ASK AN EXPERT: ABOUT THE MINNESOTA RIVER MUSSEL EDUCATOR'S GUIDE

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Ask an Expert: About the Mussel River is produced by the Water Resources Center (WRC) at Minnesota State University, Mankato. Created in 1987, the WRC serves as a regional center for environmental research and information exchange.

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WRC WATER RESOURCES CENTER MINNESOTA STATE UNIVERSITY, MANKATO

MINNESOTA RIVER BASIN DATA CENTER

THE McKNIGHT FOUNDATION

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ASK AN EXPERT INTRODUCTION

Ask an Expert: About the Minnesota River is an on-line field trip featuring scientists and experts answering questions on the health of the Minnesota River Basin. The intent behind this web-based program is to bring experts into the classroom through a series of videos designed to answer questions related to the Minnesota River and this Educator's Guide. A dramatically altered landscape has impacted the rivers and lakes of the Minnesota River Basin whether for recreation use, drinking water or the health of aquatic organisms. Today, the Minnesota River contributes a significant level of pollutants including sediment and nutrients downstream to the Mississippi River, Lake Pepin, and the Gulf of Mexico.

Water quality can be a complicated and confusing issue for students and the general public. *Ask an Expert: About the Minnesota River* strives to bridge that gap by focusing on a set of themes telling the story of how a dramatically changed landscape here in the Minnesota River Basin has resulted in water pollution problems.

The story of the Minnesota River Basin is one of sorrow, hope, and unending patience. *Ask an Expert* uses videos, fact sheets, educational modules, and more to help clarify what is happening to this state and national significant resource. Experts answer questions on a diverse array of issues organized by 20 major themes.

> **History of the Land** recalls how glaciers formed the basin and the Dakota lived on a vast prairie-wetland landscape dotted by shallow lakes and the "big woods."
>
> **Landscape Today** is dominated by agricultural production primarily growing corn and soybeans intermixed with urban areas.
>
> **Bio indicators** including fish, mussels and macroinvertebrates shed light on the current health of the system and how much it has been impacted by water pollution and landscape change.
>
> **Water Quality** represents a term for measuring the level of pollutants (sediment, nutrients, bacteria, etc.) in our rivers and lakes.
>
> **Making A Difference** describes the efforts by government agencies and citizens to protect and improve the water quality of the basin's rivers and lakes.

Ultimately, *Ask an Expert: About the Minnesota River* highlights the dedicated scientists and citizens working hard to better understand human impacts on the river system and how all of us can make a difference today and for future generations.

For more information on *Ask an Expert: About the Minnesota River*, go to http://mrbdc.mnsu.edu/learn

ASK AN EXPERT THEMES

This story of the health of the Minnesota River is being told through 20 themes beginning with how the basin formed. How has the dramatic change to the landscape impacted the prairie - wetland complex. What is the status of fish and other aquatic organisms? How is water quality affected by specific pollution sources?

History of the Land

- Geology - Ten thousand years ago Glacial River Warren carved out the present-day Minnesota River Valley creating a fairly young geological landscape.
- Pre-1850s – For centuries numerous Dakota tribes lived among an extensive prairie-wetland complex bracketed by a large swath of the Big Woods.
- Prairie – Grasses, flowers and forbs literally dominated the rolling landscape intermixed with shallow lakes and wetlands.
- Wetlands – Thousands of wetlands of all sizes found in the prairies and wooded areas and along rivers provided a valuable hydrological function throughout the basin.
- Big Woods – A deciduous forest called the "Big Woods" stood in a band on the southeastern portion of the basin in contrast to the vast prairie-wetland complex.
- Euro-American Settlement - Americans and Euro immigrants began pushing into the basin by the 1850s and accelerated after the tragic Dakota Conflict and end of the Civil War. Settlers poured in converting prairie landscape into agricultural fields.

Landscape Today

- Agricultural - Over 80 percent of the land is tied to producing crops dominated by corn and soybeans. In addition the raising of livestock (hogs, cattle and chickens) is also a major economic driver.
- Urban - The eastern portion of the basin comprising mostly of the Twin Cities suburbs have seen some the largest population growth moving southward down to Mankato.

Water Quality

- Monitoring - Water quality data is collected at hundreds of sites across the basin to assess pollution levels in rivers and lakes and to identify impaired waterbodies and the health of biological organisms.

- Impaired Waters - A significant number of the waterbodies do not meet state water quality standards and have been placed on the impaired waters list due to elevated levels of sediment, nutrients, bacteria and other pollutants.
- Sediment - The Minnesota River and some of the tributaries carry elevated levels of total suspended solids.
- Nitrogen - The Minnesota River and tributaries carry elevated levels of nitrate-nitrogen and this has implications for downstream in particular the Mississippi River, Lake Pepin and the Dead Zone.
- Phosphorus - Elevated levels of this nutrient associated with sediment has also shown concerns downstream on Mississippi River and Lake Pepin.
- Bacteria - More than 90 percent of the rivers monitored in the basin exceed health standards set by the Federal Clean Water Act.
- Downstream Impacts - The Minnesota River is contributing significant levels of water-related pollutants affecting Lake Pepin, the Mississippi River and Lake Pepin.

Bio-Indicators

- Fish – New reports have identified reproducing populations of pollution sensitive species like the Blue Sucker giving hope that water quality is improving.
- Mussels - Only 23 out of the original 41 different species are still found in the river basin. Mussel surveys show variation across the basin with some watersheds (Chippewa and Pomme de Terre) retains much of their diversity while others (Blue Earth and Lower Minnesota) have suffered from loss of species and population.
- Macroinvertebrates - These aquatic organisms including mussels are considered sentinels for water quality with studies showing mixed results for health populations.
- Frogs - In 1995, the basin drew attention when a large number of deformed Northern Leopard Frogs were discovered on a student field trip.

Making a Difference

- Urban - Construction of wastewater plants, stormwater systems and other conservation practices and programs are making a difference.
- Rural - Thousands of conservation practices and easements have been implemented to improve water quality showing some success in places like the Beaver Creek Watershed.

EDUCATOR'S GUIDE OVERVIEW

This educator's guide is designed to directly link high school students with scientist and citizen experts studying what is happening on the health of the Minnesota River Basin through lesson plans, videos, and fact sheets by concentrating on these goals:

- What happens on the landscape has a direct impact on the rivers and lakes including water quality and the living resources.
- These impacts are being studied by scientists and citizens throughout the Minnesota River Basin to identify how it affects the resource and what can be done to improve it.
- Conservation efforts are being implemented on both a small and large scale to improve, protect and restore our rivers and lakes. This will benefit the living resources and the public's ability to effectively address the consequences of how we manage the landscape.

How to Use the Educator's Guide

The goal of *Ask an Expert: About the Minnesota River* is to increase the public awareness about the health of the Minnesota River through video interviews of scientists and citizens working in the field. These experts answer questions related to their particular topic of study in an engaging manner that brings the students and public right into this world of scientific research. This Educator's Guide provides a step by step process of navigating through a particular theme involving videos, lesson plans, fact sheets/field guides, and much more.

I. Project Overview highlights each of the different themes selected to tell the story of the Minnesota River Basin through the eyes of our experts.

II. Theme Orientation will help guide the teacher and students in their use of the educator's guide and what each of the products offers for the classroom.

- Video Overview
- Key Terms
- Discussion Questions
- Fact Sheets and Field Guides

III. Lesson Plans are designed to give students a chance to learn about the particular theme through specific questions and hands-on activities.

IV. Additional Resources will allow students to conduct additional research on the various themes through websites, books, reports and more.

EDUCATOR'S GUIDE THEMES

Ask an Expert: About the Minnesota River captures scientists and citizens in the field answering questions about the health of the Minnesota River. This online field trip incorporates video of the experts answering questions related to a particular theme. Images, graphics, charts, and maps along with fact sheets, field guides, power point presentations, 360 panoramas, and website can be used along with the videos to tell this story.

For more information on *Ask an Expert: About the Minnesota River*, go to http://mrbdc.mnsu.edu/learn

THEME I: History of the Land

Early explorer accounts and paintings provide glimpses of what the landscape resembled before widespread Euro-American movement into the Minnesota River Basin. Many explorers wrote descriptions about the diverse flora and fauna and a rich culture of American Indian tribes living in the valley during the 1700s and 1800s. They described a landscape covered in tall grass, wetlands, shallow lakes and forested areas broken up with American Indian villages along the river.

- **Prairies** – Imagine a time when hundreds of plants of all shapes and sizes filled a landscape stretching to the far horizon. A vast tall-grass prairie dominated the Minnesota River Basin intermixed with wetlands and shallow lakes. Prairie plants built up a rich soil layer the foundation for the wide scale agricultural production. Today less than one percent of this ecosystem remains today. Benefits of a diverse prairie include holding soil in place, providing a valuable food source for pollinators and a diverse habitat for many different types of wildlife. Landowners, conservation organizations and others have restored hundreds of acres of prairie across the basin creating a positive effect on water quality. Prairies are a special and magical place for many people who recognize their value.
- **Wetlands** – Historically, wetlands dotted the basin's landscape playing a integral role in its hydrology and part of a massive prairie-wetland complex. Less than 3 percent of wetlands remain today. Euro-Americans settled into the valley and converted the landscape into cropland and urban areas. Water storage, improving water quality and providing critical habitat are just some of the benefits of wetlands. A diversity of plants and wildlife including birds, insects and mammals thrive in wetlands of all types. Today, numerous conservation programs on the state and federal levels restore and protect these important ecosystems. Conservation experts believe wetland restorations will help reduce pollution in these intensively agricultural regions of southern Minnesota.

THEME II: Landscape Today

- Agricultural / Urban
- Hydrologic Changes

THEME III: Water Quality

THEME IV: Bio Indicators

- **Fish -** Fishery experts and citizens alike point to species diversity as an important indicator of how the health of the Minnesota River fisheries has changed over the last 50 or more years. A basin-wide survey in the 1990s found close to 100 different species living in the main stem and tributaries. The Minnesota River has come a long way since the 1950s when peas, carrots and fecal matter floated in the water. Today, indicator species like the Blue Sucker, Paddle Fish and Lake Sturgeon are being snagged at increasing rates and the Minnesota River is being celebrated for its thriving catfish population. Minnesota Department of Natural Resources (MN DNR) fishery biologists conduct surveys on the river and identify sediment as one of the biggest concerns for maintaining and increasing a healthy fishery.

- **Mussels –** Historically, the Minnesota River Basin had an outstanding mussel assemblage of at least 41 different mussel species. Only 50 percent of those original species remain today. This loss raises concern because mussels are great water quality sentinels. They tell us a lot about the habitat, ecosystem and water quality of river systems. Mussel diversity and abundance has declined due to elevated sediment load, unstable river beds, and unpredictable water levels. The MN DNR has conducted surveys across the basin with mixed findings. Some watersheds (Chippewa and Pomme de Terre) support healthy populations of the very rare spike and black sandshell mussels. In other areas like the Lower Minnesota close to 2/3rds of the species are gone. Mussel malacologists Mike Davis and Bernard E. Sietman of the MN DNR and Paul Wymar from the Chippewa River Watershed Project put in context the life history of mussels and what has happened to them in the basin.

ASK AN EXPERT: MUSSEL VIDEO SEGMENTS

Historically, the Minnesota River Basin had an outstanding mussel assemblage of at least 41 different mussel species. Only 50 percent of those original species remain today. This loss raises concern because mussels are great water quality sentinels. They tell us a lot about the habitat, ecosystem and water quality of river systems. Mussel diversity and abundance has declined due to elevated sediment load, unstable river beds, and unpredictable water levels. The MN DNR has conducted surveys across the basin with mixed findings. Some watersheds (Chippewa and Pomme de Terre) support healthy populations of the very rare spike and black sandshell mussels. In other areas like the Lower Minnesota close to 2/3rds of the species are gone. Mussel malacologists Mike Davis and Bernard E. Sietman of the MN DNR and Paul Wymar from the Chippewa River Watershed Project put in context the life history of mussels and what has happened to them in the basin.

Segment Length Description

___ minutes Overview

0:59 seconds Why are mussels called the "Canary in the Coalmine" - Mussels are considered a sentential of a river's water quality conditions and are one of first aquatic organisms to be affected by pollution problems.

2:17 minutes **What is the current status of mussels in the Minnesota River Basin?** – The mussel assemblage in the entire basin had declined greatly with a loss of almost 50 percent of the species. In the Lower Minnesota close 2/3rds of the species are gone. Some of the upper watersheds still retain rich species diversity.

How does the Minnesota River Basin compare to other basins in the state? – The Minnesota River ranks in the lowest category of rivers in the state with mussel populations compared to the other big rivers (Mississippi and St Croix) which have kept most of their 40 or more species. The Minnesota River ranks worse than the Red River.

2:46 minutes **What caused the decline of mussels in the Minnesota River Basin?** – Mussels are among the most endangered group of animals in the world with several extinct. Numerous factors behind this include excessive sediment, an instable riverbed, hydrology changes and loss of habitat.

What are the ideal conditions for a healthy mussel population? – A number of factors have been identified that are critical for a healthy mussel assemblage –

stable river substrate or habitat, limited fluctuation of water levels and good water quality.

1:04 minutes **What is a mussel? –** They are part of the second largest group of animals in the world - the Mollusks. Mussels are bivalves, filter feeders and use fish as host for their larvae. They spend their entire life partially or fully buried in mud, sand or gravel in permanent bodies of water.

0:38 seconds **How long does a mussel live? –** Depending on the species they can be very long lived with some of them living to be over 100 years old. Typically, mussels are shorter-lived maybe up to ten years or less.

2:48 minutes **What does a mussel eat and what eats a mussel? –** A lot of what mussels eat is the bacteria and fungus of decomposing organic matter including fish poop. Part of the ecological function mussels perform is filtering organic matter. Fish and mammals like muskrats, raccoons and otters eat mussels.

1:46 minutes **How does a mussel move? –** They move very slowly and deliberately by what we call a foot that pushes out of their anterior end. Mussels travel in little increments, maybe a half an inch at a time and only for short distances. In the process they leave a furrow in the riverbed.

3:37 minutes **What is the typical lifecycle of mussels and what is an example mussels using fish as hosts? –** The complicated life history of a mussel is tightly linked to fish, who serve as a host for their larvae (glochidia). These fish also serve as the primary way mussels are distributed throughout a water body.

2:40 minutes **Water Quality Benefits –** These filter-feeding organisms in large populations can be very effective in cleaning the water and stabilizing the riverbed. Other organisms like algae and macroinvertebrates attach themselves to mussels and they provide food for other animals like fish and mammals.

3:17 minutes **What can we learn from studying mussels? –** We study mussels because they act as sentinels for water quality and tell us a lot about the habitat, ecosystem and water quality in the river systems. They have one of the most intriguing life histories of any animal in North America.

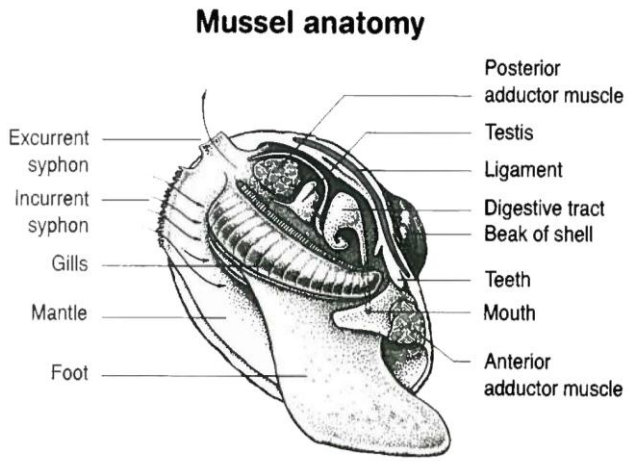
4:04 minutes **Where are mussels doing okay in the Minnesota River Basin? –** Two of headwater watersheds in the basin hold some of the best remaining mussel population and diversity in the entire basin. A number of rare species like the spike and elktoe are still found here.

1:22 minutes **Where have mussels declined in the Minnesota River Basin? –** One of the poorest mussel assemblages is found in the Greater Blue Earth River Basin with some of the most common species either gone or partially gone. Species like the threeridge and the Wabash pigtoes considered to be fairly water quality tolerant are completely gone within the system.

KEY TERMS

Adductor muscle: large muscle of the bivalve mollusk attached to both valves of the shell. When contracted this muscle tightly closes the shell.

Anatomy Diagram



Anterior end: the shorter end of the shell; also considered the front end.

Assemblage: a collection or group of animals like mussels.

Benthic: the bottom of a river or lake where organisms like mussels or macroinvertebrates live.

Bivalve: a mollusk whose body is enclosed by a pair of hard shells or two symmetrical (equal) valves.

Byssal threads: strong, silky fibers made from proteins used by mussels to attach themselves to rocks and other substrates. The byssal thread is produced by using a byssus gland found in the foot of a mussel

Clam: common name frequently used to refer to certain freshwater bivalves (i.e., fingernail clams and the Asiatic clam). They differ from a mussel in that anterior (front) and posterior (back) lateral and cardinal teeth are present.

Diversity: the total number of species that occupy an area.

Endangered: a species threatened with extinction throughout all or a significant portion of its range.

Excurrent siphon: an opening that expels the filtered water without food and oxygen the mussel uses away from its shell or body.

Extinct: a species that no longer exists.

Exotic Species: a species of animal or plant that has been introduced to an area outside of its native habitat.

Extirpated: a species that no longer is found or has been eliminated from a particular area, but still exists somewhere else.

Fauna: a collective group of animals, particularly those of a certain region or time.

Foot: a muscular organ that a mussel uses for locomotion and to anchor itself to the riverbed.

Glochidia: the larvae of mussels released by the female into the gills of a fish where it lives off the fish for a short amount of time (parasitic).

Gravid: a mussel is pregnant, carrying eggs.

Gill Chambers: they are external respiratory organs of most aquatic animals.

Gills: platelike respiratory organs in mussels that also help gather food particles ("filter-feeding") and provide a place for female mussels to store their glochidia larvae.

Host Fish: one or more species of fish whose tissues and body fluids meet the developmental needs of a particular mussel species during its parasitic glochidial life stage.

Incurrent siphon: an opening that brings water containing oxygen, food and other material into the mussel body.

Larva: the immature form of an animal that undergoes complete metamorphosis (development).

Life Cycle: this is how an organism like a mussel transforms itself from larvae stage to being released into a host fish and eventually falling off into the riverbed to become free living mussels.

Malacologist: someone who studies mussels.

Mollusk: a member of the phylum Mollusca, a group of marine and freshwater invertebrates with soft tissues that are protected by a hard shell composed of one or more parts.

Mussel: a marine or freshwater species with an elongated shell that can be found in rivers and lakes on every continent except Antarctica. They are a member of the second largest group of animals in the world – the Mollusks.
Mussel bed: a dense, natural aggregation (mass) of mussels which can support a diverse variety of benthic fauna.

Parasite: an organism that grows, feeds, and is sheltered on or in a different organism (host) while contributing nothing to the survival of the host.

Pharyngeal teeth: the triangular, often serrated, teeth located on the anterior-dorsal (front) part of the shell. They are also called pseudocardinal teeth.

Posterior end: the longer end of the shell; also considered the back end.

Special Concern: the species is extremely uncommon, or has unique or highly specific habitat requirements and deserves careful monitoring of its status but not endangered or threatened.

Species: a group of biologically distinct organisms that are self-perpetuating.

Substrate: soil on the river's bottom or bed.

Threatened: the species is likely to become endangered within the foreseeable future throughout all or a significant portion of its range.

Valve: one of the two halves of the shell of a bivalve mollusk.

The terms in this glossary are adapted from the Minnesota Department of Natural Resources website (http://www.dnr.state.mn.us/mussels/glossary.html) and the U.S. Fish and Wildlife Service (http://www.fws.gov/midwest/mussel/glossary.html).

DISCUSSION QUESTIONS

These are a series of broad questions the students will be able to answer by watching the Mussel power-point presentation and inserted videos.

1. Why do we refer to mussels as a water quality sentinel when it comes to water quality?

2. Why do we study mussels?

3. What has happened to the mussel population and diversity over time in the Minnesota River Basin and how does that compare to other major basins in the state?

4. What has been some of the causes behind this decline of mussels in the Minnesota River Basin?

5. Identify one major watershed where mussels are doing okay in the Minnesota River Basin and one major watershed where they are struggling?

6. What is the typical lifecycle of a mussel?

7. What are ideal conditions for a healthy mussel assemblage?

8. What are some important ecological functions of mussels?

9. What is another important ecosystem value of mussels?

LESSON 1: WHAT IS KILLING MUSSELS?

Lesson Objective

Upon completion of this lesson, students will understand:

- What environmental factors are killing mussels
- How these environmental factors have a devastating impact on mussel populations and diversity
- What can be done to improve the river ecosystem to create a healthy mussel assemblage

Materials

Lesson 1 Worksheet
Mussel Overview Factsheet
Minnesota River Basin Progress Report - http://mrbdc.mnsu.edu/minnesota-river-basin-progress-report
MN DNRs website's Mussel Page - http://www.dnr.state.mn.us/mussels/index.html

Background

The mussel diversity of the Minnesota River Basin has seen a dramatic decrease of almost 50 percent with 23 out of 41 species gone from the system. Mussels are impacted at a greater extent than mammals or birds because they are mostly sedentary and can't escape pollution pressures (extensive water quality and quantity). This is why we refer to them as the canary in the coal mine. If mussels are disappearing from the river an effort needs to be made to improve water quality and habitat before other animals start to die off too. Scientists are working in the field and the lab to identify what is happening to the mussels and why.

Students can either work in a small group or as individuals. Problem solving skills will be highlighted in this lesson plan. Part of the process will involve further research by the students to flesh out the reasons behind what is killing mussels in the Minnesota River Basin and how to reverse this trend.

Procedure

1. The class will be shown the mussel power-point presentation and associated videos.
2. Ask the students to think about what could be killing mussels and why? What could be done to keep this from happening?

3. Hand out the Mussel worksheet and the Mussel Overview factsheet to the students. The Mussel Overview provides a synopsis of the history and current status of mussels in the basin. A broader context on what is killing the mussels and stories of how to protect and improve the river's ecosystem can be part of a larger research project. Students should also check out the Mussel Page on the Minnesota Department of Natural Resources websites and other related websites.

Follow-Up

Let the students either present their findings as individuals or as a group activity. Additional questions for the students to answer.

- What is an example of a successful mussel propagation project in Minnesota? What type of mussels are they trying to restore? Who is in charge of the project?
- What is one of the major factors leading to the loss of mussels in the basin?
- How do exotic species like Zebra mussels impact native mussel assemblages?
- What state agency is responsible for studying mussels and is working to propagate them?
- What is the name for someone who studies mussels?

State Standards for 9th to 12th grade

- Geography
    - 9.3.1.1.1 People use geographic representations and geospatial technologies to acquire process and report information within a spatial context.
- Science
    - 9.3.4.1.1 , 9.3.4.1.2 People consider potential benefits, costs and risks to make decisions on how they interact with natural systems.
    - 9.1.3.1.1, 9.1.3.1.2 , 9.1.3.1.3 , Natural and designed systems are made up of components that act within a system and interact with other systems.
    - 9.4.2.1.1, 9.4.2.1.2 , The interrelationship and interdependence of organisms generate dynamic biological communities in ecosystems.

Lesson 1 Worksheet: What is killing the mussels in the Minnesota River Basin?

Mussels live on the bottom of rivers and lakes either partially or wholly buried in the sediment. Part of the Mollusk phylum of invertebrate animals, mussels don't have the capability to move fast or for great distances. They can close up their shells for a few days but can't survive extensive water quality or quantity problems. Students will put themselves in the shoes of scientists conducting mussel surveys in the Minnesota River Basin.

Write out a list of environmental factors that are killing mussels.

Write out a list of theories behind what is killing mussels.

Write out a list of potential ideas or projects that might help restore mussel habitat in rivers.

LESSON 2: A TYPICAL MUSSEL LIFECYCLE

Lesson Objective

Upon completion of this lesson, students will understand:

- The four stages of how a mussel reproduces
- How mussels attract fish to be used as a host for their larvae
- How mussels are tied to a fish's distribution in a river

Materials

Mussel Lifecycle Fact Sheet
MN DNR Mussel Website - http://www.dnr.state.mn.us/mussels/index.html
Examples of Mantle Display and Glochidia Release (MN DNR) - http://www.dnr.state.mn.us/mussels/quadrula/index.html
Blank Paper
Pencils and Color Pencils

Background

Mussels have one of the most fascinating and complicated lifecycles in the animal world. This is especially true of their connection with fish for reproduction. Individual mussel species have developed elaborate ways of attracting fish to serve as a host for their larvae (glochidia). By attaching larvae to a fish's gills, a mussel's distribution in the river is directly related to the host fish's distribution. One of the most interesting examples of this reproduction process is those mussels who use the freshwater drum or sheepshead fish.

Students can either work in a small group or as individuals. Drawing skills will be highlighted in this lesson plan. Part of the process will involve identifying some of the different ways mussels use lures to attract a host fish.

Procedure

1. The class will watch the mussel power-point presentation in conjunction with associated videos.

2. Ask the students to think about the different stages of a mussel lifecycle. How large of a role do fish play in this process?

3. Hand out the worksheet, the Mussel Lifecycle factsheet, to the students and blank paper. Check out the MN DNR website to see how the Plain pocketbook mussel attracts a host fish. Students will create a drawing of a typical lifecycle of mussels. How does the female display itself to attract a fish to deposit its larvae?

Follow-up

Let the students either present their findings as individuals or as a group activity. Here are some additional questions for the students to think about or answer:

- What are some of the ways a mussel will lure a fish to come close enough to release its larvae into the fish's gills?

- What are some of the barriers or hazards that prevent some fish from being able to redistribute mussels to their historical ranges?

- What native mussel to Minnesota is considered unique when attracting a host for its larvae (glochidia)? What does the process involve?

- Identify five mussels and their host fish in the Minnesota River Basin and what they use to attract a fish.

State Standards for 9th to 12th grade

- Science Standards
    - 9.1.3.1.1, 9.1.3.1.2 , 9.1.3.1.3 , Natural and designed systems are made up of components that act within a system and interact with other systems.
    - 9.4.2.1.1, 9.4.2.1.2 , The interrelationship and interdependence of organisms generate dynamic biological communities in ecosystems.

LESSON 3: MUSSEL SURVEY OR HIKE

Lesson Objective

Upon completion of this lesson, students will understand:

- How a mussel survey is conducted in a river and what type of information is collected
- What does mussel data tell us about the water quality of a river or lake
- How we know what the mussel historical record of a river or lake is

Materials

Mussel Monitoring Plan
Biological Stream Assessment Worksheet
River Assessment Worksheet
Mussel Field Guide
Mussel Overview fact sheet
Mussel Distribution Map
Field Guide to the Freshwater Mussels of Minnesota, Minnesota Department of Natural Resources - http://www.dnr.state.mn.us/eco/nhnrp/mussel_survey/fieldguide.html
MN DNR Mussel Website - http://www.dnr.state.mn.us/mussels/index.html
Guidelines for Sampling Freshwater Mussels in Wadable Streams, Wisconsin DNR - http://wisdotresearch.wi.gov/wp-content/uploads/01-09mussels-f1.pdf

Background

Surveys were conducted haphazardly in Minnesota for decades providing a glimpse of what was happening to the mussel diversity and population. In the 1980s a more concentrated effort began in Minnesota to understand this resource, led by experts like Mike Davis of the Minnesota Department of Natural Resources. Today, mussel surveys have been completed on a majority of rivers in the Minnesota River Basin including the mainstem, the major tributaries and some smaller rivers, streams and lakes. In 2008, the DNR established a long-term monitoring station on the Chippewa River, considered to have one of the best mussel assemblages in the basin.

Procedure

1. The class will watch the mussel power-point presentation in conjunction with associated videos.

2. Ask the students what mussels tell us about the water quality of a river or lake. What type of information should be collected with a mussel survey?

3. Students will identify the site(s) they want to survey and write up a brief monitoring plan that details your methods, sampling frequency, and what will be done with the data.

4. Contact the MN DNR Mussel Program to see about possibly training from a malacologist (someone who studies mollusks).

5. Apply to the MN DNR for (and receive) a permit if you will be handling or collecting live mussels. A fishing license is all that's required to collect dead shells of common mussels.

6. Conduct a walk or survey to collect data on mussel population and diversity. Conduct an assessment of the stream habitat. The class can chose to conduct a more extensive assessment by using the worksheet found on pages 27 and 28.

7. Conduct a quality assurance of the mussel data and put together a report.

8. Submit the mussel data to the MN DNR Mussel Program.

9. Use the individual mussel watershed survey fact sheets found in the appendix to compare the number of mussel species, number of total mussels and the type of mussel species found with your survey site.

Follow-Up

Let the students either present their findings as individuals or as a group activity. Additional questions for the students to think about or answer:

- What is the difference between surveying a big river like the Minnesota or Mississippi for mussels compared to smaller ones like High Island Creek or Little Cottonwood River?

- Name a watershed in the Minnesota River Basin with a good mussel assemblage. Name a watershed in the Minnesota River Basin with a struggling mussel assemblage.

- Research water quality flow data from the U.S. Geological Survey's Minnesota Science Center at http://mn.water.usgs.gov/ This website water flow data at numerous locations in the Minnesota River Basin including the mainstem and tributaries. Additional water flow data can be found at the MN DNR/MPCA Cooperative Stream

Gaging website: http://www.dnr.state.mn.us/waters/csg/index.html

- Research water quality data including chemistry and biological indicators at the Minnesota Pollution Control Agency's Environmental Data webpage: http://www.pca.state.mn.us/index.php/data/environmental-data-access.html

Minnesota Standards for 9th to 12th grade

- Geography
    - 9.3.1.1.2 People use geographic representations and geospatial technologies to acquire, process and report information within a spatial context.
    - 9.3.1.2.2 Geographic Inquiry is a process in which people ask geographic questions and gather, organize and analyze information to solve problems and plan for the future.

- Science Standards
    - 9.1.3.1.1, 9.1.3.1.2 , 9.1.3.1.3 , Natural and designed systems are made up of components that act within a system and interact with other systems.
    - 9.4.2.1.1, 9.4.2.1.2 , The interrelationship and interdependence of organisms generate dynamic biological communities in ecosystems.
    - 9.3.4.1.1 , 9.3.4.1.2 People consider potential benefits, costs and risks to make decisions on how they interact with natural systems.

Lesson 3 # Worksheet: A Mussel Survey or Hike

Mussels are an important indicator of water quality. Depending on the river surveyed in the Minnesota River Basin you will find anywhere from 5 or less species to upwards of 10 to 15 different ones. The MN DNR recognizes the need to document our rivers mussel resources in order to better measure species diversity and population. Mussels live partially or wholly buried in the sediment of a riverbed and only move slowly for short distances. Animals like muskrats and raccoons eat them leaving behind piles of shells.

Mussel Collection Procedures (MN DNR)

Here are the steps recommended in the Field guide to the freshwater mussels of Minnesota by Bernard Sietman for those who have acquired a permit to handle or collect living mussels:

- In clear water, searching with a mask and snorkel is an excellent technique. When visually searching for mussels, often all that is visible are the siphons, or a small portion of the posterior shell, the rest being completely buried.
- Wading in shallow water is also an easy way to find mussels. A useful tool can be created by cutting out the bottom of a five-gallon bucket and replacing it with Plexiglas. This will allow an unobstructed view of the stream bottom on windy days or in riffles where the water's surface is rough.
- Watch for and follow the furrow that mussels leave as they plow through the substrate while moving.
- If the water is murky, you may have to feel for mussels with your hands. The symmetrical shape and the sharp outline of the shell distinguish mussels from rocks.
- Keep live mussels moist and cool to avoid stressing them. Placing mussels in a mesh bag suspended in water is recommended. Return them to collection sites as soon as possible.
- A fact sheet on record keeping and specimen preparation for museum collections may be obtained by contacting the Minnesota Department of Natural Resources at 651-296-2835.

Field Survey Materials

Mussel Identifications:

(1) Sietman, B.E. 2003. Field Guide to Freshwater Mussels of Minnesota. Minnesota Department of Natural Resources, St. Paul, Minnesota, 144 pp.,

(2) Stern, E. M. 1990. An illustrated key to the freshwater mussels (Bivalvia: Unionacea) of Wisconsin. Reports of the Museum of Natural History, U. of Wisc.-Stevens Point, No. 20. 75 pp.

Snorkel and face mask (or clear-bottom bucket)
Plastic caliper (for measuring in length of mussel in millimeters)
Clipboard / pencil / Data Sheets
Nylon Mesh bag for holding items in the qualitative search (Mesh should have ¼" holes or smaller).
Metal or PVC frame ¼ meter squared or 1 meter squared depending on method for quantitative Quadrant Search.

Lesson 3: A Mussel Monitoring Plan

Group name:_____ **Date:** _____

Team Leader name: _____

Student Monitors (list names):

_____

_____

_____

1) Why my group wants to monitor mussels? (List interests and/or concerns):

2) Sites:

Site ID (name and/or number):
River:
Location (UTM coordinates if known, or township, range & section):
Method used for sampling:
DNR Permit: Date Requested:_____ Date Approved/Received: _____
Expected Sampling Date:
Next Sampling will occur in this year:

Site ID (name and/or number):
River:
Location (UTM coordinates if known, or township, range & section):
Method used for sampling:
DNR Permit: Date Requested:_____ Date Approved/Received: _____
Expected Sampling Date:
Next Sampling will occur in this year:

Site ID (name and/or number):
River:
Location (UTM coordinates if known, or township, range & section):
Method used for sampling:
DNR Permit: Date Requested:_____ Date Approved/Received: _____
Expected Sampling Date:
Next Sampling will occur in this year:
---

3) Data Use: What will be done with the data collected? Who will it be shared with and who has agreed to use it? How will it be used?

Lesson 3: A Mussel Survey Protocols

Qualitative Timed Search

A timed qualitative sample approach at multiple sites along the stream can be used in order to quickly estimate mussel abundance and species richness of the mussel community. At each site hand collect all live and dead mussels by wading, swimming or crawling along the stream bottom, continually sweeping hands back and forth sifting through the substrate while looking and feeling for mussels. Search all microhabitats, including the shoreline, at a particular site with the intent of locating and collecting as many live mussels and empty shells as possible thus maximizing the chance of collecting all species present.

All mussels collected are placed in mesh bags, brought to the shore, identified to species, counted, and aged (see Mussel Survey Assessment Sheet) . To compensate for the error associated with aging, mussels should be placed in one of three age classes: 1-5, 6-10, and >10 years old. Within each age class, minimum and maximum length should be determined for each species (maximum shell length, anterior-posterior axis), counted, and returned to their approximate collected location. Any zebra mussels (*Dreissena polymorpha*) and byssal threads attached to native mussels should also counted and noted, respectively. At each site, time spent searching and general habitat conditions (i.e., min. max. depth, substrate [silt/sand/gravel/cobble/boulder], general riparian zone type) are recorded.

Keep the mesh bag and the mussels in water, pulling them out of the water only briefly while they are identified. To return live mussels to the water: Distribute them in the general area where they were gathered. Lay them on their side (not upside) in the stream. See the Mussel Biological Assessment Sheet on page 23.

Quantitative samples

Quantitative samples can be collected as follows: randomly place a ¼ meter square metal frame with a ¼ inch square mesh bag attached on the stream bottom. All substrate and mussels within the frame are removed and placed into the mesh bag. Each mesh bag sample is brought to the surface, fine substrates rinse through the bag, and all mussels and any live zebra mussels removed and placed in a separate bag for analysis. Additional samples are obtained by randomly tossing the quadrat to spread effort across the mussel bed area predetermined by onsite reconnaissance. For each sample, all live mussels are identified, their total length measured, external age rings counted, number of attached zebra mussels recorded and presence of zebra mussel byssal threads noted. Any other live zebra mussels present in the sample are counted. A minimum of thirty samples is collected from each site; additional samples are collected until no new species were found in the preceding five samples.

To return live mussels to the water: Distribute them in the general area where they were gathered. Lay them on their side (not upside) in the stream.

Lesson 3: Mussel Biological Assessment Sheet

Date _____ **Time**_____

Monitoring Team _____

Site Number _____

Name of Volunteers

_____

Mussels (check all found and whether it is a live specimen or a shell and total of each)

Common
____Threeridge
____Wabash pigtoe
____Pink papershell
____Fatmucket
____Lilliput
____Plain pocketbook
____Giant floater
____Creeper
____Deertoe
____White heelsplitter
____Mapleleaf
____Fragile papershell
____Cylindrical papershell
____Pink heelsplitter
____Fawnsfoot

Rare
____Wartyback
____Black sandshell
____Pimpleback
____Creek heelsplitter
____Spike
____Elktoe
____Mucket
____Threehorn wartyback

Extirpated
____Purple wartyback
____Elephantear
____Gulf mapleleaf
____Washboard
____Sheepnose
____Ebonyshell
____Winged mapleleaf
____Monkeyface
____Pistolgrip
____Rock pocketbook
____Flutedshell
____Salamander mussel
____Butterfly
____Higgins eye
____Yellow sandshell
____Hickorynut
____Round pigtoe
____Pondmussel

Mussel Size
Measure the individual mussels to get an idea of their size by using a plastic caliper and if there is a cross selection representing a diverse population.

Mussel 1_____ Mussel 2_____ Mussel 3_____ Mussel 4_____

Mussel 5_____ Mussel 6_____ Mussel 7_____ Mussel 8_____

Mussel Age

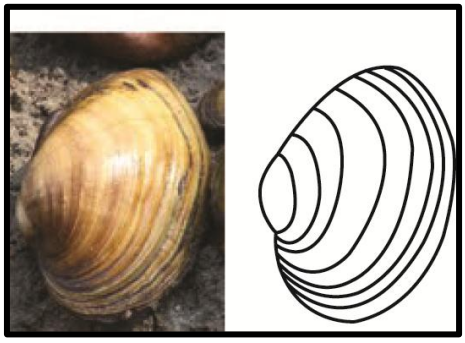
Count the rings of individual mussels to get an idea of their age and if there is a representative of different ages. The method of counting rings on the shells become tougher the older they are.

Mussel 1_____ Mussel 2_____

Mussel 3_____ Mussel 4_____

Mussel 5_____ Mussel 6_____

Mussel 7_____ Mussel 8_____



To compensate for errors associated with mussels place them in one of three age classes: 1-5, 6-10 and > 10 years old.

Weather (check all that apply)

Sunny ____ Partly Sunny ____ Cloudy ____

Rain/Snow ____ Windy _____ Calm ____

Air Temperature _____^{0} Fahrenheit

Precipitation over last 24 hours _____ inches

Wind Direction (check one)

_____ 1. Not applicable

_____2. North

_____3. South

_____4. East

_____5. West

_____6. Northeast

_____7. Northwest

_____8. Southeast

_____9. Southwest

Wind Speed (check one)

_____ 1. Calm (0-5 mph)

_____ 2. Breezy (sustained 5-15 mph)

_____ 3. Strong (sustained over 15 mph)

_____ 4. Gusty (gusts over 15 mph)

Transparency Tube ____ centimeters

Water Temperature ____ ^{0}Fahrenheit or ____^{0}Celsius

Water Level (check one)

Above Normal _____ Normal _____ Below Normal _____

Water Color (check all that apply)
Clear _____ Brown _____ Green _____ Oily _____ Reddish _____ Blackish _____ Chalky _____

Water Odor (check all that apply)
None _____ Sewage/Manure _____ Rotten Eggs _____ Petroleum _____ Fishy _____

Stream Width _____ meters

Canopy Cover (check one)
0 – 25% _____ 25 – 50% _____ 50 – 75% _____ 75 – 100% _____

Riparian Zone Width (check one for each bank)

Left Bank (facing upstream)	Right Bank (facing upstream)
_____ 0 – 5meters	_____ 0 – 5meters
_____ 5 – 25 meters	_____ 5 – 25 meters
_____ Over 25 meters	_____ Over 25 meters

Riparian Zone Plant Cover (estimate percentage of each)

Left Bank (facing upstream)	Right Bank (Facing upstream)
_____ % Trees	_____ % Trees
_____ % Shrubs / Low Trees	_____ % Shrubs / Low Trees
_____ % Grass / Low Plants	_____ % Grass / Low Plants
_____ % Exposed Soil	_____ % Exposed Soil
_____ % Other (rip rap, concrete, junk, etc.)	_____ % Other (rip rap, concrete, junk, etc.)

Adjacent Land Use (check all that apply)
Row Crop _____ Pasture _____ Urban _____ Industrial _____
Forest _____ Wetland _____ Prairie _____ Other _____

Record all other land use practices that potentially could affect the stream:

Extended Mussel Survey Assessment Form

Stream Habitat Type (check one)

Riffle _____ Run _____ Pool _____

Streambed Substrate (estimated percentages)

_____%	Bedrock – large sheets of stone
_____%	Boulder – stones larger than 10 inches in diameter
_____%	Cobble – stones, diameter between 2.5 and 10 inches
_____%	Gravel – 0.1 to 2 inch diameter
_____%	Sand – smaller than 0.1 inches
_____%	Mud/Silt – dirt or soil deposited on bottom of the stream
_____%	Other – organic material like leaf litter, tree limbs, etc.
100%	**TOTAL**

Microhabitats (Record different types that you see: algae mats, leaf packs, logjams, rock piles, root wads, undercut banks, weed beds or fallen trees.):

_____

_____

_____

_____

_____

_____

_____

Stream Banks (check one for each bank)

Left Bank (facing upstream)

_____ Cut Bank – Eroding
_____ Cut Bank – Vegetated
_____ Sloping Bank
_____ Sand / Gravel Bar
_____ Rip/Rap (or constructed bank)
_____ Other

Right Bank (facing upstream)

_____ Cut Bank – Eroding
_____ Cut Bank – Vegetated
_____ Sloping Bank
_____ Sand / Gravel Bar
_____ Rip/Rap (or constructed bank)
_____ Other

Stream Velocity

1st Spot ____ seconds	6th Spot ____ seconds	11th Spot ____ seconds
2nd Spot ____ seconds	7th Spot ____ seconds	12th Spot ____ seconds
3rd Spot ____ seconds	8th Spot ____ seconds	13th Spot ____ seconds
4th Spot ____ seconds	9th Spot ____ seconds	14th Spot ____ seconds
5th Spot ____ seconds	10th Spot ____ seconds	15th Spot ____ seconds

Average Stream Velocity = _____ meters/second

Total Flow (cubic meters per second or m3/s)

For total flow, imagine a box placed around each spot on your stream transect. A flow is determined for each box and summed for all boxes. Flow associated with each box is calculated by multiplying the width of the box at each spot (1 meter) by stream depth (which you measure) by the velocity of the spot (in the field you measure the number of seconds it takes for the tennis ball to travel one meter; velocity is one meter divided by the number of seconds). The flow of each box is in cubic meters per second (m3/s). The flow of each box is added together to give total flow.

Total Flow = (W1*SD1*SV1) + (W2*SD2*SV2) + (Wn*SDn*SVn)

Other Stream Assessment Observations and Notes:

Lesson 3: Aging a Mussel Worksheet

A mussel can live up to ten years or more with most surviving less time. This exercise will help you get an idea of a mussel's age by counting the rings on their shell (alive or dead). The method of counting the shell's rings becomes harder the older the mussel.

Mussel 1_____

Mussel 2_____

Mussel 3_____

Mussel 4_____

Mussel 5_____

Mussel 6_____

To compensate for errors associated with mussels place them in one of three age classes: 1-5, 6-10 and > 10 years old.

Lesson 1 Worksheet Answer Key: What is killing the mussels?

Write out a list of environmental factors that are killing mussels:

- Habitat loss, Dredging, Chemical pollution, Sedimentation, Channelization, Wetland drainage, Overharvesting of mussels, Excessive tiling, Dams, Industrial pollution, Competition from exotic species, Drought, Unstable substrates

Write out a list of theories behind what is killing mussels:

- Habitat loss can be the result of excessive flows from man-made drainage (both rural and urban settings) and the loss of wetlands that help control flows.
- Dredging of the river bottom to provide shipping on the Mississippi and Minnesota rivers prevents mussels from living in those sections and also destroys habitat.
- Excessive silt can cover a mussel or mussel bed smothering the animals.
- Channels and dams built for navigation and/or flood control changes the nature of the river in ways that help some species of mussels but devastate other species.
- Commercial harvesting from the early 1900s may still have an impact on certain mussel populations. Today, the state of Minnesota does not allow the harvesting of mussels from inland water and has set limited commercial harvest of a single species from the Mississippi River along the border with Wisconsin.
- Excessive tiling of the landscape changes the natural hydrology and causes the rivers to bounce up and down at faster rates leaving mussels stranded in lower water. In addition, high flows and fast currents can uproot and wash mussels downstream to a less habitable area.
- Dams block the migration of fish preventing species like the skip jack a host for Ebony shell mussel from repopulating this native mussel. Dams also impact mussels by turning free flowing rivers into a series of pools lakes or pools making it tough for mussels adapted to a riverine environment that can be difficult or impossible to survive.
- Exotic species like Zebra mussels (transported here by accident from the Black Sea) monopolize the food, oxygen and living space needed for native mussels to survive. Zebra mussels attach themselves to native mussels and can grow so thick the native mussel no longer can open its shell for feeding and movement causes the native animal to die.

Write out a list of potential ideas or projects that might help restore mussel habitat in rivers:

- The Minnesota DNR is working with the U.S. Corps of Engineers to restore a three mile stretch on the Pomme de Terre River back to its original channel.
- Restoring of critical areas along rivers and lakes from cropfields and other man-made features will reduce excessive sediment and higher peak flows.
- Construction of new wastewater treatment plants will reduce chemicals from being discharged into rivers and other waterways.
- Removal of dams will restore fish migration and the movement of mussel larvae.

SUGGESTED RESOURCES

Websites

- Mussels - MN DNR: www.dnr.state.mn.us/mussels/glossary.html
- Freshwater Mussels of the Upper Mississippi River System - U.S. Fish and Wildlife Service: www.fws.gov/midwest/mussel/glossary.html
- Minnesota River Basin Trends Report - MBRDC: http://mrbdc.mnsu.edu/minnesota-river-basin-trends-report
- Minnesota River Basin Progress Report – MRBDC: http://mrbdc.mnsu.edu/minnesota-river-basin-progress-report
- Guidelines for Sampling Freshwater Mussels in Wadable Streams, Wisconsin DNR: http://wisdotresearch.wi.gov/wp-content/uploads/01-09mussels-f1.pdf
- Zebra Mussels – Minnesota Waters: http://www.minnesotawaters.org/group/volney/zebra-mussels
-

Books for Teachers and Students

- Sietman, B.E. 2003. Field Guide to Freshwater Mussels of Minnesota. Minnesota Department of Natural Resources, St. Paul, Minnesota, 144 pp.
- Wisconsin Department of Natural Resources. 2003. Freshwater Mussels of the Upper Mississippi River, 60 pp.
- Stern, E. M. 1990. An illustrated key to the freshwater mussels (Bivalvia: Unionacea) of Wisconsin. Reports of the Museum of Natural History, U. of Wisc.-Stevens Point, No. 20. 75 pp.
- MN County Biological Survey. Native Plant Communities and Rare Species of The Minnesota River Valley Counties. Minnesota Department of Natural Resources, St. Paul, Minnesota,

POWER-POINT PRESENTATION

Introduction

Slide 1 - Ask an Expert: About the Minnesota River

- This project profiles scientists and citizens answering questions about the health of the Minnesota River.

Slide 2 – One of the most endangered group of animals in the world.

- "Mussels are among the most endangered group of animals in the world. Freshwater mollusks are imperiled worldwide. Several of them are extinct and we can't find them." – Bernard Sietman
- Mussels are among the most endangered group of animals in the world and much of it stems from the changes that have occurred to their habitat over the last 200 years. At least 70 percent of mussels in North America are extinct, imperiled or in need of special protection according to organizations like The Nature Conservancy. Compare this to 16.5 percent of mammalian species and 14.6 percent of bird species. Over the last 20 years scientists began to recognize the loss of some mussel species and the need to step up the research process to figure out why.

Slide 3 – Why do we refer to mussels as the "Canary in the Coalmine"

- **Video**
- "If the mussels aren't living in the river anymore it is like the canary dying in the coalmine. It's time to do something different." – Mike Davis
- Mussels are an indicator species and an early warning for other animals including us humans. Early coalminers would take a canary down into the mine with them because hazardous conditions usually affected this bird first. Mussels act like the bird because they can't escape like a fish that can swim off to more healthy conditions. Because of its limited mobility a mussel can only resist water quality related problems for a short amount of time. If the river can no longer support mussels it is time for us to clean it up.

Slide 4 – What is a mussel?

- A freshwater organism that can be found in rivers and lakes on every continent except Antarctica.
- It is a mollusk, a member of the second largest group of animals in the world. This freshwater organism is a bivalve, a filter feeder and unique here in North America because they use the fish as a host for their larvae. Close to 300 species are found in North America and 48 are considered native to Minnesota. Mussels spend their entire life partially or fully buried in mud, sand or gravel in permanent bodies of water. The range of shell size, color, shape and texture has led to funky names like the Monkeyface, Black sandshell and Fat mucket.

Slide 5 – A historical perspective of mussels

- Mussels have been used for thousands of year by people as a food source, tools and jewelry.
- Historically, mussels were abundant across Minnesota rivers and lakes including a large and diverse population in the big streams like the Minnesota, Mississippi and St. Croix. For thousands of years American Indian tribes ate mussels and crafted tools, jewelry and utensils out of the shells. We can see this in the large mounds of shells found along rivers near Indian villages. From the late 1800s to the wide-use of plastics in the 1950s, enormous numbers of freshwater mussels were harvested for the multi-million dollar button making industry. Today, the Japanese imports a number of mussel shells to be used for culturing pearls in oysters.

Slide 6 – Why do we study mussels?

- **Video**
- "They act as sentinels for water quality. They tell us a lot about the habitat, ecosystem and water quality in the river systems." – Paul Wymar
- Mussels act as sentinels for water quality by telling us a lot about the habitat, ecosystem and water quality in a particular river. Their presence or absence is an indicator of the river's health. Malacologists are able to reconstruct what the river supported for mussels by surveying what are still alive and what had been here once through the shell assemblage. Mussels serve as an ecological link for freshwater systems. People become interesting in studying mussels because of the variety of shapes, sizes, colors and sculptures along with them having one of the most intriguing and interesting histories of any animal in North America.

A Minnesota River Basin Perspective

Slide 7 – Historically, what was the mussel assemblage like in the Minnesota River Basin?

- "The Minnesota River Basin had an outstanding mussel assemblage. It supported 41 species of mussels." – Bernard Sietman
- At one time, the Minnesota River supported 41 species of mussels and a great mussel assemblage by mussel experts. Early explorers like George Featherstonhaugh in 1835 remarked at the "great profusion of unios [mussels] lying on the sandy bottom" of the Minnesota River from the Blue Earth River confluence to Granite Falls. The Minnesota had a big river mussel fauna in the lower reach along with the tributaries and even creeks supporting their own unique species.

Slide 8 - What is the current status of mussels in the Minnesota River Basin?

- **Video**
- "Generally we lost about 50% of what used to be here. In the lower Minnesota, we've lost 2/3rds of species that once lived there." – Mike Davis

- The mussel assemblage throughout the basin had declined greatly with at least 50 percent of the species are now gone. In the lower Minnesota River the mussel diversity and population has been hammered with over 66 percent of the species are lost. Other watersheds like the Chippewa and Pomme de Terre located in the headwater region support a healthier mussel assemblage.

Slide 9 - How does the Minnesota River compare to other major basins in the state?

- "In the lowest categories of river unfortunately. I think the Minnesota is at the bottom of the list statewide." – Mike Davis
- The forty-one species once found in the Minnesota River Basin compared to the St. Croix River, which still has its 40 or so species. At one time the Minnesota River once had a mussel assemblage similar to what is still found for diversity in the lower Mississippi River. Mussel experts point out the population and diversity had been hit hard even more than the Red River.

Slide 10 - Why have mussels declined in the Minnesota River Basin?

- A variety of factors revolving around a dramatic transformation of a prairie – wetland landscape.
- According to DNR Malacologists, the main problem is the instability of the river system in terms of excessive sediment, reduced habitat, and the hydrology.
- What is killing mussels? - Dredging, Chemical pollution, Sedimentation, Channelization, Wetland drainage, Overharvesting of mussels, Excessive tiling (causing rapid bounces in the river levels), Dams (preventing fish migration), Industrial pollution, and Competition from exotic species.

Slide 11 - Where are mussels doing ok in the Minnesota River Basin?

- The Chippewa and Pomme de Terre rivers in the upper headwaters of the Minnesota River Basin.
- Mussel assemblages in these two rivers have retained most of their historical species including rare and sensitive ones that are absent in the rest of the Minnesota River Basin. The Chippewa River has the only reproducing population of the Spike mussel and also a healthy population of the Black sandshell. Next door in the Pomme de Terre River there is a reproducing population of the rare elktoe and has a more abundant population of the threeridge than anywhere else in the basin.

Slide 12 - What is one watershed where mussels have declined?

- The Greater Blue Earth River Watershed (including the Watonwan and Le Sueur rivers).
- As one of the largest watersheds in the Minnesota River Basin, the Greater Blue Earth is one of most degraded. What epitomizes it as one of the poorest mussel assemblages in the basin is how some of the most common species are gone or practically gone. Fairly tolerant species in a board sense like the Threeridge and Wabash pigtoe are completely

gone within the system. One of the most common mussels in the basin the Fat mucket has also been hit hard. Malacologists found only two individuals in one creek across the entire basin system.

The Fascinating Life of a Mussel

Slide 13 - What is the typical lifecycle of a mussel?

- **Video**
- Mussels have one of the fascinating lifecycles in the animal world that involves using fish as a host for their larvae.
- Female mussels have evolved various strategies to get fish close enough to them to release their larvae into the gills of the fish. These include elaborate extension of the female mussel's mantle (the soft tissue that produces the mussel's shell) that resembles small fish, insects, or worms. A female mussel may actively move the lure to attract the attention of the fish. The fish thinks they are going to eat something and instead they rupture the little membranes in the mussel's gills. The larvae clamp onto the fish's gills. Other mussel species package their developing larvae (glochidia) into cases that may resemble insects on which fish normally feed. When a fish attempts to eat this "imposter insect" the fish becomes infected with the mussel's larvae.

Slide 14 - What is an example of mussels using fish as hosts?

- **Video**
- "Those mussels who are still fairly common in the Minnesota River and several of them use the freshwater drum or sheepshead as a host fish." – Mike Davis
- In some cases the female mussel sacrifices herself as food for the Sheepshead, who has pharyngeal teeth deep in their throats allowing them to eat shells. The fish pulls the whole shell of the mussel into their mouth and start slamming those teeth together crushing the shell. If the female is gravid with these larvae and ready to attach to the fish's gills this ultimate mother martyrdom role has played out. Mussel experts have observed female mussels when they are ready to release their larvae come to the surface of the riverbed. Here they roll over on their back opening up their shells a little bit to look like a nice juicy piece of meat.

Slide 15 - How long do mussels live?

- "Depending on the species they can be very long-lived. Some of them could live to be over 100 years old." – Mike Davis
- Other mussels have a shorter life of maybe 10 years and even typically shorter than that.

Slide 16 - How do mussels move?

- **Video**

- "Very slowly, very deliberately. They have a little thing that we call it a foot because they used it for locomotion." – Mike Davis
- Mussels do have the ability to move but very slowly by using what is referred to as a foot and looks like kind of a big tongue. They push the tongue out of the anterior end, inflate it with water and then retract it towards the shell. By being anchored in the riverbed the foot pulls the shell ahead as it advances. Mussels move in little increments, maybe a half an inch at a time and leave behind a furrow in the riverbed. You can find mussels in clear water by following their meandering trail.

Slide 17 - How far can a mussel move and why?

- Mussels usually don't move much, but a muscular "foot" helps them burrow and allows limited travel if disturbed by floods or drought.
- They wouldn't move miles or anything but can move short distances anywhere from a foot to thirty feet to avoid lowering water when river levels drop. According to malacologists, the mussel's nervous system senses it's time to move and start crawling until they feel secure. Mussels will also burrow a short distance into the sand or mud to wait until the water level comes back up.

Slide 18 - What do mussels eat?

- "A lot of what they are eating is the bacteria and fungus that is decomposing organic matter." – Mike Davis
- Mussels are filter feeders and pull in water filled with decomposing organic matter including fish poop and expel whatever they can't use as food. They have what we can call in intake pipe and outtake pipe, constantly pulling water into one and shooting it back out with the other.

Slide 19 - What eats a mussel?

- **Video**
- Fish are a main predator when the mussel is small and later its mammals like the muskrat and raccoon.
- Mussels are eaten by fish during their larvae stage and also from those fish species that can crush shells. As the mussel becomes larger it shifts over to mammals like muskrats, raccoons and otters. In terms of mammals, muskrats are probably the principal predator of mussels. Muskrats can split open a mussel's shell with their two big front rat-like teeth. They have learned to turn the mussel around and cut the inductor or muscles that hold the shells together and pry them open.

Mussels play an important role for our ecosystem

Slide 20 - Why do we care about mussels?

- If we lose our freshwater mussels, we lose more than a biological legacy unmatched in the world. We lose a part of our cultural heritage, we lose an economic resource, and we lose an environmental health maintenance and warning system.

Slide 21 - What are idea conditions for a healthy mussel assemblage?

- "A stable river environment. Stable by that I mean not a lot of erosion and deposition." – Mike Davis
- A stable substrate has been cited by mussel's experts as the most important factor for mussels to thrive. In addition, other factors involve the habitat and water quality with less turbidity and nutrients. They also need a healthy fish population to reproduce and less fluctuation of water levels.

Slide 22 - How do mussel impact water quality?

- A mussel's filtering ability makes them natural water purifiers and responds to changes in water quality.
- Mussels clean the water by constantly filtering out food particles from the river and deposit the organic matter on the surface of the riverbed to be eaten by aquatic organisms. The more abundant of mussels the greater this effect is on the river system. We also know mussels respond to water quality changes quicker than other aquatic organisms. Generally, a healthy river system is indicated by stable and diverse mussel populations.

Slide 23 - What is another important ecosystem benefit of mussels?

- **Video**
- When there is a healthy mussel population, they will form a dense bed on the riverbed it creates a unique ecosystem.
- In addition to the filtering benefit of many mussels, a dense bed of mussels of 30 to 40 per square meter start to form a unique ecosystem in the river. They form this self-perpetuating situation like a coral reef in the ocean. A mussel bed has a stabilizing influence on the riverbed and it becomes even more stable the more mussels reproduce.

Slide 24 - What does the future hold for Mussels in the Minnesota River Basin?

- "Some things are improving; some fish are moving back, some important fish species. The mussels haven't returned and it is probably a habitat issue." – Bernard Sietman
- Mussels are under threat everywhere in the basin by water quality problems like excessive sediment and nutrients, the decrease in habitat and loss of host fish. Exotic species like Zebra Mussels have the potential for decimating the native freshwater mussel population and diversity.