Aquatic Plant Power

Quality fish habitats are being lost throughout Minnesota.
But there are many ways we can protect them!

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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

Aquatic Plant Power

Minnesota Academic Standards

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

Language Arts

Grades 3, 4, and 5
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 1—The student will participate in and follow agreed-upon rules for conversation and formal discussions in large and small groups. ●

Math
Alignment to the 2007 Minnesota Academic Math Standards coming soon.
Grades 3
I. Mathematical Reasoning
Benchmark 1—The student will communicate, reason and represent situations mathematically. ◑
Benchmark 2—The student will solve problems by distinguishing relevant from irrelevant information, sequencing and prioritizing information and breaking multi-step problems into simpler parts. ◒
IV. Data Analysis, Statistics, and Probability
A. Data and Statistics:
Benchmark 1—The student will read and interpret data from circle graphs using halves, thirds and quarters. ◑
V. Spatial Sense, Geometry, and Measurement
C. Measurement:
Benchmark 4—The student will tell time to the minute using digital and analog time. ◑
Benchmark 5—The student will determine time elapsed to the minute. ●

Grade 4
I. Mathematical Reasoning
Benchmark 1—The student will communicate, reason and represent situations mathematically. ◑
Benchmark 2—The student will solve problems by distinguishing relevant from irrelevant information, sequencing and prioritizing information and breaking multi-step problems into simpler parts. ◒
IV. Data Analysis, Statistics, and Probability
A. Data and Statistics:
Benchmark 1—The student will collect data using observations or surveys and represent the data with tables and graphs with labeling. ◑
Benchmark 2—The student will use mathematical language to describe a set of data. ●

Grade 5
I. Mathematical Reasoning
Benchmark 1—The student will communicate, reason and represent situations mathematically. ◑
Benchmark 2—The student will solve problems by distinguishing relevant from irrelevant information, sequencing and prioritizing information and breaking multi-step problems into simpler parts. ◒
IV. Data Analysis, Statistics, and Probability
A. Data and Statistics:
Benchmark 3—The student will collect data using measurements, surveys or experiments, and represent the data with tables and graphs with labeling. ●

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 1—The student will ask questions about the natural world that can be investigated scientifically. ◑

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.
III. Earth and Space Science
B. The Water cycle, Weather and Climate:
Benchmark 1—The student will measure, record, and describe weather conditions using common instruments.
C. The Universe:
Benchmark 3—The student will observe that the sun supplies heat and light to the earth.
IV. Life Science
C. Interdependence of Life:
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
A. Scientific World View:
Benchmark 1—The student will explore the uses and effects of science in our interaction with the natural world.
B. Scientific Inquiry:
Benchmark 2—The student will collect, organize, analyze and present data from a controlled experiment.
Benchmark 3—The student will recognize that evidence and logic are necessary to support scientific understandings.
II. Physical Science
A. Structure of Matter:
Benchmark 2—The student will describe the changes in the properties of a substance when it is heated or cooled.
III. Earth and Space Science
A. Earth Structure and Processes:
Benchmark 1—The student will identify and investigate environmental issues and potential solutions.

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.
C. Scientific Enterprise:
Benchmark 1—The student will describe different kinds of work done in science and technology.

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 4 • Lesson 3

Aquatic Plant Power

Grade Level: 3-5
Activity Duration: Part 1: 45 minutes Part 2: 60 minutes
Group Size: any
Subject Areas: Science, Math, Language Arts, Environmental Education
Academic Skills: analysis, comparison, drawing conclusions, experimentation, graphing, measuring, observation, prediction, recording data, simulation, small group skills
Setting: indoor or outdoor gathering area with tables
Vocabulary: aquatic ecosystem, Aquatic Management Areas (AMAs), Aquatic Plant Management Program (APM), best management practices, buffer zone, crucial habitat, erosion, habitat, lunker structure, random spawners, sedimentation, spawning, Stream Habitat Program, substrate, sustainable use of resources
Internet Search Words: Minnesota DNR website: Aquatic Management Area, best management practices, shoreland habitat restoration

Summary

Students will conduct experiments to explore two significant ways that aquatic habitats support fish reproduction and growth. In Part 1, students will create a fish-spawning habitat in a container and compare good and poor spawning conditions. In Part 2, students will compare water temperatures in shaded and non-shaded stream environments, investigating how shoreline vegetation creates suitable water temperatures for certain types of fish.

Student Objectives

The students will:

1. Create a fish-spawning mini-habitat to explore suitable spawning conditions for some common Minnesota fish.
2. Predict and determine the effects of shade on water temperature by conducting an experiment.
3. Record observations on a data sheet.
4. Communicate results by answering questions and constructing a graph.
5. Propose ideas for conserving and improving habitats crucial to fish survival and reproduction.

Instructor's Background Information

The Value of Aquatic Habitats

Strong economies and vibrant human communities depend on healthy, resilient ecosystems. Citizens, business leaders, and public officials need to understand how ecosystems function, how they support human uses, how human uses impact them, and how resource management practices and land use patterns affect long-term ecosystem health.

Walleyes, ducks, lily pads, dragonflies, bass—Minnesotans love their lakes, rivers, and streams, and the diversity of the resident life forms. Lakes, rivers, and streams shelter many species that, in turn, interact with one another and with the nonliving components of the environment such as water, rocks, and air. An **aquatic ecosystem** is composed of any body of water (stream, river, pond, wetland, or lake) and all organisms and nonliving components within it that function as a natural system. Aquatic **habitats** meet the survival needs of many organisms by providing food, water, shelter, nesting areas, and protection from predators. Various types of aquatic habitats located underwater and along the shoreline support a wide array of aquatic plants and animals.

Aquatic habitat diversity helps to fulfill the needs of different species of fish. Rocky or gravel bottoms of lakes and streams can be critical spawning (fish reproduction) habitats for many fish such as walleye, trout, and suckers. Fallen trees, aquatic plants, and large rocks provide places for fish to feed and to hide from predators. Aquatic plants,

Materials

Part 1: The Next Generation
For each group of four or five students:

- One gallon of tap water
- One clear plastic container (mini-aquarium or shoebox size)
- Large gravel, enough to cover the bottom of the container (available at landscaping stores or gravel pits; clean the gravel well before use)
- One cup of very fine sand (art sand works well and is available at gravel pits or arts and crafts stores)
- One-half cup of pea-size glass beads or small aquarium rocks (available from arts and crafts stores, catalogs, and pet stores)
- Two cups or small containers for beads and sand
- Large spoon (optional)
- Paper towels
- **The Next Generation Sheet,** one per student
- Pencils or pens

Part 2: Be Cool
One set needed for classroom demonstration:

- One gallon cool tap water
- Two eight-inch-square pans, small bread pans, or something similar (water will heat more quickly in dark or metal pans)
- Four to six leafy houseplants large enough to shade one pan (size and number will vary with pan size)
- Two lamps with bulbs of the same wattage (the higher the wattage, the faster the results)

continued

along with living and dead trees, provide shade that helps keep water temperatures cool. What's important to remember is that when habitat diversity is degraded or destroyed, fish populations can be negatively impacted over time.

Management of Aquatic Habitats
If you've visited lakes across Minnesota, you've probably noticed that some have many plants and others have very little vegetation. Aquatic vegetation helps to maintain clear water by absorbing excess nutrients that cause algae blooms, slowing runoff rates, and stabilizing bottom sediments and shorelines. Aquatic plants also provide cover, shelter, and food for fish, waterfowl, furbearers, insects, and amphibians. Sometimes landowners wish to remove aquatic plants near the shoreline because they interfere with their access to the water—but *aquatic plants growing in public waters are owned by the state.* The Minnesota DNR Aquatic Plant Management Program protects native vegetation and the aquatic environment from unnecessary harm while still permitting lakeshore homeowners limited control of some aquatic vegetation for water access. DNR permits are required for any application of herbicides to control submerged vegetation in lakes, as well as for the removal of emergent vegetation by mechanical means. DNR Aquatic Plant Management Specialists are responsible for site inspections and for general educational activities related to aquatic plants in their respective regions. These staff members are responsible for developing and providing educational materials and information for permit applicants, technical advice for the general public, coordinating herbicide regulations with the Department of Agriculture, updating and revising aquatic plant management rules, working with commercial aquatic plant harvesters, and for coordinating statewide efforts with regional fisheries aquatic plant management specialists.

The Aquatic Management Program also includes efforts to enforce laws related to pesticide use. Aquatic pesticide enforcement specialists also supervise herbicide treatments. They investigate reports of pesticide misuse in lakes and the unlawful destruction of aquatic vegetation. Pre- and post-herbicide application inspections are conducted to determine appropriate solutions to problems and evaluate results.

The Minnesota DNR Stream Habitat Program gathers and provides information on Minnesota's 90,000 miles of rivers and streams, helping to conserve and restore them. These waterways provide enormous benefits, including recreation, fish and wildlife habitat, and economic and ecological benefits for the state's citizens. Over the past century, though, urbanization and changes in land use have degraded many Minnesota rivers. Ditching, damming, straightening, polluting, dredging, and the removal of vegetation from riverbanks are just a few examples of activities that have harmed Minnesota rivers.

One of the primary objectives of the Stream Habitat Program is to protect fish and river ecosystems by making sure that adequate amounts of water flow through rivers and streams throughout the year. By studying rivers in each of the state's 39 major watersheds, biologists determine the amounts of water that constitute healthy ecosystems. This information is given to municipalities, public and private planners, state and federal natural resource agencies, and citizens, so they can make informed decisions that will protect river ecosystems. In conjunction with natural flow regimes, healthy rivers have stable banks, high water quality, natural shapes, variation in depths and water velocities, streambed **substrates** (bottom material such as rocks, gravel, or muck), varied vegetation cover, connectivity to other water bodies, and healthy floodplains. Together, these factors create diverse habitats, which, in turn, promote diverse, thriving communities of fish, amphibians, mussels, invertebrates, and plants. The Stream Habitat Program also collects and evaluates fish and other animals to determine types of habitat preferred and required by various species.

The Stream Habitat Program is actively involved in restoring degraded stream channels. Its restoration projects include the removal or modification of dams on the Pomme de Terre River in Appleton and on the Red River of the North in Fargo/Moorhead. These projects restored the connectivity of the streams, allowing fish to migrate upstream and people in canoes to move downstream. Another project involved a four-mile stretch of the Whitewater River in southeastern Minnesota. Many years ago, this segment of the river was converted to a straight ditch. The Program recently participated in restoring it to a meandering stream rich in diverse habitats that shelter thriving fish and other aquatic organisms

Spawning Habitat

The spawning (reproduction) of freshwater fish occurs when females lay a large number of eggs. During their breeding season, the adult fish typically move to shallow areas to lay and fertilize eggs around rocks, gravel, or vegetation. Males swim over the eggs, releasing milt (fish sperm) that fertilizes the eggs. Fertilized eggs develop into embryos, which hatch into small fish called **fry**.

Fish such as bluegills, salmon, trout, and largemouth bass make depression nests. To make nests, fish use their tails to sweep sediment and debris from the lake or stream bottom. Nests can be one to two feet wide and several inches deep. In the sunfish family, the males guard the nest to protect eggs and fry from predators.

Other fish, such as northern pike and walleye, don't construct nests. These fish, known as **random** or **broadcast spawners**, scatter their eggs randomly over their preferred spawning habitat. These fish don't tend their eggs. The preferred spawning habitat for northern pike is vegetation in shallow areas, or in wetlands connected to a lake. Walleyes spawn over shallow areas containing cobble and gravel in lakes or

Materials (continued)

- Two thermometers (room temperature ranges), preferably with one-half- or one-degree markings
- One gallon ice cream bucket
- One cup or other container to transfer water from bucket to pans
- Paper towels
- Graph paper
- **Be Cool Sheet,** one per student
- Pencils or pens

A typical female walleye lays more than 100,000 eggs each spawning season.

Although most Minnesota fish spawn in the spring, a few species, such as brook trout, brown trout, and lake trout, spawn in the fall.

Soil erosion and sedimentation is, by volume, the largest pollutant in Minnesota lakes and streams.

streams. The walleye eggs fall into the crevices between rocks, which protect them from predators. Regardless of egg-laying style, fish eggs require a fresh supply of dissolved oxygen (oxygen molecules present and mixed with water) for proper development and growth. If heavy deposits of fine sediment cover the eggs, or if pollution has created low oxygen levels in the surrounding water, the probability of successful hatching is reduced.

Fish Habitat

Aquatic plants provide habitat for fish. Fish need aquatic plants, particularly for food and cover. Small fish take cover from predators in vegetation. Aquatic plants also shelter small organisms, such as zooplankton and macroinvertebrates, that are eaten by juvenile fish. These organisms are also an important food source for adult fish and waterfowl. Aquatic plants provide **crucial habitat** for juvenile fish (fish 20-100 millimeters long) of every species of interest to anglers—walleye, northern pike, bass, crappies, sunfish, and catfish–as well as for species of less interest to anglers, but essential to the effective functioning of aquatic ecosystems—minnows, shiners, and darters. The crucial habitat for juvenile fish is aquatic vegetation. No other habitat type, such as bare sediments, rocky shoreline, or deep-water, will ensure the survival of juvenile fish.

Shoreline Vegetation

Shoreline vegetation includes plants growing on the land close to shore (upland plants) as well as the plants that grow in the water. Plants produce oxygen during photosynthesis, and plants growing in water add oxygen to the water. Fish use gills to "breathe" this oxygen from the water. Shoreline vegetation, both in and out of the water—such as trees, grasses, reeds, and lily pads—prevents **erosion**. Erosion is the gradual wearing away of land by natural forces such as flowing water or wind, or from human or other animal disturbance to the soil. Vegetation anchors soil, naturally filters surface runoff water, and can actually break down some chemicals and toxins, making them less harmful.

Shoreline vegetation also shades streams and lakes, giving fish valuable hiding and resting areas away from bright sunlight. (Fish have no eyelids to protect their eyes from the sun.) Fish also benefit from water temperature regulation afforded by the shade of plants. (Springs also keep some stream waters cold. If people draw too much water from a stream for irrigation, industry, or other uses, or there isn't sufficient recharge of underground springs, streams can become warmer, or even dry up.)

Although Minnesota fish have a range of temperature preferences, they usually become stressed in very warm water. Warmer water doesn't hold as much oxygen as colder water, so fish may have difficulty breathing in water that is too warm. Some fish, such as brook trout, require high concentrations of dissolved oxygen for survival and reproduction.

Cold water (50˚ to 60˚ F) can support these high dissolved oxygen levels. Many trout streams must have shade provided by trees or other overhanging vegetation in order for cool water temperatures to be maintained throughout the warm summer months. If shade sources are removed from shorelines, water temperatures can increase dramatically. Over time, these changes affect the types and numbers of fish that can survive in streams.

Water quality requirements for freshwater fish.

	Channel Catfish	Bluegill	Walleye	Rainbow Trout	Northern Pike
Water Temperatures	75-85 F	65-80 F	35-80 F	40-60 F	45-75 F
Water Type	Eutrophic; warmwater streams, rivers, and ponds	Eutrophic to mesotrophic; warmwater streams, rivers, and ponds	Mesotrophic; coolwater large lakes and streams	Mesotrophic to oligotrophic; coldwater streams, rivers, and deep lakes	Mesotrophic to oligotrophic; coolwater lakes, large rivers, and reservoirs
Clarity	Clear to turbid; can adapt to waters most fish canít tolerate	Less turbid waters than tolerated by channel catfish	Clear, sometimes turbid waters with good fertility	Clear, with some to very little fertility and moderate vegetation	Clear, with moderate amounts of aquatic vegetation
Oxygen (Minimum)	3 ppm	3-5 ppm	5 ppm	6 ppm	4 ppm
pH	4.5-9	5.5-9	6-9	6.5-8.5	6-9

Human Impact and Fish Habitat

Human activity has tremendously impacted aquatic habitats in Minnesota. Historically, farming, industrial waste, and untreated municipal sewage have been the worst polluters in our aquatic environments. More recently, the furious pace of lake home construction, the straightening of streams for irrigation, and poorly-planned development within the watershed have led to numerous problems in lakes and streams throughout the state. A negative impact on just one component of a complex aquatic community can directly or indirectly affect many other components of the system. For instance,

Lawns that run to the edge of a lake increase runoff and erosion.

Buffer zones reduce runoff and erosion.

the removal of native vegetation from land or water increases erosion and eliminates important habitats for fish. The resulting increase in fine soil particles (sediment) in the water, **sedimentation**, damages spawning habitat by covering rock and gravel patches that many fish need for successful reproduction. Sediment that settles after eggs have been laid prevents them from obtaining sufficient oxygen. The vegetation itself may have been spawning habitat for other species of fish such as northern pike. The removal of shoreline plants also eliminates the shade that helps regulate water temperatures. Many human activities—on the land and in the water—contribute to decreased water quality and loss of productive fish habitat.

In some cases, activity on land *increases* plant growth in aquatic ecosystems. Intense cultivation or land development near a lake often causes nutrients to run off from the watershed into the water, stimulating the growth of aquatic plants. Nutrient-laden discharges from sewage treatment plants, livestock feedlots, and leaky septic systems promote heavy growth of algae and aquatic plants. Development within a watershed also speeds up a lake's aging process, or eutrophication. The addition of houses, paved driveways, and other hard surfaces also promote a more rapid flow of nutrient-rich runoff into lakes and streams. For these reasons, lakes and ponds that didn't naturally support a dense growth of aquatic plants may show increased plant growth due to human activities.

Because plants add oxygen to the water and provide habitat for aquatic macroinvertebrates, it's often assumed that dense vegetation helps rather than harms fish, invertebrates and other microorganisms. It's important to remember that healthy plant growth must be distinguished from excessive plant growth. Excessive plant growth can negatively impact fish populations by reducing the effectiveness of predators on prey fish (dense vegetation hides smaller prey fish more effectively.)

When algae and plants die, bacterial decomposers go to work, consuming dissolved oxygen in the process. Because aquatic plants are often confined to a narrow littoral zone, their decay doesn't greatly affect overall dissolved oxygen levels in deeper waters (hypolimnion). But floating mats of dense algae produced by nutrient-rich or fertile water can drift over the deeper areas of a lake. When these algae mats die and decompose, dissolved oxygen levels in the lake can be significantly reduced. The balance of a water body's aquatic life can be upset when oxygen levels fall too low to support fish populations and other aquatic organisms.

Resource Managers Work With Citizens and Communities

To be most effective, the Minnesota DNR must work with all Minnesota citizens to solve the problem of fish habitat loss. It's a big job. Aquatic vegetation is so important to fish. Education is one of the most important management tools of Minnesota DNR Fisheries. When people understand the value of lake and river vegetation to aquatic ecosystems, they have reason to maintain their shoreline vegetation. Fortunately, there are many things that we can all do to reduce or reverse fish habitat loss if we work together now! Best Management Practices (BMPs) outline what shoreline property owners can do to reduce damage to aquatic environments. BMPs for shorelines most often involve retaining the natural characteristics of shoreline. If a shoreline has already been altered, BMPs call for restoring it with filter strips or buffer zones of natural vegetation. Buffer zones help restore degraded aquatic habitat to productive habitat that include places for fish to feed, hide, and spawn. Planning and participating in a shoreline-planting event is one way that people can work together to efficiently replant buffer zones with native shoreland vegetation.

To improve fish habitat, the DNR implements a variety of cooperative projects to restore disturbed areas to more natural conditions. The Shoreland Habitat Restoration Program works with shoreland property owners and citizen groups to replant native aquatic and shoreland plants and protect existing shoreline from erosion to improve the quality of shoreline habitat. Other restoration efforts include adding dead trees, or **snags** to provide habitat, constructing underwater habitats known as **lunker structures** (box frames placed in the water along the edges of streams where fish can safely hide from predators and grow larger), and improving the substrate for spawning. These efforts improve feeding, hiding, and spawning habitats for fish. Restoration projects raise awareness of the value of native shoreline and aquatic vegetation by enlisting volunteers from local schools and community organizations. Signs posted in restored areas inform visitors of the goals and benefits of shoreland habitat restoration projects.

Look for this sign at shoreline habitat restoration sites.

It's more cost effective to maintain existing vegetation and aquatic habitat than to restore them after damage or disturbance. To this end, the DNR works with citizens through the **Aquatic Management Areas (AMA) Program.** AMAs are purchased from landowners willing to preserve shoreline and littoral (shallow water) edges of lakes and streams. The AMA Program targets critical shoreline habitats for its acquisitions—these often include fish spawning and nursery areas. Once purchased, these public areas are protected from development. In 2006, there were more than 100 AMAs throughout Minnesota.

Government and Habitat Protection

The Minnesota Legislature has long recognized the enormous value of the state's water resources and understands that sustainable shoreland ecosystems promote healthy communities, environment, and economy. **Sustainable** use of natural resources (**sustainability**), means using natural resources in ways that meet the needs and aspirations of the present generation without compromising the ability of the environment to meet the needs and aspirations of future generations.

The Legislature acted to preserve and protect our waters and adjacent lands. In 1969, it enacted the Shoreland and Flood Plain Management Acts, and in 1973, the Minnesota Wild and Scenic Rivers Act. These statutes enabled the Minnesota DNR to establish standards and criteria that are periodically reviewed and amended. On July 3, 1989, the revised statewide standards for shoreland management were adopted. Other programs, such as Local Water Planning and the Pollution Control Agency's Clean Water Partnership, also address the challenge of watershed management at the local government level.

Maintaining a High Quality of Life *and* Sustaining High-quality Natural Resources

A high quality of life can be achieved through low impact development that meets communities' social and economic needs as it sustains high-quality natural resources. Recommendations for **water quality and watershed protection and management** include:
- Watershed-wide impacts and benefits must be considered in all land use decisions.
- All surface water must have healthy buffer or filter strips along the shoreline to reduce and slow runoff, filter remaining runoff, and increase infiltration.
- Land use beyond the filter strip must also be carefully managed.
- Healthy wetland systems are critical to good water quality.
- Preservation and restoration of native vegetation on shorelines and throughout the watershed provide a diverse plant community and healthy aquatic and upland habitats.

Recommendations for **natural resource conservation and balanced land use** include:
- Residential communities that preserve natural vegetation and habitats that improve the environment.
- Development in the entire watershed must follow established Best Management Practices.
- Sustainable farming practices are critical for a balanced and healthy natural environment.
- Commercial development must be integrated into the environment in ways that minimize negative effects on the natural environment.
- An understanding of how plants keep fish habitat and aquatic ecosystems healthy is vital to sustainable use of natural resources.

Procedure

Preparation

Part 1: The Next Generation

1. Collect the materials needed. Wash the gravel prior to use.
2. Set up a demonstration container with an appropriate amount of gravel for comparison. The amount of gravel will vary with the size of the container. Add at least enough to completely cover the bottom of the container and create small crevices.

3. Make copies of **The Next Generation Sheet** on which students can record their observations.

Part 2: Be Cool

1. Set up a class experiment as a demonstration in an area where all students will be able to see from their seats.
   - Fill an ice cream bucket with cool tap water.
   - Use a smaller container or measuring cup to transfer water into one pan until the water is about one-half-inch deep. Add the same volume of water to the second pan.
   - Around one of the pans, place several plants that are large enough to shade the entire container. The other pan should not be shaded.
   - Set up a lamp next to each pan. Adjust the lamps so they're exactly the same distances from the pan, and directing light towards the water. The bulbs should be as close to the water as possible without touching any plant parts. The lamplight simulates solar energy hitting the water in one pan and the plants in the other pan. Both lamps should be turned off.
   - Set a thermometer in each pan, making sure that the tips are submerged.
2. Photocopy the **Be Cool Sheets** for students to use to record data. Write any additional desired questions on the whiteboard.

Part 2 of this activity requires one class period dedicated to observing temperature changes in the water. Students may become restless during the intervals between temperature readings. To prevent this, you may wish to begin the lesson starting with the Part 2 demonstration and take the first water temperature reading. Then proceed to the Part 1 activity. Have students continue taking the temperature readings of the two water samples when the timekeeper calls out the time during the Part 1 activity.

When you set up this experiment, be sure that the plants cover and shade the entire container—no light energy should reach the water.

Activity

Part 1: The Next Generation
Warm-up

1 As a group, ask students to create a list of animals that lay eggs. If fish are not mentioned, tell them that most fish also lay eggs that develop into small fish called fry. What unique survival challenges might fish eggs face that eggs laid on land do not? Explain some of the conditions necessary for successful hatching of fish eggs: protection from predators and the circulation of clean water, which provides oxygen and keeps the eggs free of dirt and silt.

2 Ask students to imagine a mud puddle. Ask them to describe the appearance of the water in a mud puddle. Is it clear? Is it murky? What happens to the water if you stir up the bottom? Explain that, if large amounts of sediment from land continue to wash into the water over time, lakes and streams can begin to resemble a large-scale mud puddle. Explain that some sediment washes into lakes and streams naturally, but if a lot of sediment washes in over a long period of time, this causes problems for fish. Ask them to think of some reasons why the land may erode near water bodies. Remind students that most fish need clean water to successfully reproduce. Then inform them that they will be exploring these themes by constructing a spawning habitat with features similar to those used by some common Minnesota fish.

Lesson

1 Separate students into groups of four or five. Give each team a clear plastic container, gravel, sand, glass beads, and paper towels. Distribute **The Next Generation Sheet** to each student.

2 Each team should add enough gravel to the container to cover the bottom completely, and to create spaces into which glass beads can fall. This container represents a rocky substrate used by random spawners, such as walleye, to lay their eggs. After students have created the spawning habitat, they should carefully add enough water to the container to fill it halfway. Have students record what type of fish would use this habitat for spawning.

3 Explain to students that their glass beads represent fish eggs. To simulate fish spawning, one student should slowly "sprinkle" the glass beads over the water so all areas of the container have been exposed to the beads. The glass beads will sink to the bottom. Another student should gently stir the water by hand or with a spoon (without disturbing the rocks on the bottom) for five to ten seconds—this simulates water currents. Tell students that the beads represent fish eggs that will develop into fry if conditions are right.

4 Students should observe the location of glass beads among the gravel. Encourage them to view the spawning habitat from the top and all four sides to help them make complete observations. Where did most of the beads settle? Did some beads settle in crevices? Does it appear that the beads in the gravel are exposed to clean,

fresh water and oxygen? Each group should record their observations.

5. Tell students that they will now simulate erosion-causing sediment entering the lake from an area recently cleared of its shoreline vegetation. Water running off the cleared land will wash soil into the lake and over the spawning bed. Have one student carefully sprinkle one-half to one cup of sand (depending on the size of the container) over the entire surface of the water. Again, one student should gently stir the water by hand or with a spoon for five to ten seconds to simulate water currents. Allow the sand to settle.
6. Have students record observations about where the sand settled in the habitat. Are the eggs covered with sand? Does it appear that the beads in the gravel are still exposed to clean, fresh water and oxygen?

Wrap-up

Ask students to imagine that their model is a real fish spawning area in a lake or stream, and that they are DNR Fisheries staff working to protect spawning areas. Will the eggs covered with sediment survive? Why or why not? Ask them to review some possible causes of erosion and sedimentation in natural lakes or streams. What might they be able to do, as DNR Fisheries staff, to protect spawning habitats from erosion and sedimentation?

Part 2: Be Cool

Warm-up

1. Ask students to imagine being outside in a park on a clear and sunny summer day. Where is the air temperature cooler—in the shade of a tree or out in the open? Then ask them to imagine being near a stream. On a data sheet, students should predict whether there would be water temperature differences between a stream shaded by trees and another with little vegetation along its banks.
2. Remind students that both humans and fish breathe oxygen, but that fish get their oxygen from the water. Explain that cool water can hold more oxygen than warm water. Because fish breathe the dissolved oxygen as water passes over their gills, oxygen levels in the water impact the types and numbers of fish that the water can support. Tell them that some fish, such as brook trout, are very sensitive to changes in water temperature and oxygen concentration. If a stream is too warm, these sensitive fish will be unable to survive the low-oxygen conditions.

In this activity, you'll detect only a slight difference (one to four degrees) in water temperature between the two pans. Explain that the sun is hotter than a light bulb, and that lack of shade will increase the water temperature enough to eventually affect the type of fish that can live in the stream.

Caution! Lamp bulbs and frames will get very hot.

Caution! Be careful using electricity near water.

Data for each pan can be plotted on the same graph (as long as the two lines are distinguishable.)

Lesson

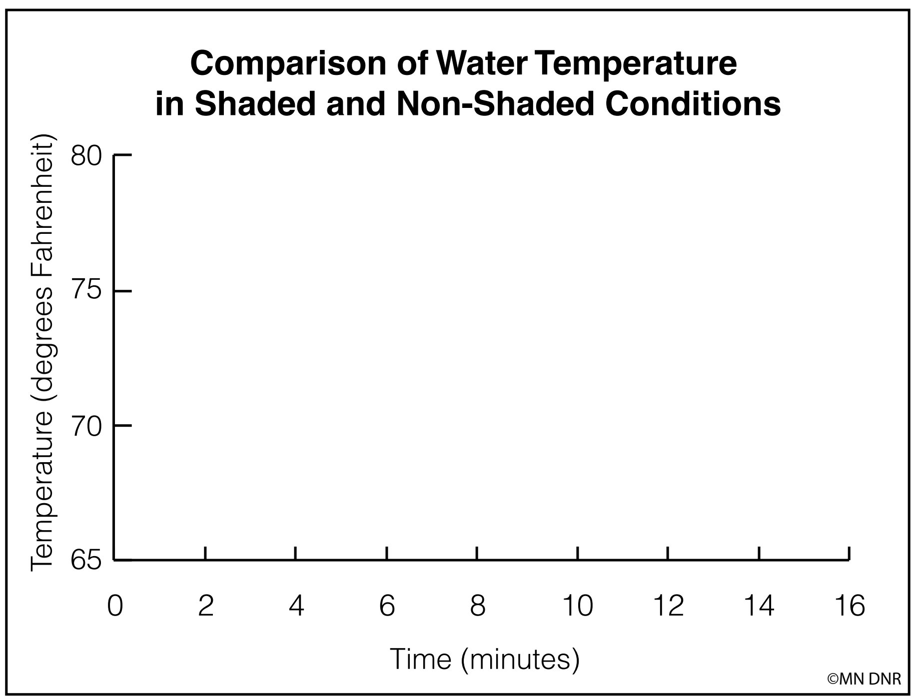
1 Ask students to imagine that they are DNR Fisheries staff members trying to find ways to improve the trout fishing in an impaired local stream.

2 Distribute the **Be Cool Sheets** and graph paper. Make sure all students know how to read a thermometer.

3 Have them direct their attention to the experiment setup and prepare to take notes. Ask for a volunteer to read the temperature of the water in each pan without removing the thermometers from the water. Students should record these pre-experiment temperatures.

4 Ask for another volunteer to be the class timekeeper. The timekeeper should note the time, and both lamps should be turned on. Every five minutes, the timekeeper announces that it's time to take a reading. Each time, have a different student volunteer read and announce the water temperature in each pan. Students should record the temperatures on their data sheets.

5 After 60 minutes (or one class period), stop the experiment. Each student should construct a two-line graph of temperature vs. time for both pans: one line for shaded pan temperatures, the other line for unshaded pan temperatures. To get them started, draw a sample graph on the whiteboard or projection device.



Wrap-up

1 Did students observe a temperature difference between the two pans? If so, what could explain the difference? Have students review their predictions. Were their predictions accurate?

2 Extend these results to the natural world and to the hypothetical fish management situation. What consequences do warm streams pose to fish species? What are some natural sources of shade along stream banks? How might a fisheries manager cool a warm stream so that trout can survive there again? Have students record their answers and ideas on their data sheets.

Assessment Options

1 Assess student participation in each activity and in the Warm-up and Wrap-up discussions. Collect and evaluate all data sheets, observations, and graphs.
2 Evaluate students' proposals and ideas for ways to protect and improve aquatic plant habitat.
3 Have students write an acrostic poem that summarizes what they learned in both activities. To write an acrostic poem:
- choose a word or concept related to activities in the lesson
- write the word vertically as shown to the right. (bold type)
- for each letter of the word, insert horizontally a phrase or word that contains that letter—the words should string together to make a sentence or phrase that demonstrates understanding of the vertical word in relation to the activities in the lesson

4 Have students work together in small groups to create a graphic organizer of a fictional lake that connects concepts used in the lessons, including: the impact of runoff and erosion on fish spawning areas, how plants influence water temperature and what this means for fish, the impact of habitat loss and habitat restoration on fish, and the role of plants in maintaining water quality. Graphic organizers are visual tools that can take the form of a concept map, tree, star, or web to show definitions, attributes, examples, classifications, structures, examples, relationships, and brainstorming. Charts and tables are graphic organizers that show attributes, characteristics, comparison, and organization. A chain or timeline illustrates processes, sequences, cause-and-effect, and chronology. Diagrams, charts, and drawings show physical structures, spatial relationships, and concrete objects. A piece of paper can be cut and folded to create flaps, windows or dials that reveal details, a definition, a description, or explanation when lifted, folded back, or otherwise manipulated.
5 Have students draw a map of a lake illustrating concepts from the lesson and including a key identifying: the impact of runoff and erosion on fish spawning areas, how plants influence water temperature and what this means for fish, the impact of habitat loss and habitat restoration on fish, and the role of plants in preventing erosion and maintaining water quality for fish.
6 Assessment options include the Checklist and Rubric on the following pages.

An acrostic poem.

Plan**T**s
shad**E**
strea**M**s and
kee**P** the
wat**E**r
coole**R**
And help
Trout to
s**U**rvive
with mo**R**e
oxyg**E**n.

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

23-25 points = A
Excellent. Work is above expectations.

20-22 points = B
Good. Work meets expectations.

16-19 points = C
Work is generally good. Some areas are better developed than others.

12-15 points = D
Work does not meet expectations, it isn't clear that student understands objectives.

0-11 points = F
Work is unacceptable.

Aquatic Plant Power Checklist

Possible Points	Points Earned Student	Points Earned Instructor	
3	______	______	Student can explain how sediment from erosion prevents fish eggs from surviving and hatching.
2	______	______	Student can give an example of a species of fish that deposits eggs in gravel stream bottoms.
2	______	______	Student can define *spawn* and *fry*.
3	______	______	Student can record observations and data from an experiment.
4	______	______	Student can describe two causes of erosion and sediment in a water body.
2	______	______	Student can graph data from a water temperature experiment and present data to class.
2	______	______	Student can reasonably predict how shade affects water temperature in a stream.
3	______	______	Student can describe one way that the water temperature of a stream impacts trout.
4	______	______	Student can propose two ideas on improving or conserving fish habitat

Total Points

25	______	______	**Score** ______

Aquatic Plant Power Scoring Rubric

Fish Habitat Experiments	4 Excellent	3 Good	2 Fair	1 Poor	0 Unacceptable
Habitat requirements for successful spawning	Can describe three ways erosion and sediment impact fish egg survival.	Can describe two ways erosion and sediment impact fish egg survival.	Can describe one way erosion and sediment impact fish egg survival.	Description of how erosion and sediment impact fish egg survival isn't reasonable.	Can't describe how erosion and sediment impact fish egg survival.
Shade and water temperature	Can make a reasonable and measurable prediction as to how shade impacts a stream's water temperature; can describe how water temperature impacts a stream's oxygen levels and how this affects fish.	Can make a prediction as to how shade impacts water temperature; can describe one way this impacts fish.	Can make a prediction as to how shade impacts water temperature.	Doesn't understand how to make a reasonable or measurable prediction, but can make a guess as to how shade impacts water temperature.	Can't guess how shade impacts water temperature in a stream.
Communicating results	Can record observations and data accurately and clearly, construct a neat graph illustrating experimental data; can clearly communicate experimental results.	Can record observations and data and construct a graph illustrating experimental data; can communicate experimental results.	Can record observations and data and construct a graph illustrating experimental data; needs assistance to communicate experimental results in an organized and understandable way.	Inaccurately records observations and data. Graph doesn't accurately reflect data.	Doesn't record observations and data; can't construct a graph to illustrate data.
Ideas for improving and conserving habitat	Can develop four reasonable ideas for improving and conserving fish habitat soundly based on experimental results.	Can develop three reasonable ideas for improving and conserving fish habitat based on experimental results.	Can develop two reasonable ideas for improving and conserving fish habitat based at least in part on experimental results.	Can develop one idea for improving and conserving fish habitat, but idea isn't based on experimental results.	Can't develop an idea improving and conserving fish habitat after completing Part 1 and Part 2 of the lesson.

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

Diving Deeper

Extensions

1 Take a field trip to a local stream and measure water temperatures in a shady part of the stream and a sunny part of the stream. Compare results.
2 Watch the 20-minute *Save Our Shorelines* CD as a class. Created by the Minnesota DNR, this presentation outlines strategies that shoreline property owners can use to protect aquatic wildlife and water quality. Contact your local DNR office to obtain a copy.
3 Explore an Aquatic Management Area. If there is an AMA near your town, research it in class. If possible, take a field trip to the AMA.
4 Volunteer in a shoreland restoration project. Help plant native shore plants, help to inform and educate the community or school about the project, or help maintain a shoreland restoration site. Contact your local DNR Fisheries office for notices of projects in your area.
5 Have students visit the DNR website to find examples of ways in which the DNR is protecting fish habitat. Students can read a success story, find the lake or stream on a map, and summarize work that has been done to protect critical aquatic habitats.

For the Small Fry

K-2 Option

1 The spawning habitat activity can be done as a demonstration, excluding steps 5 and 6, and the class could make collective observations. Be sure to limit the demonstration to one variable.
2 The temperature experiment could also be done as a demonstration (without data collection). Be sure to model the scientific method and use real scientific tools. Temperatures can be read as numbers and the students determine if one temperature is greater or less than the other.

STUDENT COPY

Names ______________________________________ Date ______________

The Next Generation

1. Name a type of fish that lays its eggs in a gravel bed. ______________________

2. Where did the fish eggs (glass beads) settle in the gravel bed? ______________________

   Are the eggs exposed to clean water and oxygen? ______________________

3. When sand was poured into the gravel bed, where did the sand settle? ______________________

4. What happened to the "fish eggs"? ______________________

____

____

5. What happens to real fish eggs when they're covered with sand? ______________________

____

____

6. How could soil get into the water of a stream or lake? ______________________

____

____

7. What are two things people can do to help prevent soil from entering our lakes and streams? ______________

____

____

STUDENT COPY

Names ______________________________ Date ______________

Be Cool

1. Prediction: Which stream will get warmer in this experiment? The one with plants or the one without plants? Why do you predict this?

____

____

____

2. Record the water temperature in each of the pans every five minutes.

Time (Minutes)	TEMPERATURE	
	No Plants	Plants

continued

STUDENT COPY

Names ____ Date ____________________

Be Cool

3. Did you observe a temperature difference between the two pans of water? __________

4. If so, what could explain the temperature difference? ______________________________________

____

____

____

____

5. What effects could warmer water temperatures have on cold-water fish such as trout? ______________

____

____

____

____

6. What are some ways we could manage streams to help keep them cool during the summer? __________

____

____

____

____

INSTRUCTOR COPY

The Next Generation Answer Sheet

1. **Name a type of fish that lays its eggs in a gravel bed.**
   Walleye, trout

2. **Where did the fish eggs (glass beads) settle in the gravel bed?**
   Most of the eggs should settle in the gravel crevices.

   Are the eggs exposed to clean water and oxygen?
   Yes

3. **When sand was poured into the gravel bed, where did the sand settle?**
   Most of the sand settles in the crevices and on top of the fish eggs.

4. **What happened to the "fish eggs"?**
   They were covered by sand, either partially or totally.

5. **What happens to real fish eggs when they're covered with sand?**
   The eggs will no longer be exposed to clean water. Without the oxygen they need to stay alive, they'll die.

6. **How could soil get into the water of a stream or lake?**
   It washes into lakes from the land when it rains.

7. **What are two things people can do to help prevent soil from entering our lakes and streams?**
   Don't remove plants near the shore or in the water; help with shoreline restoration projects, and so forth.

Be Cool Answer Sheet

1. **Prediction: Which stream will get warmer in this experiment? The one with plants or the one without plants? Why?**
   The stream without plants over it will get warmer because there's no shade.
2. **Record the water temperature in each of the pans every five minutes.**
   Answers will vary.
3. **Did you observe a temperature difference between the two pans of water?**
   Hopefully.
4. **What could explain the temperature difference?**
   The amount of shade, the distance of the lamps from the water, the wattage of the bulbs might explain the temperature difference.
5. **What effects could warmer water temperatures have on cold-water fish such as trout?**
   It would reduce the amount of oxygen dissolved in the water and make it hard for them to breathe.
6. **What are some ways we could manage streams to keep them cool during the summer?**
   Add shoreline plants to provide shade and keep the water cool.