chlorophyll pigment within their cells. Chlorophyll allows algae and aquatic plants to make their own food. This food-making process, photosynthesis, occurs when sunlight energizes reactions in chlorophyll that eventually produce sugars such as glucose. These sugars give energy to the plant and to any organism that eats the plant. Plants need carbon dioxide, water, light, and chlorophyll for photosynthesis. Plants can absorb nutrients and water from the soil, which travel to the leaves through the plant's xylem. Xylem consists of vessels, or tubes, that conduct water and dissolved minerals. Xylem also stores food and supports the plant.

Summary

Students conduct experiments to explore the value of aquatic vegetation to lakes and streams. In Part 1, students learn that aquatic vegetation provides food and shelter for fish and other wildlife. They will also learn about the types of aquatic vegetation living in the littoral zone. In Part 2 students learn how algae blooms can occur in nutrient-rich conditions. In Part 3, students learn that aquatic plants absorb nutrients and some polluting chemicals.

Student Objectives

The students will:

1. Illustrate different types of aquatic plants growing along the lakeshore.
2. List the value of aquatic plants to fish and wildlife.
3. Demonstrate that aquatic plants absorb nutrients and other chemicals.
4. Propose ideas for ways to use plants to help keep water resources healthy.
5. Understand that excessive nutrients in the water will cause algae growth (or an *algal bloom*), and propose ways to prevent excessive algae growth.

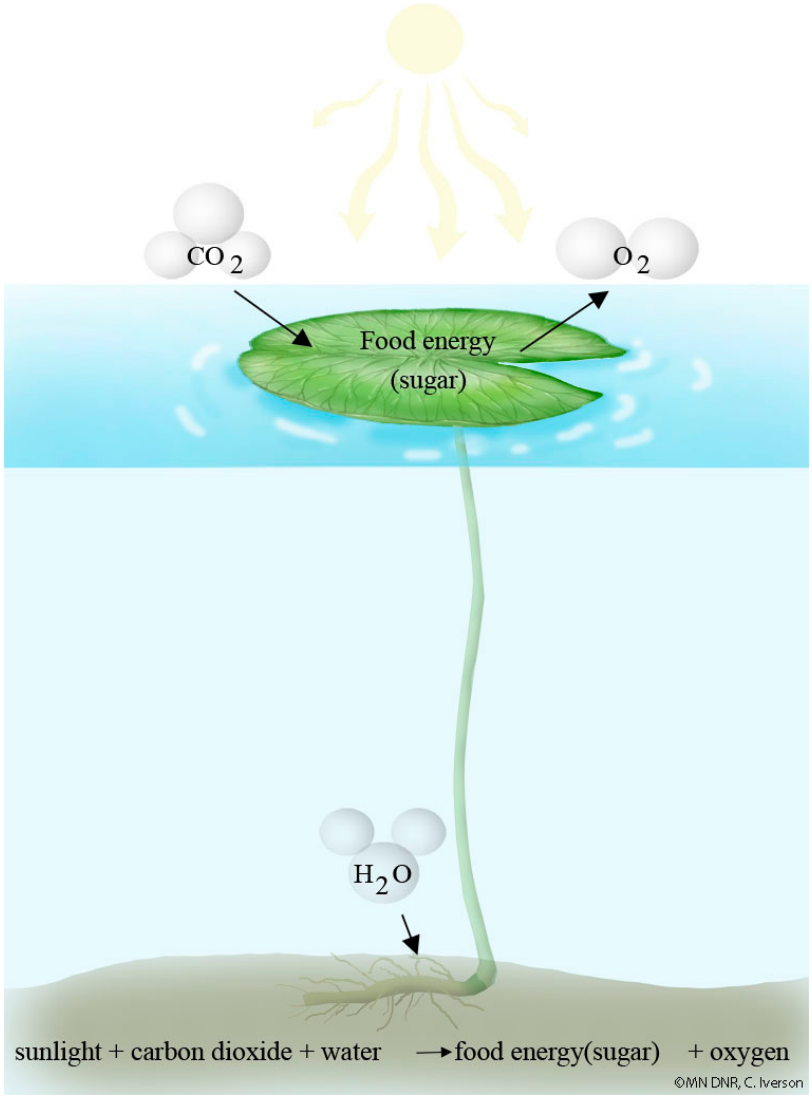
© 2010 Minnesota DNR • MinnAqua • USFWS Sport Fish Restoration

Materials

Part 1: Littoral Zone
In sufficient quantities for students to create a bulletin board display:

- Large sheets of poster board or paper
- Colored paper
- Colored pencils or markers
- Scissors
- Glue
- Magazine photos of wildlife
- Pictures or specimens of algae and emergent, submerged, and floating-leaf plants
- *Restore Your Shore or Save Our Shorelines* PowerPoint presentations on CD (optional); available from DNR Area Fisheries offices, or contact the Minnesota DNR Information Center at 651-296-6157, or toll free at 1-888-646-6367.

continued

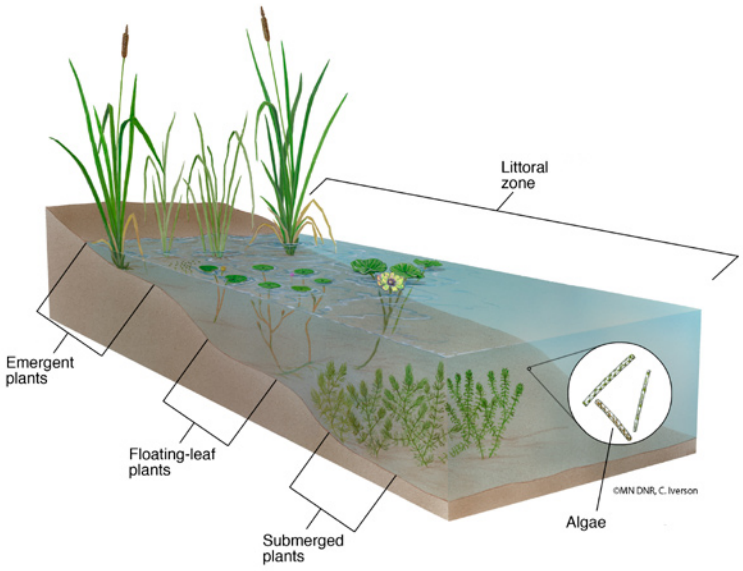


Photosynthesis

Littoral Zone

The area where aquatic vegetation grows in a lake is its **littoral zone**—the shallower portion of the lake, where sunlight can penetrate to reach the bottom with enough intensity to allow the growth of rooted aquatic plants. In Minnesota, the littoral zone extends from the shore to a depth of fifteen feet, depending on water clarity. Shallow water, abundant light, and nutrient-rich sediment provide ideal conditions for plant growth in the littoral zone. Aquatic plants, in turn, provide food and shelter for many animals such as fish, frogs, birds, moose, muskrats, turtles, insects, and snails. Aquatic plants also produce the oxygen that aquatic life needs for survival.

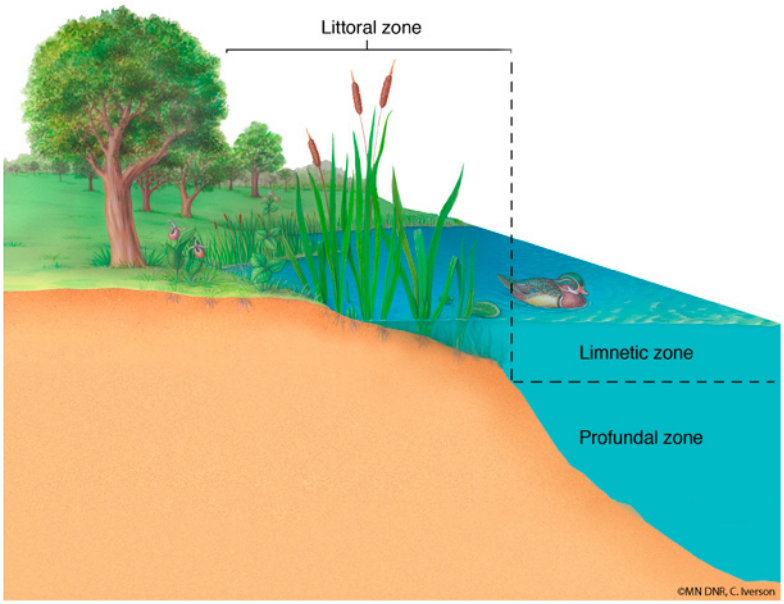
Some lakes are loaded with aquatic plants. Others have relatively few plants. Major factors influencing the amounts and types of aquatic plants include water depth, bottom type, water clarity, and nutrient availability. Shallow lakes have extensive littoral zones, but lakes with steep drop-offs have narrow littoral areas.



Free-floating plants can grow anywhere on the surface of a water body. The zone in which emergent, floating-leaf, and submerged plants grow is called the littoral zone. In many Minnesota lakes, this zone extends to a depth of approximately fifteen feet.

The **limnetic zone** is the open surface water above a lake's deep water (surrounded by the littoral zone), where rooted plants cannot grow. Plankton, phytoplankton and zooplankton inhabit this zone. A variety of freshwater fish also occupy this zone.

The **profundal zone** lies beneath the limnetic zone and extends to the bottom of the lake. Because sunlight doesn't penetrate these greater depths, this zone contains no green plants. Large numbers of bacteria and fungi live in the bottom (benthic) muck. The benthic community in the profundal zone may also include macroinvertebrates.



Limnetic and profundal zones

Materials (continued)

Part 2: Nutrient Soup

- Glass containers (such as baby food jars) or plastic cups
- Bucket of water from a pond, lake, or stream
- Pond plant, whole or parts (use a submerged plant that isn't an invasive species)
- Liquid fertilizer, such as Miracle Gro (or dry plant fertilizer)
- **Nutrient Soup Report Sheets**, one copy per student
- Pencils
- Clipboards

Part 3: Nature's Strainers

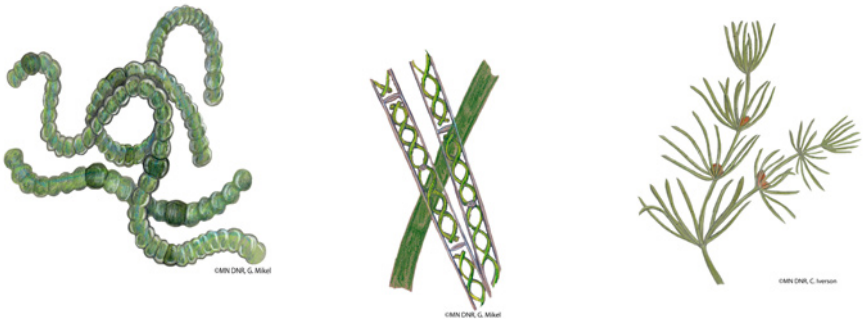
- Paper cups (large enough to support a celery stalk)
- Tape
- Fresh stalks of celery with leaves, two stalks per group
- One to two cups of salt

Permits are required for aquatic plant removal, but small amounts may be collected for educational use without a permit. You may legally collect small amounts of emergent and floating-leaf plants for educational purposes. But usually, due to their ecological value, these plants may not be removed without a permit from the Minnesota DNR.

Types of Aquatic Vegetation

Within the littoral zone, there are four categories of aquatic vegetation: submerged plants, floating-leaf plants, emergent plants, and algae. Each type of aquatic vegetation favors a certain water depth and bottom type. However, the growth areas are not sharply divided.

Algae have no true roots, stems, or leaves. They range in size from tiny, one-celled organisms to large, multicelled, plantlike organisms. Algae can be planktonic (single-celled, float in the water column), filamentous (forming chains, filaments, or colonies), or plantlike (such as chara). Although some algae aren't classified as plants (such as blue-green algae, which is considered to be related to bacteria), they're functionally similar to plants because most types are photosynthetic. They're primary producers—they can directly convert the sun's energy to make food energy. Planktonic algae grow throughout the littoral zone as well as the well-lit surface waters of an entire lake. Other forms of algae are common only in the littoral area.



Anabaena
planktonic

Spirogyra
filamentous

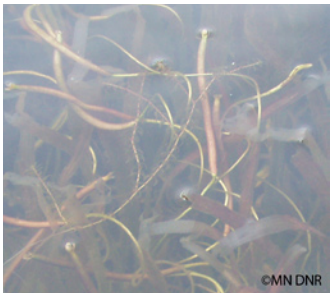
Chara
plant-like

Common types of Minnesota algae.

The roots, stems, and leaves of **submerged plants** grow entirely underwater, although some may also have floating leaves. Submergents grow from near shore to the deepest part of the littoral zone, and display a wide range of shapes. Common Minnesota submerged plants include coontail, bladderwort, water marigold, and wild celery.

Northern Water Milfoil
Myriophyllum sibiricum

Coontail
Ceratophyllum demersum



Wild Celery
Vallisneria americana

Large-leaf Pondweed
Potamogeton amplifoliu

Floating-leaf plants are rooted in the lake bottom with leaves and flowers that float on the water's surface. They usually grow in protected areas with little wave action. Common Minnesota floating-leaf plants include water lilies, American lotus, and floating-leaf pondweed. Free-floating plants also grow in the water. Duckweed and watermeal drift, freely and unattached, with wind and currents. Some are rootless. Others have roots consisting of simple hair-like projections that dangle from the underside of their leaves.

White Water Lily
Nymphaea odorata

American Lotus
Nelumbo lutea

Water Smartweed
Polygonum amphibium

Emergent plants are rooted in the lake bottom, but their leaves and stems extend beyond the surface. Emergent plants tolerate fluctuating water levels, and their dense stands dampen shoreline waves and **erosion**, the gradual wearing away of soil and rock surfaces by natural forces such as flowing water, wind, and ice. Erosion also occurs when human and animal activities disturb the soil and the vegetation that holds soil in place. The leaves of emergent plants have extensive spongy tissue and air spaces. Examples of emergent plants include cattails, bulrushes, and wild rice. Emergent plants typically grow in wetlands and along the shore, where the water is less than four feet deep.

Northern Blue Flag
Iris versicolor

Broad-leafed Cattail
Typha latifolia

Wild Rice
Zizania spp.

Pickerelweed
Pontederia cordata

The Value of Aquatic Vegetation

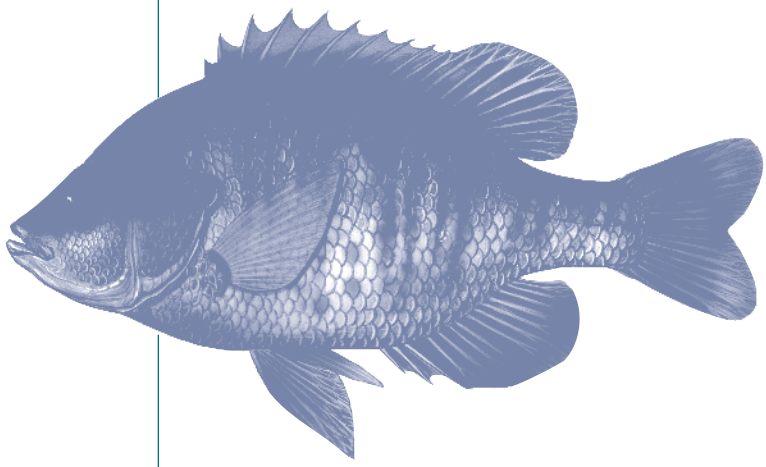
Aquatic vegetation is a vital part of a lake. Plants provide food and shelter for wildlife, improve water quality, protect shorelines, and provide economic value to lakeshore property. They're also aesthetically pleasing.

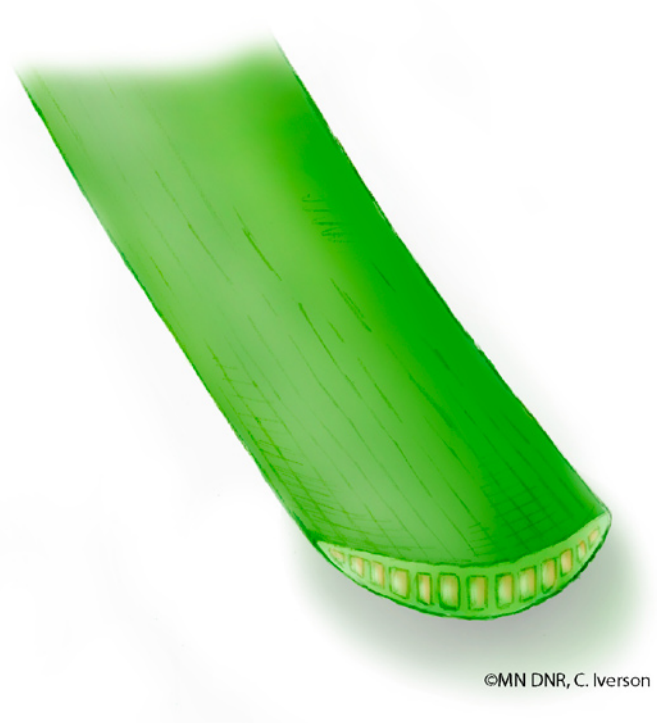
Food and Shelter for Fish and Waterfowl—Plants are the primary producers of food in aquatic ecosystems. In addition to providing a food source, they support the growth of other members of the food web. Areas of aquatic vegetation produce more food for fish than areas without plants. Insect larvae, snails and other macroinvertebrates, and zooplankton thrive among plants. These organisms provide an essential food source for the juveniles of game fish species such as walleye, northern pike, bass, crappies, sunfish, and catfish. Minnows, shiners, and darters (which aren't game fish, but essential to the effective functioning of ecosystems) feed on aquatic plants, too. The many organisms that thrive in vegetated areas are an important food for many kinds of adult fish and waterfowl.

Plants provide shelter, too. Juvenile fish, many types of adult fish, and wildlife seek safety from predators by hiding in vegetation. Aquatic plants provide **crucial habitat** for juvenile fish. **Crucial habitat** includes areas vital to viable populations of fish and wildlife during certain times of the year, reproduction periods, or other phases of life cycles. Bass and sunfish, for example, usually nest in areas with vegetation.

Many emergent plants, such as cattails, have leaves containing spongy tissue and air spaces. Made from these buoyant leaves, the nests of ducks and other birds float up and down with changing water levels. Nests constructed on the water's surface keep eggs and young birds out of the reach of many land-dwelling predators.

Aquatic vegetation isn't just another term for "weeds." A lake's aquatic vegetation is essential to healthy populations of fish and other animals. Weeds are defined as undesirable or useless plants. But "weed" is a subjective term because one person's weed is often another person's treasure. Encourage students to use the term aquatic vegetation when discussing plants that live in the water.





Cross-section of a cattail leaf.

Oxygen Production—Fish and other aquatic organisms depend on the water's dissolved oxygen for their survival. Plants use the sun's energy to produce food through the process of photosynthesis, and oxygen is a by-product of photosynthesis. The oxygen that aquatic plants produce is released directly into the water.

Water Clarity and Quality—Aquatic plants can improve water quality. Certain plants, such as bulrushes, can absorb and break down polluting chemicals. Water plants also absorb nutrients that, left unchecked, would cause nuisance algae blooms. The finely-divided leaves of aquatic plants function as a filtering system, trapping and settling particles from **surface runoff,** the precipitation and water that flow over the surface of the land directly into streams, lakes, and rivers. Shoreline plants act as a filter strip, holding soil in place and preventing erosion. Aquatic plants also provide oxygen, which fish and other animals need to survive. Aquatic plants also provide shade, which keeps water temperatures cool—a critical factor in the survival of fish species such as trout.

Shorelines and Lake Bottom Protection—Aquatic plants, particularly emergent plants like rushes and cattails, reduce the force of waves and prevent shoreline erosion. Their spreading horizontal roots create an interlocking network that helps these plants withstand wave action and stabilizes sediment, reducing erosion. Submerged and floating-leaf aquatic plants also cushion wave action and stabilize bottom sediment.

Fish don't have eyelids to protect their eyes from bright sunlight. Plants provide shady retreats for fish on sunny days.

Did you know that ashes from bonfires contain phosphorus? After your shoreline bonfire has died and cooled, grab a shovel, scoop the ashes, and dump them inland to prevent the phosphorus from leaching into the water.

Aesthetics—The visual appeal of a lake's shoreline often includes aquatic plants, a natural and critical part of any lake community. Water lilies, arrowhead, and pickerelweed have flowers that many people enjoy. The ecological diversity provided by native aquatic plants also contributes to keeping aggressive and harmful exotic plant species in check.

Economic Value—As a natural component of water bodies, aquatic plants support the economic value of all lake and river activities. Minnesota's extensive tourism industry depends on water bodies and the recreation they support. Tourists spend billions of dollars yearly to hunt, fish, camp, and watch wildlife around the state's waterways. Aquatic plants are a critical component of that enjoyment. The best thing that we can do for our lakes and streams at the water's edge is to avoid altering the natural shoreline—and to restore altered shorelines. A natural shoreline includes upland plants (those on land near shore), as well as emergent, submergent, and floating-leaf plants to provide a buffer zone between land and deep water. Human and non-human residents benefit from the maintenance of buffer zones between the land and water. In addition to protecting water quality and preventing erosion, a buffer zone adds beauty, increases privacy, and creates habitat for many wildlife species.

One pound of phosphorus can fuel the growth of 300 to 700 pounds of algae.

Too Much of a Good Thing

Although aquatic plants and algae are natural and healthy components of lakes and streams, they're "too much of a good thing" when they grow rapidly. The naturally-occurring elements **nitrogen** and **phosphorus** are nutrients essential to plant and algae growth. But too much nitrogen or phosphorus in a water body can stimulate an overgrowth of algae and aquatic plants.

Excessive algae and plant growth prevents light from reaching deeper waters, harms aquatic life, and poses an unpleasant nuisance to people. In most cases, dense plant growth helps rather than harms fish. Plants add oxygen to the water and promote the growth of organisms that fish eat. Too many plants, however, reduce predators' effectiveness, causing prey fish populations to increase beyond the limits of the food supply. Underfed fish can't grow properly, resulting in a stunted fish population. Dense aquatic vegetation is usually more of a nuisance to anglers than to fish, but it does make fishing more difficult and impacts fish population size structure.

When plants and algae die, bacterial decomposers begin to break them down, using oxygen in the process. Because most aquatic plants are confined to the littoral zone—in shallower water—they usually don't have much of an impact on the total dissolved oxygen levels in deeper water when they die and decay. But, floating mats of algae do grow over deeper water. When excessively large algae mats die and decompose, dissolved oxygen levels in deeper water can drop significantly. Without sufficient oxygen, fish and other aquatic organisms can't survive.

Excess amounts of nitrogen and phosphorus often enter water when fertilizers, grass clippings, and leaves enter waterways by way of storm drains. Many Minnesota communities have enacted ordinances limiting or banning the use of phosphorus fertilizer in an effort to protect water quality. Some dishwasher detergents also contain phosphorus that isn't removed by treatments in sewage facilities or septic systems. Phosphorus-free dishwasher detergents are available, providing an alternative to this form of pollution.

Procedure

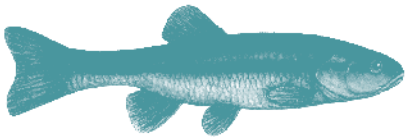
Preparation

1. Prepare a bulletin board or wall to showcase the littoral zone plant drawings. Collect examples of algae, emergent, submergent, and floating-leaf plants to show to the class. Use pictures if live specimens aren't available. These plants can be collected from a local pond or lake, but when collecting plants from the wild, be sure to follow local laws, ordinances, and posted signs.

Be careful not to collect, transport, or spread invasive species. Don't transfer plants from one water body to another. If you buy plants, discard them in the trash—not in a lake or stream. Consult the Minnesota DNR website for a list of waters infested with invasive plants: **www.mndnr.gov/eco/invasives/index.html**

2. Collect drawing supplies and colored paper for the students' plant drawings.
3. Collect magazines so students can cut out pictures of fish and other aquatic wildlife of the littoral zone.
4. Copy the **Nutrient Soup Report Sheets**, one per student.
5. Collect pond water for the algae growth experiment. *Do not dump water from one pond into another pond, lake, river, or stream.* If you can't return the water to its original pond, dispose of it on dry land well away from any body of water or storm drain.
6. Purchase household plant fertilizer. Liquid fertilizer is easy for students to use.
7. Purchase celery stalks with leaves (two stalks per group).
8. Bring in approximately one to two cups of salt.
9. Obtain plastic cups or glass containers (four per group).

If aquatic plants won't be available when you teach this lesson, collect the plant samples at the end of summer and make direct color photocopies of the entire plant. Color photocopies provide plant images with a lot of detail. You may wish to laminate the photocopies to preserve them for future use.



Activity

Part 1: The Littoral Zone

Warm-up

1. Begin the lesson on aquatic plants by discussing the various plants that grow in lakes or streams. Ask students to brainstorm examples of aquatic plants familiar to them, and where they grow. Use pictures of aquatic plants, or show the Minnesota DNR *Save Our Shorelines*, a 20-minute narrated PowerPoint presentation available on CD from your Area Fisheries office.
2. Compare how plants in a lake or stream are similar to the plants in a forest. Discuss the ways in which fish and other animals benefit from aquatic vegetation.
3. Explain the littoral zone and why plants grow in this zone.

Lesson

1. Share pictures or plant specimens representing the four aquatic plant communities of the littoral zone. Explain the four communities of plants (submerged, emergent, floating leaf, and algae) and where they're found in the littoral zone. Place the pictures or specimens at stations and allow the students to explore the four categories of plants.
2. Divide the class into four groups. Assign a plant community to each group.
3. Distribute the colored paper and drawing materials. Working in small groups, students should make large drawings of the samples of plants found in their plant community. For instance, the group assigned to emergent plants will draw cattails, bulrushes, and blue flag iris. A field guide to aquatic plants and the Minnesota DNR CD programs are useful sources of additional examples, if available. The group working on algae will need a microscope to view live specimens, except for chara. Photos may work better than algae specimens for detailed observations. But actual specimens will show the small relative sizes of this plant group.
4. Each group should also draw pictures of types of wildlife or fish that live among their plant community.
5. When the students have completed their drawings, have them place their artwork on the bulletin board within the appropriate area of the littoral zone. Both plants and animals should be placed on the bulletin board.
6. As an alternative to posting the artwork on a bulletin board, the length of the classroom can be transformed into a three-dimensional littoral zone. By displaying the artwork at various heights throughout the room (to represent various water depths), students could "swim" through the different zones to visit the inhabitants. In addition to drawings, the students could also create three-dimensional models of plants and animals.

© 2010 Minnesota DNR • MinnAqua • USFWS Sport Fish Restoration

Wrap-up
Have each group deliver a class presentation about their plant community. They should share the plants' names, where the plants live within the littoral zone, which animals and fish use the plants, and how the plants benefit these animals.

Part 2: Nutrient Soup
It takes approximately seven to fourteen days for this algae growth experiment to develop observable results.

Warm-up
1. Explain that phosphorus and nitrogen are essential nutrients for plants, but that excessive amounts of these nutrients cause algae blooms. Explain that shoreline plants can absorb some excess phosphorus, nitrogen, and other nutrients that fuel nuisance algae blooms.
2. Explain why excessive algae growth harms aquatic organisms.
3. Display pictures or items of common household and yard products containing nitrogen and phosphorus. Discuss the ways in which these products are used, and how they enter waterways.

Lesson
1. Divide students into small groups.
2. Give each group two clear plastic cups or glass containers such as baby food jars.
3. Label one cup "Fertilizer" and the other "No Fertilizer."
4. Have the students fill both cups with pond water.
5. Add ten drops of liquid fertilizer (or about one-quarter teaspoon dry fertilizer) to the cup labeled "Fertilizer."
6. Place both cups in a sunny window. Keep light and temperature conditions identical for both cups. Plants need light energy from the sun to grow. Cover the containers with a lid or aluminum foil.
7. Give each student a copy of the **Nutrient Soup Report Sheets**. Each group should make a prediction about what they think will happen to the "Fertilizer" and "No Fertilizer" cups during the experiment and write their predictions on the sheet.
8. Over the course of seven to fourteen days, students should make daily observations of the plant and algae cultures in each of the containers, and record those observations on the **Nutrient Soup Report Sheets.** Observations may include water color, water clarity, and smell (relative to the other container and to the previous day.)
9. If desired, the containers may be kept for a few extra weeks so students can observe additional changes over time (for example, a change in the dominance of particular forms of algae). When the experiment is complete, dispose of the samples on the ground outdoors, well away from water. Don't pour them down any drain.

Avoid getting fertilizer on hands. In high concentrations, it can irritate skin.

Students should observe that both cups become greener over time, but the "Fertilizer" cup should contain a higher concentration of algae and appear greener.

Depending on the size of your containers, the type of fertilizer used, and temperature and light conditions in your room, results may vary, and you may want to decrease the amount of fertilizer that is suggested.

Wrap-up
Within their groups, have students complete the Conclusions section of their **Nutrient Soup Report Sheets.** On the back of the sheet, have students summarize their observations and some possible reasons for the phenomena they observed. Have groups prepare a report on their observations, conclusions, and summary. Students should be able to describe the effects of excessive algae growth on fish and other aquatic organisms. Students should conclude their reports with proposed ideas for things that can be done to keep lakes and streams clean by preventing nuisance algae growth. Groups can present their reports as an oral presentation for the rest of the class, or turn it in as a written report.

For additional study, discuss residential and agricultural fertilizer use with the students. Then have them perform research to investigate how statewide fertilizer use has changed over time As a class, create a chart that illustrates how statewide use of lawn care and agricultural fertilizers has increased during the past century. Note the positive and negative effects over time.

Part 3: Nature's Strainers
This experiment requires a 48-hour waiting period before results become observable.

Warm-up
1. Discuss how some aquatic plants, such as bulrush, can filter and break down pollutants. Also discuss how plants can absorb excess nutrients.
2. Discuss with students some of the ways chemicals enter lakes or streams. Some examples include an oil or gasoline spill on the ground that washes into the water through a city storm drain, or winter road salt washing from roads into lakes and streams.

Lesson
1. Divide students into small groups of three to five students.
2. Give each group two cups, two stalks of celery (with the leaves attached), and two tablespoons of salt.
3. Have the students label the cups "Water" and "Salt Water."
4. Fill the cups half full with drinking water.
5. Add the salt to the "Salt Water" cup. Carefully stir the water with a straw or spoon to dissolve the salt.
6. Place a stalk of celery in each cup.
7. Place both cups in a window. Keep light and temperature conditions identical for both cups.
8. Each group should make a prediction about what they think will happen during the experiment. This prediction should be recorded on paper.
9. After 48 hours, taste the leaves from each celery stalk.
10. Record the results.

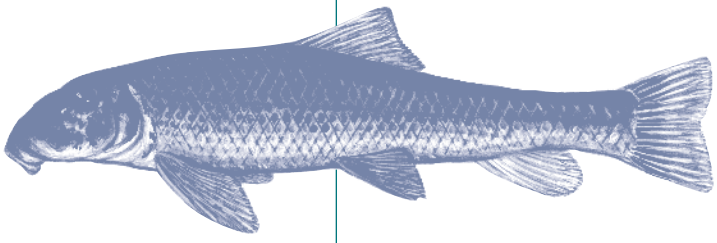
© 2010 Minnesota DNR • MinnAqua • USFWS Sport Fish Restoration

Wrap-up

1. The leaf in the "Salt Water" cup should taste salty. Ask the students to explain why the leaves taste like salt even though the leaves weren't touching the water. Plants absorb the salt and the water, which move to the leaves through the xylem. Ask students to think about how this experiment relates to aquatic plants. How does salt get into lakes and streams, and how might high concentrations of salt affect aquatic life?
2. Tell the students that outdoor plants can remove excess nutrients and some pollutants from runoff before they flow into lakes and streams—just as they witnessed in their experiment. Wetlands are particularly valuable environmental filtration areas. Plants in wetlands and in zones surrounding lakes and streams absorb and filter excess nutrients and chemicals that run off the land. For example, high concentrations of road salt that entering water body with snowmelt can make the water toxic to fish and other aquatic animals over time. But if plants surround the lake or stream, they can absorb the salt—or filter it from the runoff water, preventing a large influx of salt (and other harmful compounds) into the lake or stream.
3. Ask students to think of other chemicals that can get into the water (a very long list, containing, oil, detergent, fertilizers), and discuss the ways which plants could be used to prevent these chemicals from reaching the water.

Assessment Options

1. Evaluate students' presentations about the plant communities they drew for Part 1. Presentations should include where their plant type grows, and how organisms benefit from the plants.
2. Evaluate the students' predictions, observations, and conclusions on the **Nutrient Soup Report Sheets** for Part 2.
3. Evaluate students' explanations of why the celery leaf tastes salty and what this means for aquatic plants exposed to chemicals in aquatic environments for Part 3.
4. Assessment options include the Checklist and Rubric on the following pages.



Checklists are tools for students and instructors. Checklists involve students in managing their own learning. They help students understand and set learning goals before the lesson begins, and help them monitor their progress during the lesson, ensuring that they meet learning goals and objectives by the end of the lesson. Students can also use checklists to discover areas that may need improvement. Checklists help instructors monitor each student's progress throughout the lesson, facilitating appropriate adjustment of instruction to ensure learning by the end of the lesson. The instructor may wish to have students add several of their own learning goals to the checklist to personalize it, and to accommodate varied learning needs and styles.

Grade

28-31 points = A
Excellent. Work is above expectations.

24-27 points = B
Good. Work meets expectations.

19-23 points = C
Work is generally good. Some areas are better developed than others.

15-18 points = D
Work does not meet expectations; it isn't clear that student understands objectives.

0-14 points = F
Work is unacceptable.

The Function of Aquatic Plants Checklist

Possible Points	Points Earned Student	Points Earned Instructor	
4	_____	_____	Group includes at least four examples of their plant type in the poster.
4	_____	_____	Plants are drawn with lifelike shapes and dimensions.
5	_____	_____	Poster shows combination of at least five types of native wildlife and fish species that utilize each plant type.
3	_____	_____	Design well-organized. Organisms easily seen and placed in habitats.
4	_____	_____	Plants and animals appear under the water's surface, on the bottom, on the surface, and in habitat above the water.
4	_____	_____	Design utilizes at least four types of materials.
2	_____	_____	Student can define *littoral zone*.
2	_____	_____	Student can define *surface runoff* and *erosion*.
3	_____	_____	Student can describe three benefits to wildlife and habitats provided by aquatic plants.
Total Points			
31	_____	_____	**Score** _____

© 2010 Minnesota DNR • MinnAqua • USFWS Sport Fish Restoration

The Function of Aquatic Plants Scoring Rubric

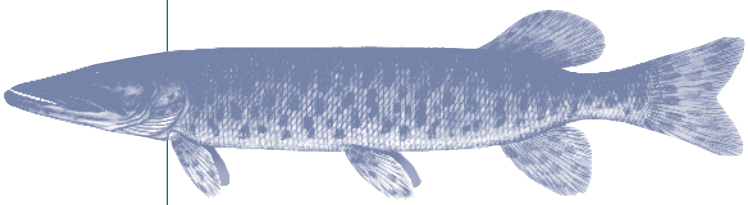
Group Project Criteria	4 Excellent	3 Good	2 Fair	1 Poor	0 Unacceptable
Aquatic plant type	Group includes at least four examples of their plant type in the poster. Plants drawn with lifelike shapes and dimensions.	Group includes three examples of their plant type in the poster. Plants drawn with lifelike shapes and dimensions.	Group includes two examples of their plant type in the poster. Plants drawn with lifelike shapes, but dimensions aren't quite right.	Group includes one plant type in the poster. Plants aren't drawn with lifelike shapes or dimensions.	Group doesn't complete the poster.
Wildlife and fish species	Poster shows at least five types of native wildlife and fish species that utilize each plant type.	Poster shows at least four types of native wildlife and fish species that utilize each plant type.	Poster shows at least two to three types of native wildlife and fish species that utilize each plant type.	Poster shows only one native wildlife and fish species that utilize each plant type.	Wildlife species shown don't utilize plant species shown.
Design	Design nicely organized. Organisms easily seen and appear in entire water column, bottom, and area above water.	Design well-organized. Some organisms hard to see, and appear only in below- surface water column.	Design is okay, but it's hard to see all organisms. Organisms appear only on lake bottom.	Haphazard design. Doesn't represent a real lake or stream system.	Poster not completed.
Materials	Design utilizes at least four types of materials.	Design utilizes at least three types of materials.	Design utilizes at least two types of materials.	Design utilizes just one material.	Poster not completed.

Score _____ (Calculate score by dividing total points by number of criteria.)

Diving Deeper

Extensions

1. Take a field trip to a local pond. Ask students to bring wading shoes or boots. Have them examine the littoral zone and locate the four communities of plants that they see. As they explore the littoral zone, students should look for animals hiding within vegetation. They may use a journal to record the numbers and types of animals they observe in a vegetated area compared to a non-vegetated area.
2. An extension of the algae growth experiment in Part 2 could include examining samples of pond water under a microscope at various times throughout the observation period. Over time, different algae may become dominant—and students can record these observations in addition to their macroscopic observations.
3. Have students design posters advertising phosphorus-free fertilizer and dishwashing detergents. These can then be given to the stores that carry them.
4. Have students become involved in a local shoreland restoration project.



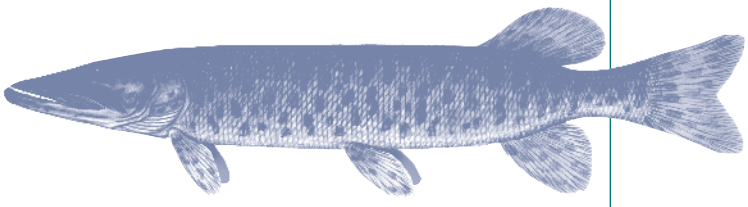
For the Small Fry

K-2 Option

1 Ask students if they've ever seen a lake or pond in the summer that has "turned green." Explain that tiny organisms called algae turn the water green. Excessive algae blooms affect fish and other animals that live in and on the water, too. Do the algae growth experiment, using a simpler data sheet on which students can record observations.

2 Ask students about plants they may have seen in and around lakes, streams, or ponds. Ask them what they think plants do to keep the environment healthy.

- Demonstrate how plants absorb nutrients by placing one white carnation in two glasses of colored water. To do this cut the stem of the carnation in half lengthwise from the end to approximately halfway to the flower. Fill each of the two glasses three-quarters full of water. Add three to five drops of red food coloring to one glass, and the same amount of blue food coloring to the other glass. Gently stir to mix in the food coloring. Place one end of the flower stem in the glass with the red water and the other end of the flower stem in the glass with the blue water.
- Let the flowers stand in the water for 48 hours. The white flower will then turn half red and half blue. The colored water was absorbed through the tiny tubes, called xylem, in the plant's stem. When the colored water reached the petals, the color was distributed to all the cells in those areas of the plant. This is how nutrients in the water move to a plant's cells: the nutrients dissolve in water and move to the roots, leaves, and flowers. Aquatic vegetation along shorelines absorbs excess nutrients in the water that can cause algae growth to run amok.



STUDENT COPY

Name(s) _____ Date _____

Nutrient Soup Report Sheet

Prediction

What do you expect to happen in the cup labeled **Fertilizer?**

What do you expect to happen in the cup labeled **No Fertilizer?**

Observations

© 2010 Minnesota DNR • MinnAqua • USFWS Sport Fish Restoration

STUDENT COPY

Name(s) _____ Date _____

Nutrient Soup Report Sheet

Record your observations of the two containers. Notice things like the color of the water, whether or not it's clear, and how it smells when compared to the other container and to the previous day.

Day #	No Fertilizer (control)	Fertilizer (experimental)
1		
2		
3		
4		
5		
6		
7		

© 2010 Minnesota DNR • MinnAqua • USFWS Sport Fish Restoration

STUDENT COPY

Name(s) _____ Date _____

Nutrient Soup Report Sheet

Conclusions

Did you observe what you expected to observe in your prediction? Explain why or why not.

What would you do to improve the experiment for next time?

How could an algae bloom like the one you may have observed in this experiment occur in a lake instead of a cup?

What are some consequences of an algae bloom in a lake or pond? How do algae blooms affect fish in a lake?

What can you do to prevent an algae bloom from happening in your favorite lake?

© 2010 Minnesota DNR • MinnAqua • USFWS Sport Fish Restoration