PENN-E-01-001

ENVIRONMENTAL REDISCOVERIES

(CURRICULUM)

A partnership of:

BAYFRONT CENTER for MARITIME STUDIES

DEP

Sea Grant
Pennsylvania

2001

This program is funded by a grant from the Pennsylvania Department of Environmental Protection (DEP). The Environmental Rediscoveries program was created in cooperation with DEP, Pennsylvania Sea Grant, and the Bayfront Center for Maritime Studies (BCMS).

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OVERVIEW

Pennsylvania Sea Grant, the Pennsylvania Department of Environmental Protection and the Bayfront Center for Maritime Studies have teamed up to provide the opportunity for students to participate in a unique, hands-on educational experience.

Participants will sail aboard the Friendship Sloop *Momentum*, a historic, 42-foot traditionally rigged vessel, and engage in scientific research while learning about the environmental quality and ecology of Presque Isle Bay. Students will be transformed into sailors and scientists for a day as they raise and lower the sails and search for aquatic plants and animals.

Through the ***Environmental Rediscoveries*** experience, both teachers and students will gain a deeper understanding of environmental issues that affect Presque Isle Bay and Lake Erie environments as well as become active participants in caring for and protecting their environment.

GOALS

The goals of the ***Environmental Rediscoveries*** program are to:

- Foster an awareness of environmental issues and concerns affecting the Lake Erie region.
- Create environmental stewards of our fragile environment of Presque Isle Bay.
- Provide students with a unique maritime experience aboard the Friendship Sloop *Momentum*, a 42-foot traditionally rigged wooden sailing vessel.
- Build students' teamwork skills, self-discipline and self esteem through the cooperative efforts of sailing and sample collection.

Curriculum

This packet of lessons is designed to prepare students for their ***Environmental Rediscoveries*** excursion aboard the Friendship Sloop *Momentum*. The lessons are designed for seventh grade, but can be adapted for most grade levels, with all lessons touching on some aspects of the Pennsylvania Academic Standards. Not all materials included have to be reviewed in their entirety, but it is ***strongly*** recommended that the activities and procedures for the field experience be reviewed with the students prior to the field trip.

Cross-Curricular Applications

Most of the lessons have a predominately science theme, but incorporate some aspects of other traditional academic subjects such as language arts, mathematics, and social studies.

Some of the skills students will use in each area include:

Science process skills: Students will learn about observation, measurement, classification, inference, prediction, communication, formulation of hypotheses, experimentation, and data interpretation.

Language Arts: Students will talk and write about the exciting science activities they are doing, as well as their personal interpretation of their experiences.

Art: Students will interpret their findings through illustrations and drawings.

Mathematics: Many of the scientific investigations and observations will result in an opportunity for students to apply mathematical skills such as algebra in a variety of ways. Often students will need to apply mathematical operations to solve problems or answer questions.

Social Studies: Students will learn about past human activities and about their influences on the present and future.

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Sponsors

Primary funding for this manual was provided through grant money from the Pennsylvania Department of Environmental Protection. Additional support was provided by Pennsylvania Sea Grant and the Bayfront Center for Maritime Studies.

For more information about these programs, consult the ***Environmental Rediscoveries*** website at http://www.pserie.psu.edu/seagrant/rediscoveries/index.html or contact staff at the addresses listed below.

Pennsylvania Department of Environmental Protection
Office of the Great Lakes
230 Chestnut Street
Meadville PA 16335
(814) 332-6816
http://www.dep.state.pa.us/

Pennsylvania Sea Grant
Penn State Erie
Station Road
Erie PA 16563
(814) 898-6420
http://www.pserie.psu.edu/seagrant

Bayfront Center for Maritime Studies
Foot of Holland Street
Erie PA 16507
(814) 456-4077
http://www.goerie.com/bcms

Additional Copies

Order from the Bayfront Center for Maritime Studies.

Acknowledgements

I would like to thank Ray Danielski, Marlene Keene, Dr. Robert Light, Dr. Ed Masteller, Eric Obert, Jim Rutkowski, Ruth Ruud and Jim Stewart who served as content resources throughout the compilation of this manual.

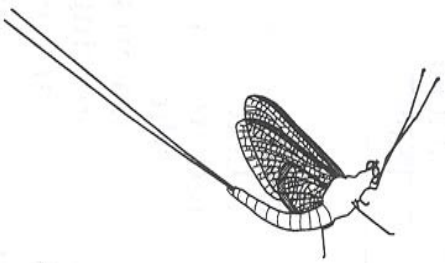
Mayflies on the Move!

GRADE LEVEL/SUBJECT

Grade 7: Ecology/Environmental Studies/Biology

TIME

One class period



OVERVIEW

Mayflies are insects that are considered water quality indicator species. Because they require clean sediments and an abundant supply of oxygen to survive, their presence in a lake or stream environment is and indication of good water quality conditions. Water quality is something that affects everyone. We all use water everyday and assume that it is good quality and safe to drink. Pollution of the water can affect the organisms that live in Presque Isle Bay and in other habitats. Presque Isle Bay, located in Erie, PA, has been designated an Area of Concern (AOC) because its sediments are contaminated. An improvement to the contaminated sediments could be indicated by the presence of mayflies.

PURPOSE

The purpose of this lesson is to introduce students to mayflies and the environment, and to appreciate the relationship between the mayfly and the water quality of Lake Erie and Presque Isle Bay.

OBJECTIVES

At the end of this section students will be able to:

- Identify a mayfly and know its basic biology and life cycle.
- Recognize the relationship between the presence of mayflies and the overall status of Presque Isle Bay.
- See the effect that pollution can have on the ecology of Presque Isle Bay.

PENNSYLVANIA ACADEMIC STANDARDS

Science & Technology

- 3.3 Biological sciences

Environment & Ecology

- 4.6 Ecosystems & their interactions
- 4.8 Humans & the environment

RESOURCES/MATERIALS

Mayfly samples
Pennsylvania Sea Grant data sheets
Worksheet for each student

PRIOR KNOWLEDGE

Prior knowledge of the food web concept
Prior knowledge of insect anatomy/morphology
Prior knowledge of point and nonpoint source pollution

MOTIVATION

Ask the class:

- How many of you have ever been to the bayfront?
- How much do you know about water?

Background Information

What is a Mayfly?

Mayflies are insects that can be found throughout the world. "Canadian Sailors" are the largest mayfly in North America and are common in the Great Lakes. You might know them as those pesky critters that cover the screens on your house or the hood of your car on a warm summer evening. In Erie, we usually see these insects emerge for the first time in the summer months beginning in June. Their body shape is very similar to other insects except for their remarkably huge wings! They have the three main parts of an insect: head, thorax and abdomen.

Like many other winged insects, mayflies have different life stages. They live in the water as a **nymph** (Figure 1) stage for a very long time, but have a very short adult (Figure 2) life stage. Therefore, most of their life cycle is spent in the nymph stage on the bottom of lakes. They live in U-shaped burrows (at right) that they construct. Their food source is primarily microscopic particles that are present around their burrow. They may live in their burrow for up to two years, depending on the environmental conditions. The mayflies emerge when favorable conditions exist, the mayfly nymphs swim to the surface of the water and shed their **exoskeleton**. Once they have left their exoskeleton behind they are ready to spread their wings and fly! Amazingly, during the summer of 1999, so many mayflies were seen emerging from the water at night that they were captured on Doppler radar (Figure 3) by the weather staff at WJET-TV Channel 24. Weather conditions probably play an important role in the emergence of the mayflies.

As mayflies leave the water, they begin to search for a place to land. They are attracted to bright lights. Mayflies are considered poor fliers. The adult mayfly (at left) may live up to three days. Neither the male nor female mayflies feed because their mouthparts are not fully developed. Since they only live as adults for a very short time, mayflies have to reproduce within a short span of time, therefore their main concern is finding a mate. Males swarm in one area and the females fly into that group in search of a mate. Once they mate, the female will fly out over a body of water, deposit her fertilized eggs directly onto the water's surface and die shortly thereafter. A single female can produce as many as 8,000 eggs! These eggs then sink to the bottom and after a few days or months a tiny nymph hatches from the egg. This completes the lifecycle of the mayfly.

Mayflies role in the food web

Mayflies play an important role in the **food web**. They acquire the energy from decomposed plant material and move it on to higher consumers (macroinvertebrates, fish, birds, etc.) Most importantly, they are a food source for many different kinds of fish, including walleye and yellow perch. It is thought that several endangered species of fish namely sturgeon, whitefish, lake herring and silver chub consume mayflies as a major portion of their diet. These species have been increasing in numbers possibly due to the return of mayflies. More mayflies should result in more fish! The more fish, the more fish people have to catch and eat!

Why should we be concerned about mayflies?

Mayflies were very abundant in Lake Erie until the early 1950s when pollution from untreated sewage and industrial discharges contaminated the sediments. The nutrients in the untreated sewage produced tremendous growths of algae, which matured, died and decomposed. Aerobic bacteria use oxygen in the decomposition process of the algae. Consequently, when these large algal growths decomposed and sank they used all the available oxygen in the lake bottom and the mayflies died out because they could not survive without oxygen.

Our technology and lifestyle play a big role in polluting our waters. In the 1960s and 70s we did our laundry with phosphate detergents and provided minimal treatment for sewage. In addition, human impacts came from development of surrounding land: landfills, sewage outfalls and industry. Since we depend on the water in Presque Isle Bay and Lake Erie for drinking, bathing, watering our lawns, washing our dishes, among other things, it is important that the water is **potable**. Presque Isle Bay (Figure 4) receives **nonpoint source pollution** in the form of runoff from streets and parking lots which can contain oils and other pollutants produced by cars and trucks. Fertilizer and pesticides are also added to the bay from lawns, gardens and other sources. The bay also receives **point source pollution** from industrial and municipal discharge pipes.

These sources of pollution affect the animals living in the water. Certain animals are more sensitive to pollutants in the water. Some mayflies are viewed as a **water quality indicator species.** In mayflies, the nymph stage is very sensitive to pollutants in the water and the sediments because they are in constant contact with the sediments where the pollutants accumulate. If a pollutant impacts the water in high enough concentrations, the mayflies could die or their development could be affected. If the sediments are clean and the water quality is good then the mayfly nymphs will complete a normal life cycle. By monitoring the populations of these animals, we can get some indication of the water quality. If we don't see the mayflies emerging, as was the case in Lake Erie from the late 1950s until the early 1990s, we know that there is a problem. Could the increased quality of the water or sediments be the cause of their reappearance?

PROCEDURE

1. Begin a class discussion by asking questions: What kinds of insects do you see around your house in the summer? Then list these types of insects.

2. Display Figure 2. How many of the students recognize this insect? Are there other insects that they think look similar to the mayfly?

3. With that brief introduction now review: ***What is a mayfly?***

4. Pass around preserved samples of mayfly adults and nymphs so the students have a chance to observe them.

5. Pass out a blank piece of paper to each student and have each student draw the preserved sample of the mayfly they have.

6. Display Figure 1 and discuss the mayfly life cycle. What noticeable differences do the students recognize between the two life stages?

7. Briefly discuss the mayfly life cycle. Stress the significance of the mayfly nymph stage of the life cycle. Why would you think the nymph is so sensitive to pollution?

8. Briefly discuss the ***Mayfly's role in the food web***. How would the disappearance of the mayfly affect other animals in the food web?

9. Now that the students have background information about mayflies and their life cycle, should they be concerned about mayflies? Review: ***Why should we be concerned about mayflies?***

10. **Group activity:** Have students form several groups. Have each group develop a list of ways it affects the water around them. Have them brainstorm about what steps they can take to change the water quality and make a difference. Have them think about what they would they do if Presque Isle Bay became so polluted that they didn't have any clean water to drink or use for bathing.

11. **Tying it all together:** Mayflies are an important component of the ecosystems of Presque Isle Bay and Lake Erie. Because they are sensitive to pollution, they can be used as one indication of the quality of the water that we all depend on. By controlling and preventing point and nonpoint source pollution, the mayflies stand a better chance of survival and so does the rest of the ecosystem, including us.

12. Pass out student worksheet: Mayflies on the Move!

VOCABULARY

Exoskeleton
Nonpoint source pollution
Nymph
Point source pollution
Potable water
Water quality indicator species

QUESTIONS/INQUIRY

- ✓ Using data collected by Pennsylvania Sea Grant and historic records, compare and contrast mayfly populations from previous years. Hypothesize what the conditions might have been when mayflies were abundant in previous years as compared to the present situation?
- ✓ Do you think mayfly populations are related to the fish populations?

ASSESSMENT

- ✓ Students should be able to correctly identify and describe a mayfly from a group of similar insects. What do they have in common? What are their differences?
- ✓ Students will be able to articulate (written or orally) how the mayfly population relates to the local fish population, and why? And how do local environmental factors impact the mayfly population?
- ✓ Students will be assessed on the completion and correctness of their worksheet.

GLOSSARY

Exoskeleton: The outside covering of the body of an insect or spider or other arthropods.

Nonpoint source pollution: Pollution that results from runoff of melting snow or rainwater picking up pollutants as it is carried to streams and lakes. These pollutants consist primarily of sediments and nutrients but can carry bacteria, viruses, oils, grease, toxic chemicals and heavy metals. The major contributors of nonpoint source pollution in our watershed are urban runoff and air deposition.

Nymph: The interim stage of development, between egg and adult, among insects that undergo incomplete metamorphosis.

Point source pollution: Pollution that originates from a specific identifiable source such as a pipe from a factory. Other sources could be discharge from wastewater treatment plants, or other industrial sources.

Potable water: Water that is clean and can be used for drinking, bathing, or other uses.

Water quality indicator species: A species that is environmentally sensitive to pollution. Mayflies are an indicator of good water quality.

REFERENCES

- ✓ Krieger, K. A. 1997 Mayflies and Lake Erie: A Sign of the Times. Ohio State University Sea Grant Fact Sheet FS-069, Columbus, Ohio.
- ✓ Mayflies Return to Lake Erie. Pennsylvania Sea Grant Fact Sheet 99-01. Erie, PA.
- ✓ Kentucky Water Watch: Water Resource Monitoring. http://www.state.ky.us/nrepc/water/group1.htm

Figure 1: Mayfly Nymph

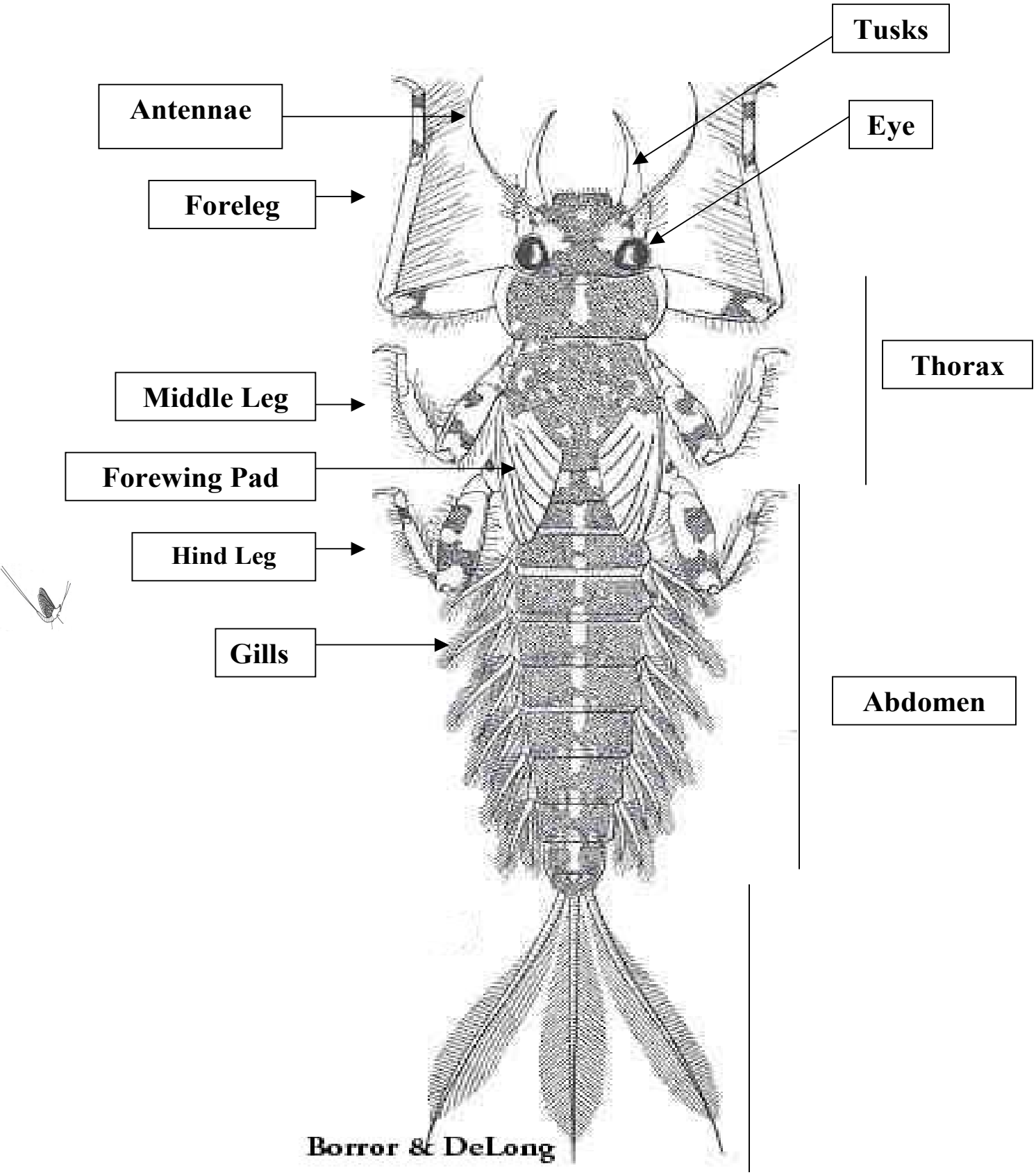
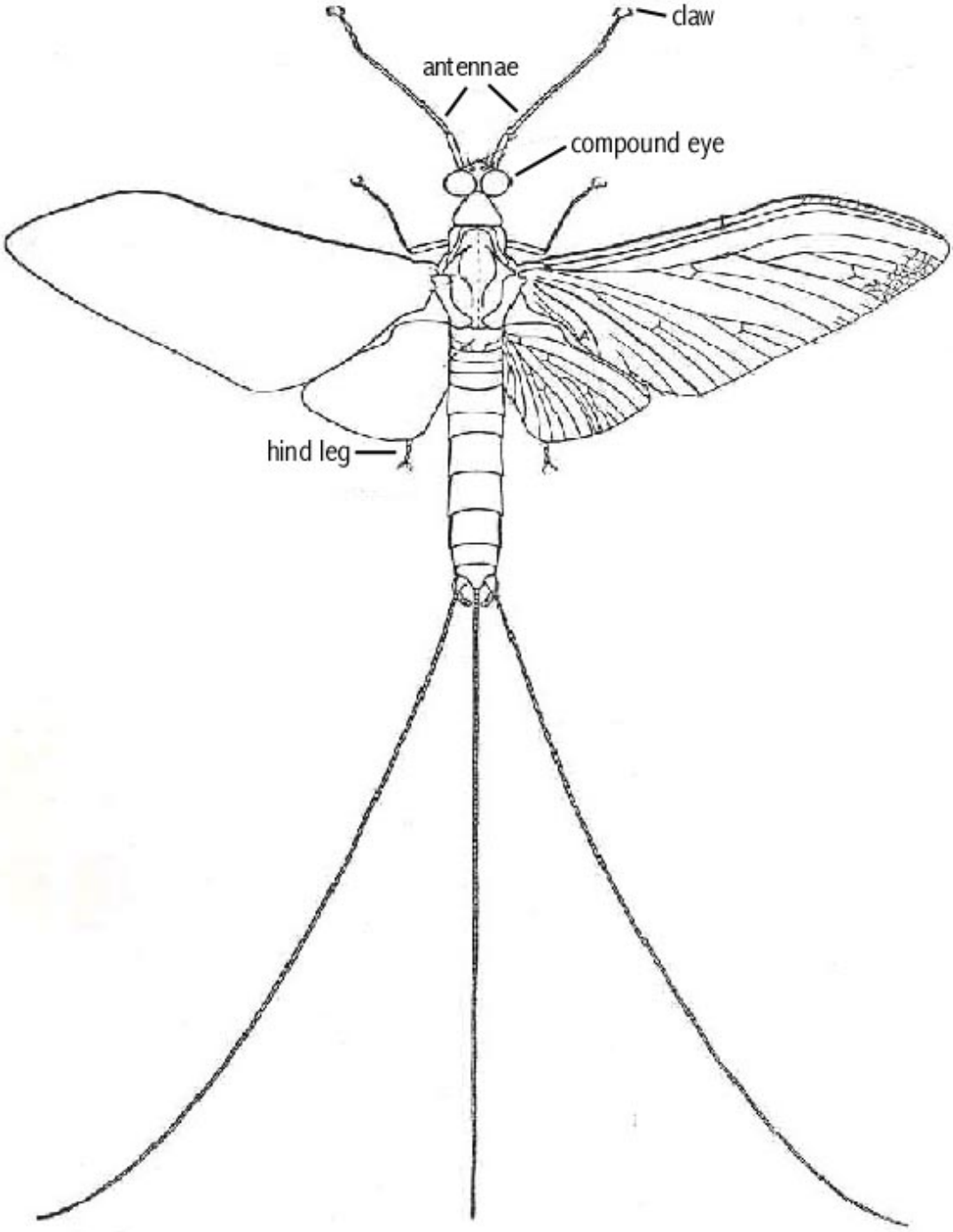


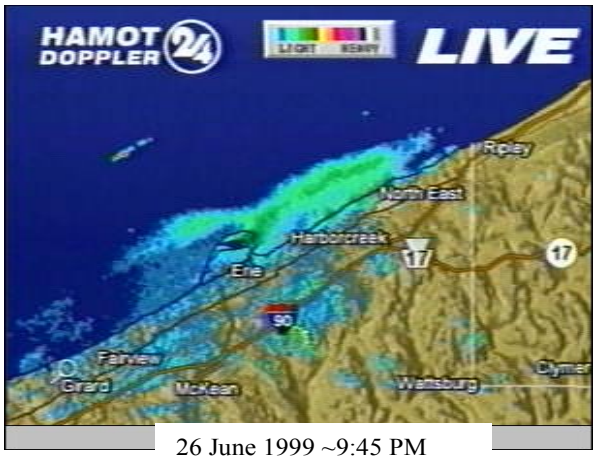
Figure 2: Mayfly Adult



Burks, 1953

Figure 3:Doppler Radar Images

This image shows the lake before emergence. Ground clutter can be seen on land and several small ships east of Presque Isle peninsula.



26 June 1999 ~9:45 PM

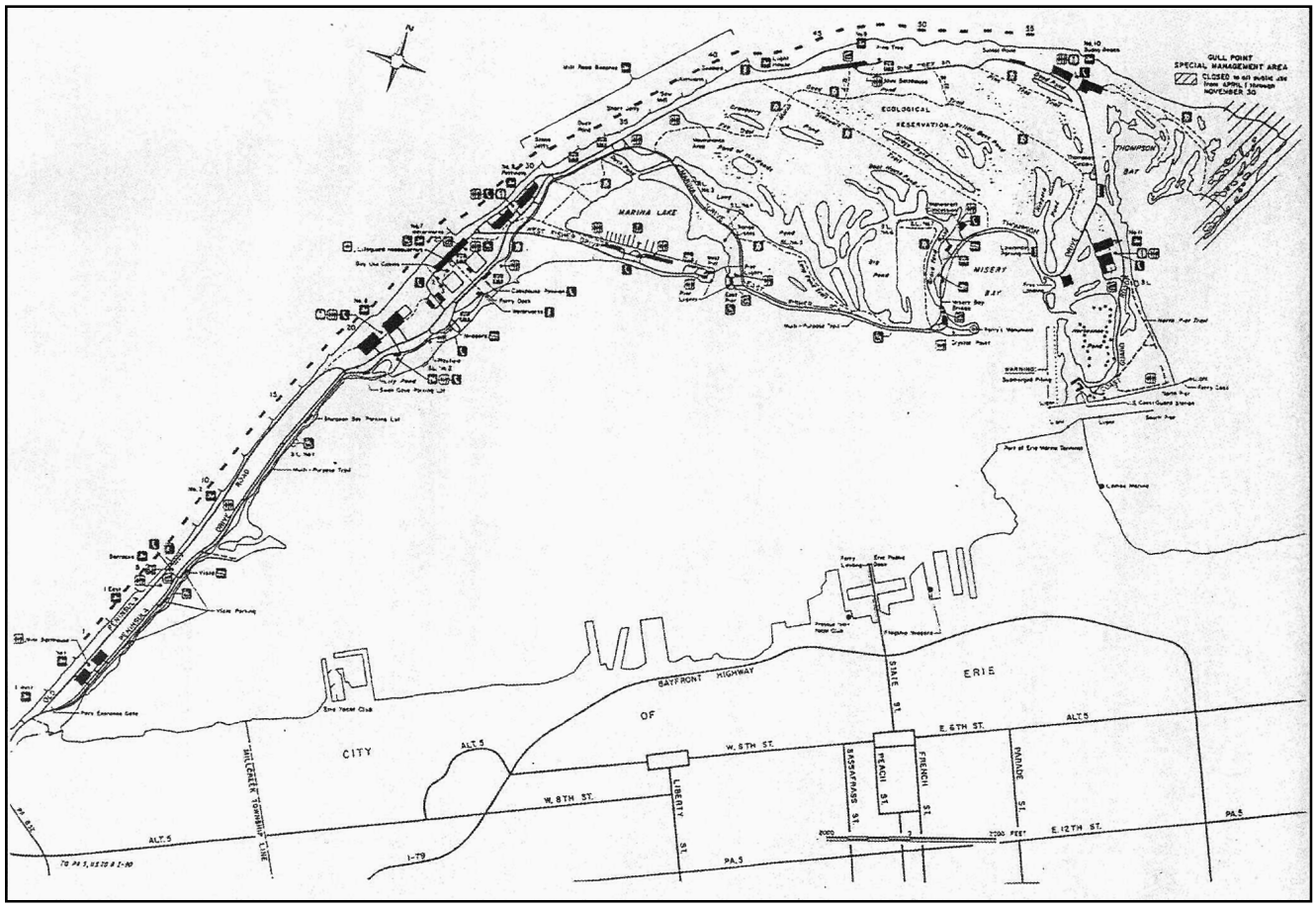
15 minutes later, the emergence begins. Clouds of mayflies can be seen east of Presque Isle peninsula all the way to the NY state line.

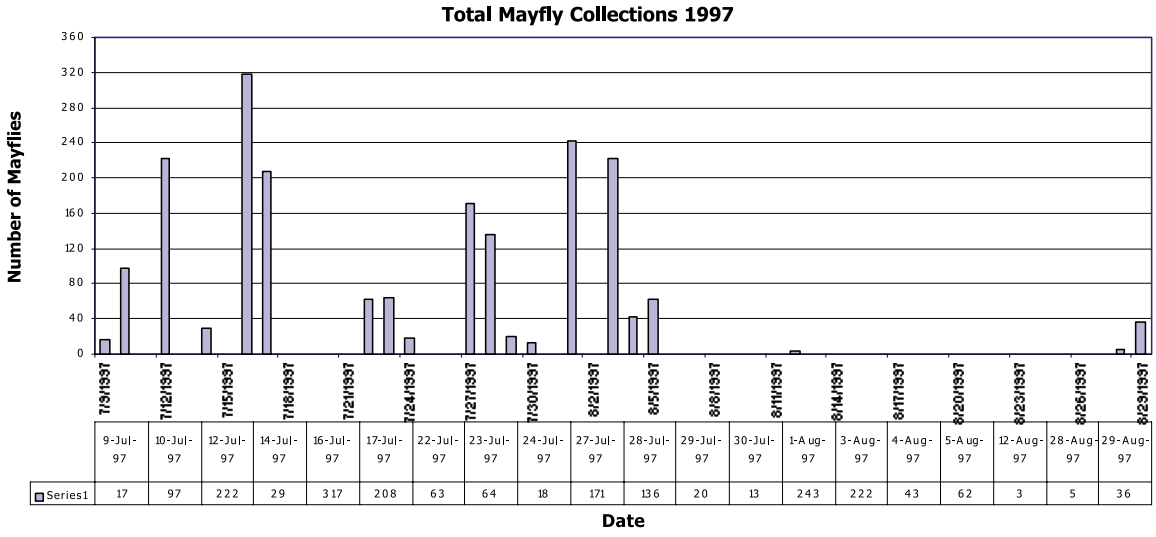
26 June 1999 ~9:30 PM

July 15th shows the beginning of one of the larger emergences. Notice that the next radar sequence shows a greater reflected echo as more mayflies emerge.

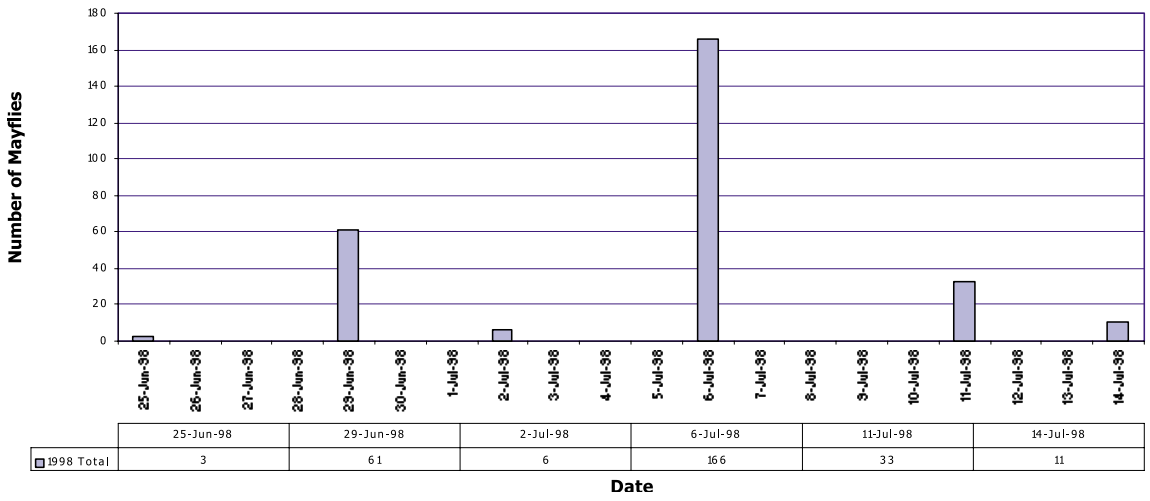
July 15th was one of the largest emergences. Two distinct coulds of mayflies are seen stretching along nearly 40 miles of lakershore.

Figure 4: Presque Isle Bay

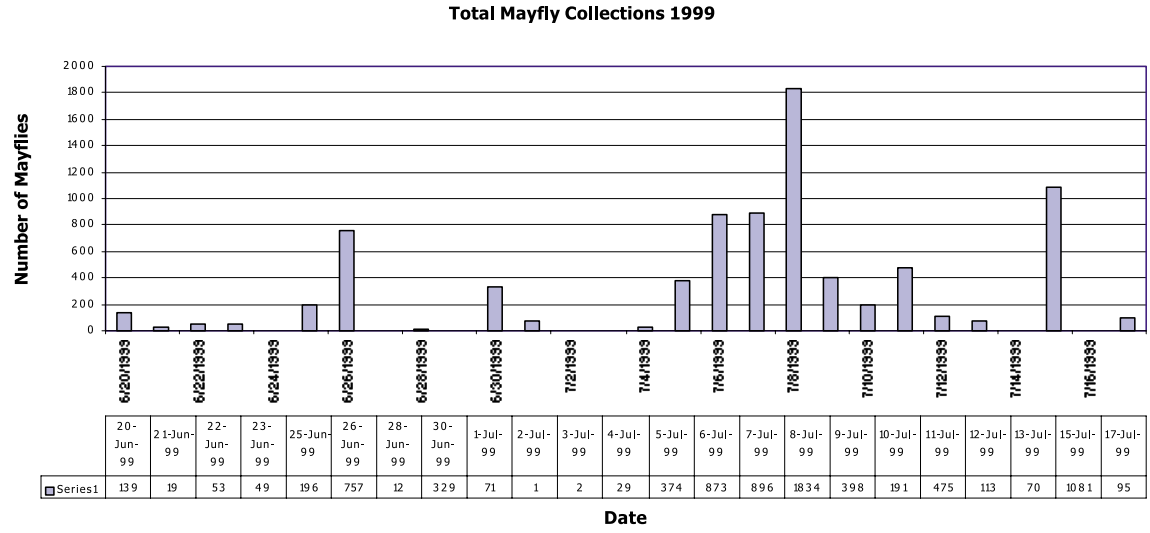




	9-Jul-97	10-Jul-97	12-Jul-97	14-Jul-97	16-Jul-97	17-Jul-97	22-Jul-97	23-Jul-97	24-Jul-97	27-Jul-97	28-Jul-97	29-Jul-97	30-Jul-97	1-Aug-97	3-Aug-97	4-Aug-97	5-Aug-97	12-Aug-97	28-Aug-97	29-Aug-97
Series1	17	97	222	29	317	208	63	64	18	171	136	20	13	243	222	43	62	3	5	36



	25-Jun-98	29-Jun-98	2-Jul-98	6-Jul-98	11-Jul-98	14-Jul-98
1998 Total	3	61	6	166	33	11



	20-Jun-99	21-Jun-99	22-Jun-99	23-Jun-99	25-Jun-99	26-Jun-99	28-Jun-99	30-Jun-99	1-Jul-99	2-Jul-99	3-Jul-99	4-Jul-99	5-Jul-99	6-Jul-99	7-Jul-99	8-Jul-99	9-Jul-99	10-Jul-99	11-Jul-99	12-Jul-99	13-Jul-99	15-Jul-99	17-Jul-99
Series1	139	19	53	49	196	757	12	329	71	1	2	29	374	873	896	1834	398	191	475	113	70	1081	95

Masteller, 1999

Mayflies on the Move!

Name:_____ **Date**:_____ **Class**: _____

Section I: Completion

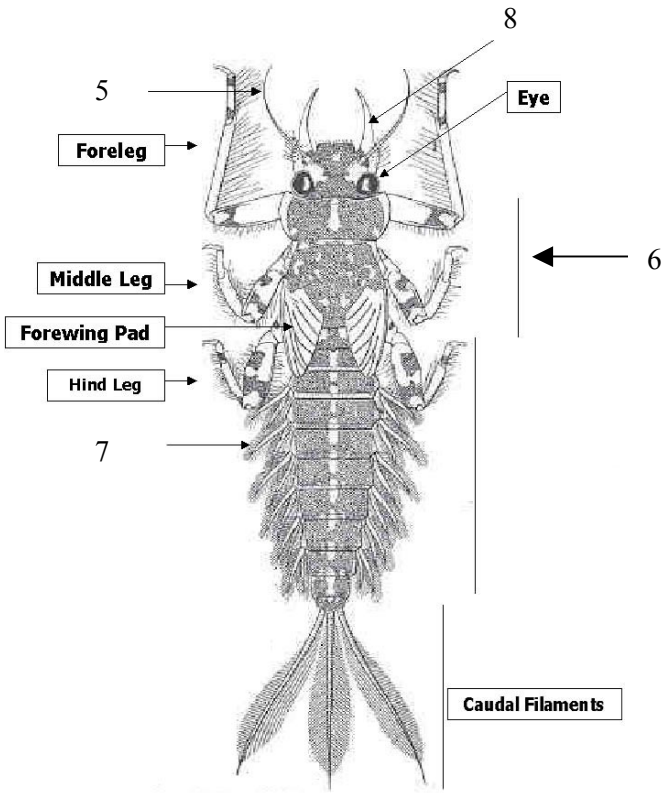
nymph *walleye* *adult* *nonpoint source* *point source pollution*
water quality *exoskeleton* *potable* *food web*

1. Most of a mayfly's life is spent on the bottom of lakes in the _____stage.
2. Mayflies play an important role in the food web. They are a food source for many types of fish, especially _____.
3. _____ pollution results from runoff of melting snow or rainwater picking up pollutants and carrying them to streams and lakes.
4. Mayflies are a _____ indicator species. Their presence in sediments indicate good water quality.
5. Having a clean supply of water or water that is _____ is important because we depend on water for drinking, bathing, watering our lawns and washing our dishes.

Section II: Label Me!

Word Bank

antennae *thorax* *caudal filaments* *gills* *legs*
abdomen *wings* *eye* *tusks*



1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____

Section III: Critical Thinking

Remembering what you learned in class, write a paragraph describing what you think caused the decline of the mayfly population in the 1950s. State why you think they have made a return to Lake Erie in the 1990s.

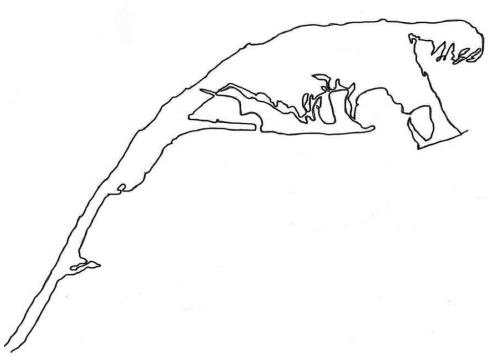
Presque Isle

GRADE LEVEL/SUBJECT

Grade 7: Ecology/History/Environmental Science

TIME

Two class periods



OVERVIEW

Presque Isle is a recurved sand spit that was formed over 14,000 years ago when a massive glacier retreated and left a deposit of sand and gravel. Since that time, humans have taken advantage of such a unique and delicate region. From the Iroquois Indians in 1650 to Commodore Oliver Hazard Perry in the Battle of Lake Erie, to the present day opportunities offered by Presque Isle State Park, Presque Isle truly is a natural wonder to be appreciated and preserved.

PURPOSE

The purpose of this lesson is to educate students about the origin, history and ecology of Presque Isle, so they are better able to appreciate its uniqueness to our region.

OBJECTIVES

At the end of this lesson students will be able to:

- State how Presque Isle has evolved and changed over time.
- Recount Presque Isle's role in the War of 1812 and Battle of Lake Erie.
- List the stages of ecological succession and relate them to the biodiversity of Presque Isle.

PENNSYLVANIA ACADEMIC STANDARDS

Science & Technology

- 3.3 Biological Sciences
- 3.5 Earth Science

Environment & Ecology

- 4.1 Watershed & Wetlands
- 4.3 Environmental Health
- 4.6 Ecosystems & their Interactions
- 4.7 Threatened, Endangered & Extinct Species
- 4.8 Humans & the Environment

RESOURCES/MATERIALS

Map of Presque Isle State Park/Presque Isle Bay
Pennsylvania Trails of Geology booklet
Worksheet for each student
Computer with internet access-optional

PRIOR KNOWLEDGE

War of 1812
Concept of ecological succession

MOTIVATION

- Who likes to go swimming, in-line skate, ride their bike, or go hunting or fishing?
- How many of the students have ever visited Presque Isle or been on Presque Isle Bay?
- Ask students what they know about Presque Isle. Make a list.

BACKGROUND INFORMATION

Note**:** *For* more in-depth information on the origin and migration of Presque Isle, refer to the *Trails of Geology* brochure.

Origin of Presque Isle

Note: Refer to *Trails of Geology* page 2

Presque Isle, French for "almost an island," is a recurved sand spit that was formed more than 11,000 years ago according to geologists. On a geologic time scale this is a very short time. This peninsula was formed as a result of a glacial deposit called a **moraine**, which consists of particles of sand, clay and gravel. The glacier that formed the moraine across Lake Erie was a late, minor advance of the last major ice sheet that covered much of northern Pennsylvania. Approximately 13,000 to 14,000 years ago, the small glacier moved southward into the valley now occupied by Lake Erie (Figure 1). This moraine marks the location where the glacier stopped, and was left behind as the ice melted away.

Migration of Presque Isle

Note: Refer to *Trails of Geology* page 3,6,12

Throughout its 11,000 year history, Presque Isle has been anything but stationary. During the last several hundred years, wind and wave action have acted on this fragile sand spit and have progressively moved it eastward (Figure 2). The formation of the spit is controlled by the relative intensity of erosion and transport and deposition of the sand into different areas on the peninsula. Presque Isle has been an island several times. In 1819 the westerly winds and accompanying wave action broke through the neck of the peninsula and separated the peninsula from the mainland. Its longest span as an island was from 1833 to 1864. The gap occurred as a result of wave action and remained open for 32 years, until it was filled in by natural **siltation**.
Refer to *Trails of Geology* page 12
A variety of efforts have been used to keep Presque Isle from migrating eastward. In order to protect and maintain the beaches, bars, and dunes on the park, man-made structures have been placed along the shore-lines to provide protection from erosion. Examples of these structures include groins, seawalls and detached breakwaters. Refer to Trails of Geology for descriptions of each type. Beach nourishment has also been used to combat erosion.

History

Presque Isle was discovered and named by the French in the 1720s. The name Presque Isle was later translated into English to mean "almost an island." Before that time there was evidence that the first users of the protected waters of Presque Isle were indians. The Eriez Nation inhabited the Lake Erie shoreline giving Lake Erie and the city of Erie its name. The Eriez were thought to have been an agricultural people who used the land on Presque Isle for farming and settlement.

First Settlers

Presque Isle has seen many settlers come and go since the Iroquois of 1650. Since Presque Isle Bay was a natural harbor, the French used it for protection from attack by the English. Between 1720 and 1759, the French established two military outposts on Presque Isle to protect them from the invasion of the English. Both posts were believed to be made of brick; one thought to be at the easternmost tip of the peninsula and the other at the neck of the peninsula. Following their defeat by the British in the French and Indian War, the French destroyed their fort on the mainland near the mouth of Mill Creek and subsequently abandoned their claims to northwest Pennsylvania.

The War of 1812

A dispute arose over who should take ownership of the Erie Triangle, which encompassed the northern half of Erie County and the peninsula. In 1792, Pennsylvania was able to purchase this land from the federal government, but it wasn't until 1795, when Anthony Wayne (at right) defeated the western Indians, that the Americans could permanently settle in this region. This defeat marked the true end of the American Revolution. General Anthony Wayne was headed back to Pittsburgh in December of 1796 and became ill with gout. He died on December 16, 1796, in the Erie Blockhouse and was buried beneath the flagpole. The blockhouse was originally built in 1795 and served as one of the first outposts in the post-Revolutionary War era. Today, the Anthony Wayne Blockhouse stands as a memorial to General Wayne and is located at the foot of Ash Street in Erie, Pennsylvania.

The War of 1812 brought much activity to Presque Isle. The park harbored a naval base during the war and it was here that Commodore Oliver Hazard Perry built his ships and trained his men for battle. On September 10, 1813, the British and American fleets clashed in a battle on Put-in-Bay, (near Sandusky, Ohio) that was the turning point in the War of 1812. Following the defeat of the British, Perry returned with his fleet to Presque Isle and built a bunkhouse and storage building at Misery Bay. Six of his nine vessels, including two brigs, the *Niagara* and the *Lawrence*, were constructed in the bay using trees most likely from the peninsula.

During the cold winter of 1813-1814, many of Perry's men suffered from smallpox and were quarantined in Misery Bay. Many of the men who died were buried in a neighboring pond, which is now named Dead Pond.

Preserving the Fleet

In 1814, the hull of two of Perry's ships, the *Niagara* and the *Lawrence*, were sunk in Misery Bay in an effort to preserve them. They were raised again in celebration of the centennial of the war (at right). When the *Lawrence* was raised, it was in such disrepair that it was sold for souvenirs. The *Niagara* was sunk again later to be raised and restored.

Development of a State Park

The uniqueness of Presque Isle was recognized and much effort went into protecting the peninsula. In 1921, for the purposes of creating a state park, Pennsylvania acquired full ownership of Presque Isle. This began the most intense development period in the history of the park. The first paved road in the park was built in 1924. This road allowed visitors a better view of the lake. During the years that followed, many structures were built, such as cabins, picnic pavilions, the nature center, boat liveries, and others. These improvements attracted many more visitors. The 1950s brought more people and major changes to the park. The neck of the peninsula was widened with the addition of 3,000,000 cubic yards of sand taken from Long Pond located on the park. This removal of the sand created an inland lake for the marina that still exists today. The neck was now large enough to accommodate a one-way traffic system with off street parking (at right)and beach facilities. In 1957, three modern bathhouses were constructed.

Today, Presque Isle State Park has grown tremendously and today provides recreational opportunities for its over 4 million annual visitors. Some of these recreational opportunities include hiking, biking, boating, hunting, fishing, picnicking, and a multipurpose trail. Other events that take place on the park are bicycle, running, and Discover Presque Isle.

Ecology of Presque Isle

Presque Isle has a unique **ecosystem**. Presque Isle's diversity of habitats gives it a high level of **biodiversity**. The biodiversity of Presque Isle is represented by over 640 species of plants, 325 species of birds, 50 species of mammals, 31 species of reptiles and amphibians, and thousands of invertebrates, including 84 different spiders, and 35 different butterflies. Over many years, these plant and animal communities change through the process of succession. **Succession** can be thought of as the sequence of changes that take place in a community following some disturbance to the environment such as flood, fire, or human activities. You can witness these ecological changes and experience over 600 years of ecological succession simply by walking from the beaches to the climax forest. These changes are represented by six distinct **ecological zones**, each with different plant and animal **communities** (Table 1). Each of these distinct zones provide unique physical environments for animals called **habitats** and **niches**. These six zones are Lake Erie, the bay, and shoreline; sand plain and new ponds; dunes and ridges; old ponds and marshes; thicket and sub-climax forest; and climax forest.

Ecological Stages of Succession

Why do these zones exist? The major factors that create these zones are the wind and wave action of Lake Erie acting on the beaches of Presque Isle.

Stage One: Water's Edge, Drift Beach and Upper Beach

The first stage of succession occurs where the Lake Erie waters meet the beaches of Presque Isle (at right). Wind and wave action hit the sandy beaches at an angle and cause **erosion** and redeposition of the sand to the east (recall from "Migration of Presque Isle"). The newly formed beaches are very unstable for a time until vegetation is able to take root. Once the vegetation is established, and the sand is stable the scene is set for stage two.

Stage Two: New Dunes, New Ponds and Sand Plain

Over time, the sand that was moved by the wind and wave action begins to move farther inland out of reach of these elements. As the eastern moving sand is redeposited at the tip of the peninsula, the water that was beating the shoreline gets enclosed as a pond. This beach pond is not likely to be permanent because the windblown sand may be washed away, build up around the base of trees, begin to form dunes or fill in the ponds. If the pond survives these natural occurrences, plants and wildlife will slowly appear. This sets the scene for the next stage of succession.

Stage Three: Fore Dunes, Back Dunes and Ridges

Sand is continually carried inland from the beaches where it is blocked by vegetation. As the sand continues to build up around the base of trees, it starts to form small dunes and dune grasses begin to colonize. As the vegetation and dunes grow, more and more sand accumulates. The new vegetation and sand creates habitat for many types of birds, reptiles and amphibians and mammals. The ridges present on Presque Isle are actually examples of long, old dunes that represent shorelines of the past. The ridges were formed from prevailing west winds building up sand parallel to the shoreline. Long Pond (refer to park map), located one-half mile inland from the east shore, provides evidence of waves crashing against the shore in 1862.

Stage Four: Old Ponds and Marshes

Surrounding the ponds (at right) are dunes and ridges that provide barriers from the wind, allowing the ponds to develop into a stable habitat for many species of plants and animals. The many years that it took to form this habitat allows for a high level of biodiversity. This high biodiversity spans the entire area of the pond, from the water's edge to the open waters. As the pond ages, various types of vegetation can be used to determine its age. When the vegetation at the edges of the pond accumulates soil and debris, along with the growth of heavy algae on the surface of the pond, a **marsh** slowly begins to develop and the pond slowly dies due to the lack of light and oxygen. Over time, some marshes will begin to dry out from the build up of dead vegetation. This leads to the next stage in ecological succession.

Stage Five: Thicket and Sub-Climax Forest

A thicket begins to form when dense, shrubby vegetation begins to grow on a drying marsh. Seeds from various trees are carried by the wildlife or blown by the wind into the thicket and begin to grow. As these trees grow they provide shade that prevents the thicket from growing further and thins the shrubby undergrowth called the sub-climax forest. The border between the thicket and the sub-climax forest forms the **edge habitat**. This habitat provides protection from predators for wildlife that travel between the sub-climax forest and the thicket. Larger trees eventually colonize the sub-climax forest and grow very tall, creating a large **canopy**. This canopy changes the nature of the vegetation growing under the trees. The sub-climax forest is then transformed into the final stage of ecological succession: a climax forest.

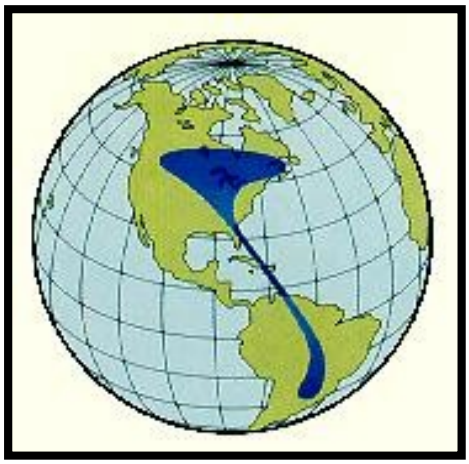
Stage Six: Older and Climax Forest

After years of slow change, the sub-climax forest is transformed by the growth of many trees into a climax forest. The term "climax forest" suggests that if nature is left alone without human or natural disruption, the more prevalent trees will persist for many years. The large stand of trees provides much of shade and also a diversity of habitats for animals and plants. Some animals find shelter in the niches produced by the layers of trees, others inhabit the forest floor. Many of these same animals would not be able to survive without the canopy of the forest. Found in the interior of the park, the climax forest is the oldest region. It provides evidence of the history and movement of succession stages.

Human Impacts on Natural Succession

Human disruptions can positively or negatively affect the natural succession process seen on Presque Isle. Our need for access to recreation on the park has led to an elaborate system of roads, parking lots, and buildings. These structures cannot exist if the sand underneath them moves. Efforts to protect Erie and its harbor from lake storms sometimes conflict with the natural system of moving sand. New construction can create barriers for plants and wildlife. For example, plants cannot grow on the asphalt roads and water is not absorbed on asphalt roads like it is by soil. Therefore, the water runs off and causes erosion. Roads also can cause **fragmentation** of a larger habitat into smaller ones. This makes it difficult for animals or plants that need large areas of habitat. It is important to realize that everything that humans do to an area will affect it either negatively or positively. This is why it is so important to understand the processes of succession so that we are better able to preserve and protect the uniqueness of Presque Isle.

Gull Point: A Haven for Birds



The most understood and widely studied of all the animals on Presque Isle are the birds. The diversity of habitats makes Presque Isle a haven for migrating and resident birds. Over 325 species of birds have been found on Presque Isle at one time or another throughout the year, however, not all 325 species are year round residents to the park. Located at the tip of Presque Isle, Gull Point is a perfect stop for migrating birds. Migrating shorebirds flying north arrive in April and stop to rest before flying over the lake. They use Presque Isle once again as their rest stop when flying south in November. Each year shorebirds migrate from beyond the Arctic Circle to the southern reaches of South America and back again. Presque Isle is located along the **Atlantic Flyway** (at right). About 67 acres of Gull Point have been set aside as a special management area in hopes of allowing rare and migratory shorebirds to nest, rest, and feed successfully. Because of this, Gull Point is closed to all public use from April 1 to November 30.

PROCEDURE

Origin of Presque Isle

1. Display Presque Isle State Park map to class.
2. Display Figure 1 to show relationship of Presque Isle to Lake Erie and other Great Lakes.
3. Hand out *Trails of Geology* booklet. Review the information given about Presque Isle's origin.
4. Discuss with students the relationship between glaciers and Presque Isle's formation.

Migration of Presque Isle

1. Refer to *Trails of Geology* booklet.
2. Discuss how sand is transported by wind and wave motion and how that relates to Presque Isle's migration over the past several hundred years.
3. Handout Figure 2 (Migration of Presque Isle 1790-1971). Point out the differences over the years. In which direction did it move since 1790? Has the size of it changed?
4. Review information on page 12 of *Trails of Geology* booklet regarding manmade structures that have been placed on the park in order to protect Presque Isle. Point out structures on the park map. Discuss the effectiveness of these structures and how they prevent erosion of the beaches.

History

1. Review the information given about Presque Isle's history.
2. Discuss the role that Presque Isle played in the Battle of Lake Erie and the War of 1812.
3. Review the information given about the development of Presque Isle as a state park.
4. Discuss the changes that have taken place from the time the park was first established to the present day. List the major changes on the chalkboard. What are the impacts of these changes on Presque Isle?

Ecosystem

1. Display Table 1 (Inventory of Wildlife and Plants) to students.
2. Review the information given about Presque Isle State Park's ecosystem.
3. As you discuss each stage of succession, ask the students to describe or list the changes that they see in plants and wildlife through the stages. Make a list on the chalkboard.
4. Refer to Table 1 and compare the diversity of each stage. Is there higher diversity in certain habitats? Why?
5. Pass out student worksheet: Presque Isle

VOCABULARY

Atlantic Flyway
Biodiversity
Canopy
Community
Ecological Niche
Ecological Zones
Ecosystem
Edge Habitat
Erosion
Fragmentation
Habitats
Marsh
Moraine
Siltation
Succession

QUESTIONS/INQUIRY

HISTORY/ CREATIVE WRITING:

- ✓ Students will write what they would have done if they were the first settlers on Presque Isle in the 1600s. Have them list what Presque Isle looks like in terms of the wildlife, plants etc. Are there a lot of trees or deer? Are there any other settlers there with you?

ECOLOGY GROUP ACTIVITY:

- ✓ To give students a better understanding of the ecological stages of succession, split the class up into six groups. Each group will represent a different stage of succession. Students will be responsible for knowing what type of habitat their groups' stage represents as well as the types of plant and wildlife are characteristic of their stage. Students should also provide a brief history of how their stage fits into the six stages of ecological succession and how their stage originated. Students should list what possible impacts humans could have on their stage if they were to disrupt it through a construction project.

ASSESSMENT

- ✓ Students will be assessed on their participation in the ecology group activity. Students should be able to describe the characteristics of their ecological stage of succession and how it relates to the other five stages.
- ✓ Students will be assessed for the completion and correctness of their worksheet.

GLOSSARY

Atlantic Flyway: The route that migrating birds follow on their journey to their wintering/breeding grounds.

Biodiversity: A measure of the variety of living things in a community, based upon one of several mathematical formulae, which account for both numbers of species and numbers of individuals within species. High diversity results from high numbers of species and an even distribution of numbers within species. Stressed environments generally have low diversity.

Canopy: The high covering in a forest formed by the upper leaves and branches of trees.

Community: A group of species that live together in the same area.

Ecological Niche: The way a species 'makes its living'; where it lives, what it consumes, and how it avoids consumption by predators or displacement by other species.

Edge Habitat: Unique habitat bordering a forest's or thicket's edge and grassland or marsh.

Ecosystem: A natural system including the sum total of all living things, the non-living environment and its physical forces; and the relationships among these, including processes such as predation, competition, energy flow, and nutrient cycling. Presque Isle is an ecosystem.

Erosion: The natural processes of wearing away of the earth's surface by floods, glaciers, waves or wind.

Fragmentation: The division of a large habitat into small sections.

Habitat: The environment in which a species lives, providing life requirements such as food and shelter.

Marsh: An ecosystem that has the qualities of land and water. Example: swamps.

Moraine: A ridge of sediment that consists of clay, sand and gravel that is carried by huge bodies of slowly moving ice, called glaciers.

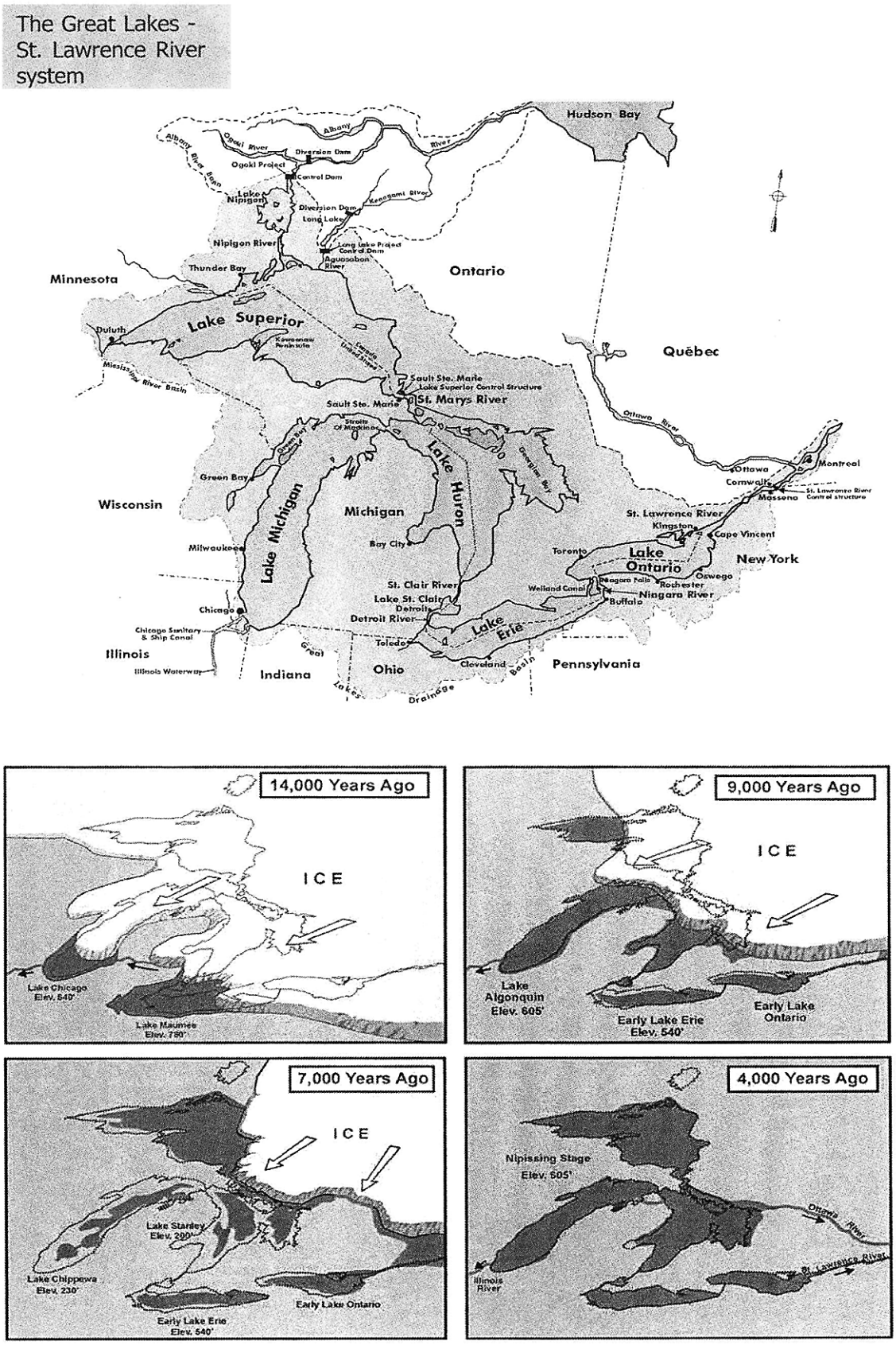
Siltation: The accumulation of sediments transported by water.

Succession: Stages of growth that take place in the plant and animal community following some disturbance to the environment such as flood, fire, or human activities.

REFERENCES

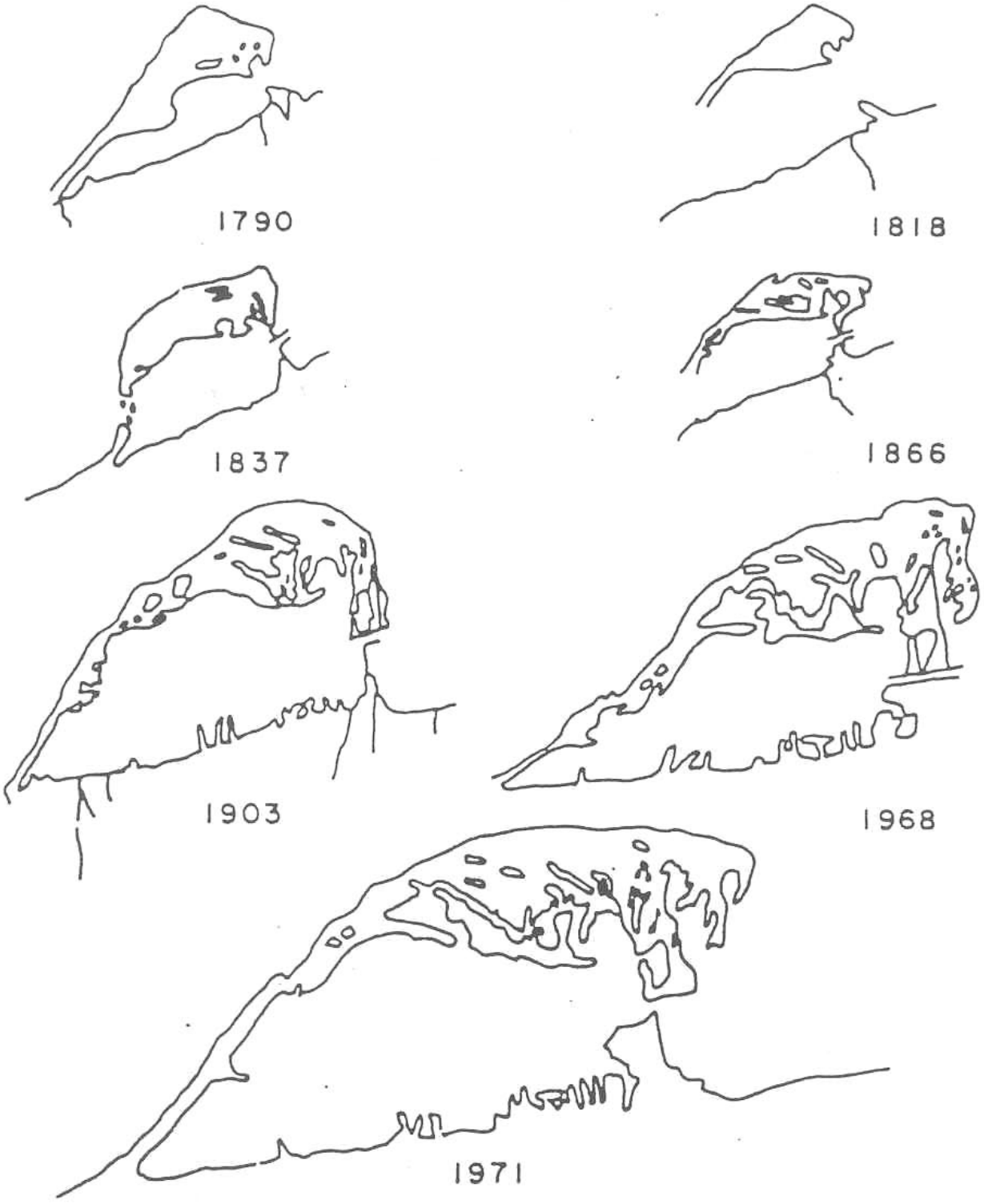
- ✓ Presque Isle State Park Home Page: http://www.dcnr.state.pa.us/stateparks/presqueisle
- ✓ Resource Management Plan Presque Isle State Park; Commonwealth of Pennsylvania, Department of Environmental Resources, Office of Parks and Forestry, Bureau of State Parks; May 6, 1993.

Figure 1: Formation of the Great Lakes



Prehistoric glacial movements and lake shapes

Figure 2:Migration of Presque Isle



Source: U.S. Army Corps of Engineers.

Table 1: Inventory of Wildlife and Plants

INVENTORY LIST OF WILDLIFE AND PLANTS FOUND IN SUCCESSIONAL STAGES

	Water's Edge and Beach	New Pond/Sand Plain	Back Dunes/Ridges	Old Pond/Marshes	Thicket/Sub-Climax Forest	Older/Climax Forest
Vegetation	Sea Rocket Sun/Beach Spurge Beach Clotbur Mugwart Clammy Cudweed Common Evening Primrose	Cottonwood seedlings Umbrella Sedge Bayberry Beach Pea Cyperus Spurge Phragmites Lubgrass Japanese Honeysuckle American three square	American Beach grass Switch Grass Cottonwood Audits Mugwart Ground Nut Riverside Grape Cyperus Spurge Choke Cherry Poison Ivy	Cattails Sedges Bulrushes Willows Blueflag Swamp Rose Mallow Fragrant Waterlily Tufted Loostrife	Poison Ivy Bittersweet Wild Grapes Wild Cherries White Pine Red Maple Mayapple Starry False Solomon's Seal Orchids	Hemlock Red Maple Black Oak Red Oak Fern Moss Black Cherry White Ash Choke Cherry
Birds	Ring Billed Gull Sanderling Pipping Plover Ruddy Turnstone	Eastern Bluebird Redwinged Blackbird Great Blue Heron Mallard	Yellow Rumped Warbler	Marsh Wren American Bittern Red Winged Blackbird	Finch Cardinal Wood Thrush	Great Horned Owl Red Headed Woodpecker Piliated Woodpecker Crow
Mammals			Fox Coyote	Muskrat Beaver Wood Duck Black Duck	Cottontail Rabbit Raccoon Virginia Opossum White Footed Mouse White Tailed Deer	Red Bat Little Brown Bat Fox Squirrel
Reptiles		Map Turtle Northern Water Snake	Garter Snake	Snapping Turtle Northern Brown Snake Map Turtle Painted Turtle	Black Rat Snake	Box Turtle
Amphibians		Spring Peeper		Bullfrog	American Toad Spotted Salamander	Eastern American Toad
Invertebrates	Wolf Spider	Dragonfly	Monarch Butterfly	Mosquito	Luna Moth Tent Caterpillar	Paper Wasp Ladybug Termites
Fish		Bluegill		Sunfish Carp		

Presque Isle

Name: _____ **Date**: _____ **Class**: _____

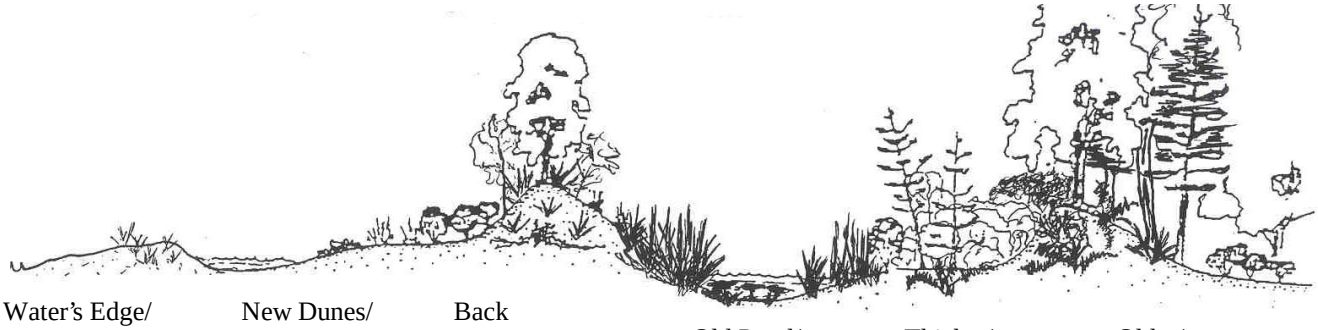
Section I: Completion

War of 1812 *Succession* *Niagara* *Sand spit* *Atlantic flyway*
Fragmentation *Lawrence* *Biodiversity* *Put-In Bay*

1. Presque Isle, French for "almost an island" is a recurved _____that was formed over 11,000 years ago.
2. Misery Bay served as a harbor for Commodore Oliver Hazard Perry's fleet during the _____.
3. Perry defeated the British in the U.S. Brig _____ in a battle at Put-In Bay, September 10, 1813.
4. Ecological _____ is a sequence of changes that take place in an environment following a disturbance such as flood, fire or human activities.
5. Presque Isle is a very diverse ecosystem with a high level of _____ represented by over 640 species of plants, 325 species of birds, and 50 species of mammals.
6. Gull Point's location along the _____ is an important resting and feeding spot for migrating birds.

Section II. Matching

Match the ecological stage of succession from the map with the characteristics listed



Water's Edge/ Drift Beach — **A**
New Dunes/ Sand Plain — **B**
Back Dunes/Ridges — **C**
Old Pond/ Marsh — **D**
Thicket/ Subclimax Forest — **E**
Older/ Climax Forest — **F**

1. ____ Beaches are newly formed; wind and waves cause erosion.
2. ____Shrubby vegetation begins to grow; edge habitat provides protection from predators.
3. ____Sand builds up around base of trees; grasses begin to colonize.
4. ____Sand is out of reach of wind and waves; temporary ponds begin to form.
5. ____Thick canopy of trees provides shelter for many animals.
6. ____This stage has a high level of biodiversity and various plants can be used to age the ponds.

Section III: Critical Thinking

Remembering what you learned, think about how Presque Isle might look 100 years from now. Think about how the sand has migrated in the past, moving the sand spit eastward and what affect that has on the plants and animals that live on Presque Isle.

Presque Isle Bay: Area of Concern (AOC)

GRADE LEVEL/SUBJECT

Grade 7: Ecology/Environmental Science

TIME

Two class periods

OVERVIEW

Presque Isle Bay is located along the Pennsylvania shores of Lake Erie, and provides the City of Erie with a protected harbor. The bay is widely used for recreational boating activities and is also a regular recipient of runoff, industrial discharge, sewage effluent, and other toxic pollutants from the City of Erie. In 1991, Presque Isle Bay was designated the forty-third Area Of Concern (AOC) due to its contaminated sediments and incidence of tumors on brown bullheads.

PURPOSE

The purpose of this lesson is to introduce students to Presque Isle Bay and to inform them as to why it was named an AOC and what impact that has on the Erie community.

OBJECTIVES

At the end of this lesson students will be able to:

- Define what an AOC is.
- State ways that designation as an AOC affects the ecosystem of Presque Isle Bay.
- State ways that designation as an AOC affects the Erie community.
- Understand the effect that sources of point and nonpoint pollution have on Presque Isle Bay.
- Identify steps they can take to make Presque Isle Bay a cleaner environment.

PENNSYLVANIA ACADEMIC STANDARDS

Science & Technology

- 3.3 Biological Sciences
- 3.5 Earth Science

Environment & Ecology

- 4.1 Watersheds & Wetlands
- 4.3 Environmental Health
- 4.8 Humans and the Environment

RESOURCES/MATERIALS

Map of Presque Isle State Park/Presque Isle Bay
Topographical map of Presque Isle Bay watershed
Worksheet for each student
Computer with Internet access (optional)

PRIOR KNOWLEDGE

Concept of watersheds
Point and nonpoint source pollution

MOTIVATION

- Who washes their family car in the street in the summer?
- Who likes to swim at the beaches on Presque Isle?
- Who likes to fish?

BACKGROUND INFORMATION

Presque Isle Bay

The Presque Isle ecosystem contains an ecological resource that is unique within the state and rare within the Great Lakes basin. Covering approximately 3,718 acres, Presque Isle Bay is formed by a natural sand spit to the north (at right). It is a shallow embayment with an average depth of 13 feet. The bay is a relatively sheltered body of water that has a restricted exchange of water with its outer harbor and Lake Erie. Because of this, the bay has a "**flushing time**" of almost 2.5 years, short in comparison to Lake Superior, with a flushing time of 191 years. This 2.5 year time period allows the pollutants entering the bay as runoff to settle in the primarily fine and organically rich bottom sediments. However, large rocks and sand persist in certain areas where currents have restricted the settlement of finer sediments. The animal and plant population of Presque Isle Bay consist of different types of fish, birds, plants mammals and invertebrates. Some examples of fish include yellow perch, bluegill, rock bass, and large mouth bass.

What is a watershed?

Humans need water for drinking, irrigation and industry, yet we have a very casual attitude toward water pollution. Every day, wastes are poured down the sink, flushed down the toilet, or dumped into rivers and lakes without considering where they will end up. We all depend on Lake Erie as a water supply so we can take our shower in the morning and wash our dishes at night. Much of the water we use comes from Presque Isle Bay and Lake Erie. And they both depend on the network of streams or **watershed** that replenish their water.

A watershed, also known as a drainage basin, includes the entire land area drained by a particular creek or river. Precipitation that falls in this area runs off as surface water into a stream channel, lake, reservoir, or other body of water. Stand along any stream and look upstream. All of the water flowing in that stream has fallen on an area of land, which by the nature of its topography, has caused the water to drain to that particular point of the stream. The area that drains to that point is called the stream's watershed.

The topography of the land determines the boundaries of the watershed. These boundaries are the highest points and ridges surrounding a watershed and are called "divides." The city of Erie is perched on an elevated lake plain (*Trails of Geology* page 5). Presque Isle Bay sits at the lowest point in the elevation of the plain. Further inland and at the higher elevations is the **drainage basin divide** (Map 1). This divide separates the Lake Erie Basin (streams that flow north toward the lake), from the Allegheny Basin (streams that drain south). Streams in the Lake Erie Basin drain into either Lake Erie or Presque Isle Bay. Watersheds can range in size from the smallest mountain stream that drains only an acre of land to huge river systems such as the Susquehanna, which drains over 27,000 square miles. The Presque Isle Bay watershed spans approximately 25 square miles. Its primary tributaries are Cascade Creek and Mill Creek, which together account for about two-thirds of the water flowing into the bay. Additional inflow of water comes from precipitation directly on the surface of the bay, **combined sewage outfalls** (CSOs), groundwater discharge, and wastewater discharges.

Presque Isle Bay's watershed

Presque Isle Bay is the oldest U.S. harbor on the Great Lakes, appropriated in 1824 from the national legislature for harbor improvements. The City of Erie, founded in 1792, has grown up around its port. Historically, Erie experienced the growth and decline of the steel industry in the U.S., together with its related heavy manufacturing. Much of the surrounding land has become urbanized with manufacturing industries that coexist with the residential and commercial neighborhoods. The surrounding watershed of Presque Isle Bay (See Topo map) is directly impacted by the use of this land. In the past, both industrial and domestic wastewater was discharged directly into the bay or into streams leading to the bay. At this time, many of the urban streams were used at as sewers rather than as natural resources.

The main tributaries of Presque Isle Bay, Cascade and Mill Creeks, account for two-thirds of Presque Isle Bay's water supply. The two creeks receive runoff from the surrounding land and carry it directly into the bay. This **urban runoff** contains contaminants that affect fish and other aquatic life, drinking water, and recreation. Fertilizers and pesticides applied to agricultural lands and residential lawns can be carried into the streams after a rain event. The discharging of excess phosphorus and other nutrients that are in fertilizers can actually accelerate the natural aging process of the bay (**eutrophication**). This inflow of excess nutrients benefits some plants and causes them to overpopulate, harming other plants and animals living in the bay. When the excess aquatic plant growth dies and decomposes and settles to the bottom, it uses up the available oxygen in the water. This decreases the amount of available oxygen for other aquatic organisms and many of them die as a result. The natural decay of plants and nutrients is called **biodegradation**.

Because 80 percent of the surrounding land use within the Presque Isle Bay watershed is urban, Presque Isle Bay receives high levels of **nonpoint source pollutants** from runoff. The most significant amount comes from residential areas. Land developed with asphalt parking lots (at right) and buildings contribute oils and greases from cars that move into the surrounding streams after a rain event.

AOC Designation

The unique ecosystem of Presque Isle Bay has been subjected to pollution from both **point** and nonpoint sources (Figure 1). Because of this pollution, the U.S. Department of State designated Presque Isle Bay as the forty-third Great Lakes AOC in January 1991. The AOC designation is used to indicate severely degraded geographic areas within the Great Lakes Basin. A designation as an AOC has serious environmental implications. As an AOC, the bay receives priority attention from the Pennsylvania Department of Environmental Protection to restore its impaired **beneficial uses**. The International Joint Commission (IJC) lists 14 beneficial use impairments for AOCs. A water body may be designated as an AOC if certain beneficial uses are determined to be impaired.

In Presque Isle Bay, the two impaired beneficial uses are: 1) Restrictions on dredging of sediments; and 2) fish tumors and other deformities. Fish tumors are thought to be related to elevated levels of organic contamination from nitrosamines or **Polycyclic Aromatic Hydrocarbons** (PAHs) in the sediments. Nitrosamines can be naturally produced in sediments when *anaerobic* (no oxygen) conditions exist along with an available source of excess nitrogen. Excess sources of nitrogen could come from sewage, fertilizers, or large fish kills. PAHs can come from the combustion of fossil fuels such as coal and petroleum. Other sources include asphalt and tar used to pave roads and parking lots, and to waterproof the roofs of houses. PAHs are believed to have detrimental effects on the aquatic life in the bay.

The Brown bullheads (right), a member of the catfish family, lives in Presque Isle Bay and have been found to have skin and liver tumors. Scientists test the bile of the fish (located in the gall bladder) to look for the presence PAH metabolities. PAH metabolites are suspected to be the cause of liver tumors in the Presque Isle Bay brown bullheads. Research studies pertaining to Presque Isle Bay are reviewed by the Presque Isle Bay Advisory Committee (PAC).

The PAC is comprised of representatives from local, state and federal agencies, environmental and civic organizations, academia and industry and was developed in order to identify the problems within the AOC and to develop remediation plans to correct them. Since its inception, the PAC has made considerable progress in improving the health of Presque Isle Bay.

Time, experience and change bring understanding

Today, we have a better understanding about the effects that pollution can have on the watershed of Presque Isle Bay. When you remember that even a small watershed can have a great impact on the entire drainage system downstream, you start to realize just how important it is to understand what is going on in the watershed area where you and your neighbors live. Understanding how our actions affect the environment will help us take steps to change those activities that are detrimental to our environment.

PROCEDURE

1. Review information: **Presque Isle Bay**. Display map of Presque Isle Bay and point out the state park, the city of Erie, Lake Erie and the channel. Ask the students how many of them can name any other bays. Comparing what they know about those bays, what do they think makes Presque Isle Bay unique?

2. How many of the students have a stream or creek by their house? When they wash their family cars or sprinkle their lawns with fertilizer where do they think all of the excess water containing those pollutants goes? Review information: **What is a Watershed?**
Hint: To illustrate better the effect that pollution can have on the surrounding watershed, draw a sample watershed on the board so students can see how a watershed forms somewhat of a webbing pattern that leads to one common body of water (Refer to Map 1).

3. Ask the students to name any streams that they can think of that are in their neighborhood. Write the names on the board. Try and locate the stream on the map of the Presque Isle Bay watershed.

4. Review information: **Presque Isle Bay's watershed.** Display map of Presque Isle Bay watershed. Point out Cascade Creek, Mill Creek and Garrison Run.

5. Have students attempt to locate their street on the map so they see where they live in their watershed. What is the nearest stream located to their house?

6. Discuss with students what impact washing their cars in the street could have on the watershed. (*They might think that if they live in the city and are not close to a stream that they are not polluting the bay. Most don't realize where the water runs to after they see it disappear from their driveway. In many cases it disappears into the storm drains and eventually gets filtered and dumped into the bay.)* Ask the students how many storm sewer drains are near their house?

7. Review information: **AOC Designation.** Ask students how they think Presque Isle Bay got this designation. Is this designation cause for concern? Would any of them go swimming in Presque Isle Bay? Why or why not?

8. Review information: **Time, experience and change bring understanding.** It is obvious that taking action has made a difference in protecting and restoring Presque Isle Bay. Ask students what they think they can do to make a difference? Have them make a list on paper.

Group Activity: Students may form groups of five and work together to write down things they would do to change how we use and abuse our streams. Have them research local pollution incidents that have occurred in their neighborhood or school neighborhood. Put together a presentation for the class detailing the changes you would make. Use specific examples.

9. Pass out student worksheet: Presque Isle Bay: AOC

VOCABULARY

Beneficial uses
Biodegradation
Combined sewage outfalls
Drainage basin divide
Eutrophication
Flushing
Nonpoint source pollution
Point source pollution
Polycyclic aromatic hydrocarbons (PAHs)
Urban runoff
Watershed

QUESTIONS/INQUIRY

- ✓ What effect does development of land near streams or creeks have on the surrounding watershed? If the surrounding land does have to be developed, what are some things that can be done to protect the stream or creek from pollution due to the development?
- ✓ Brainstorm ways that pollution affects the animals in the streams and bay. List them.

ASSESSMENT

- ✓ Students should have gained an understanding of what a watershed is, and they should have also gained an understanding of how polluting streams can affect their community.
- ✓ Students will present their ideal watershed to the class. Assess for organizational skills, content, and accuracy.
- ✓ Students will be assessed for completion and correctness of their worksheet.

GLOSSARY

Beneficial use: Impaired beneficial use means a change in the chemical, physical, or biological integrity of the Great Lakes system sufficient to cause detrimental changes to the ecosystem.

Biodegradation: The natural process of plant decay and decomposition.

Combined sewage outfalls: Under "non-rain event" situations (normal flow conditions) the wastewater flows to the wastewater treatment plant to be processed. During large rain events, the excess flow causes the rainwater and wastewater to be mixed and a portion of the wastewater flows directly into the bay.

Drainage basin divide: A ridge that separates one drainage basin from another. One example is the ridge that separates the Lake Erie Basin drainage from the Allegheny Basin drainage.

Eutrophication: The natural aging process of a lake whereby the lake goes from low production to high production as a result of enrichment by nutrients.

Flushing: The natural process of water replacement in an estuary; for example, Presque Isle Bay is flushed every 2.5 years by lake water and other runoff. In other words, it takes 2.5 years for water entering Presque Isle Bay from a storm to get to Lake Erie.

Nonpoint source pollution: Pollution that results from runoff of melting snow or rainwater picking up pollutants as it is carried to streams and lakes. These pollutants consist primarily of sediments and nutrients, but can carry bacteria, viruses, oils, grease, toxic chemicals, and heavy metals. The major contributors of nonpoint source pollution in our watershed are urban runoff and air deposition.

Point source pollution: Pollution that originates from a specific identifiable source such as a pipe from a factory. Other sources could be discharge from wastewater treatment plants, or other industrial sources.

Polycyclic Aromatic Hydrocarbons (PAHs): A family of organic compounds derived from fossil fuels and their combustion. The higher molecular weight PAHs are an environmental concern because they can cause cancer in humans and animals.

Watershed: The land area drained by a river or stream. The watershed is the natural hydrologic unit associated with numerous ecological and physical processes involving water. Increasingly, the watershed is being accepted as the most appropriate geographic unit for management of water quality.

REFERENCES

- ✓ Presque Isle Ecosystem Study: Background Report. Potomac-Hudson Engineering, Inc.; Bethesda, Maryland; June 1991.
- ✓ Environmental Protection Agency: Presque Isle Bay 43rd Area of Concern http://www.epa.gov/glnpo/aoc/presque
- ✓ Nyer, Randy EES Presque Isle State Park; DCNR/PA Bureau of State Parks/Environmental Education and Information Division; Watershed Curriculum, 2000.

Figure 1: Point and Nonpoint Source Pollution

NONPOINT SOURCE

Runoff from Farm and Lawn Nutrients

POINT SOURCE

Emissions from Factories

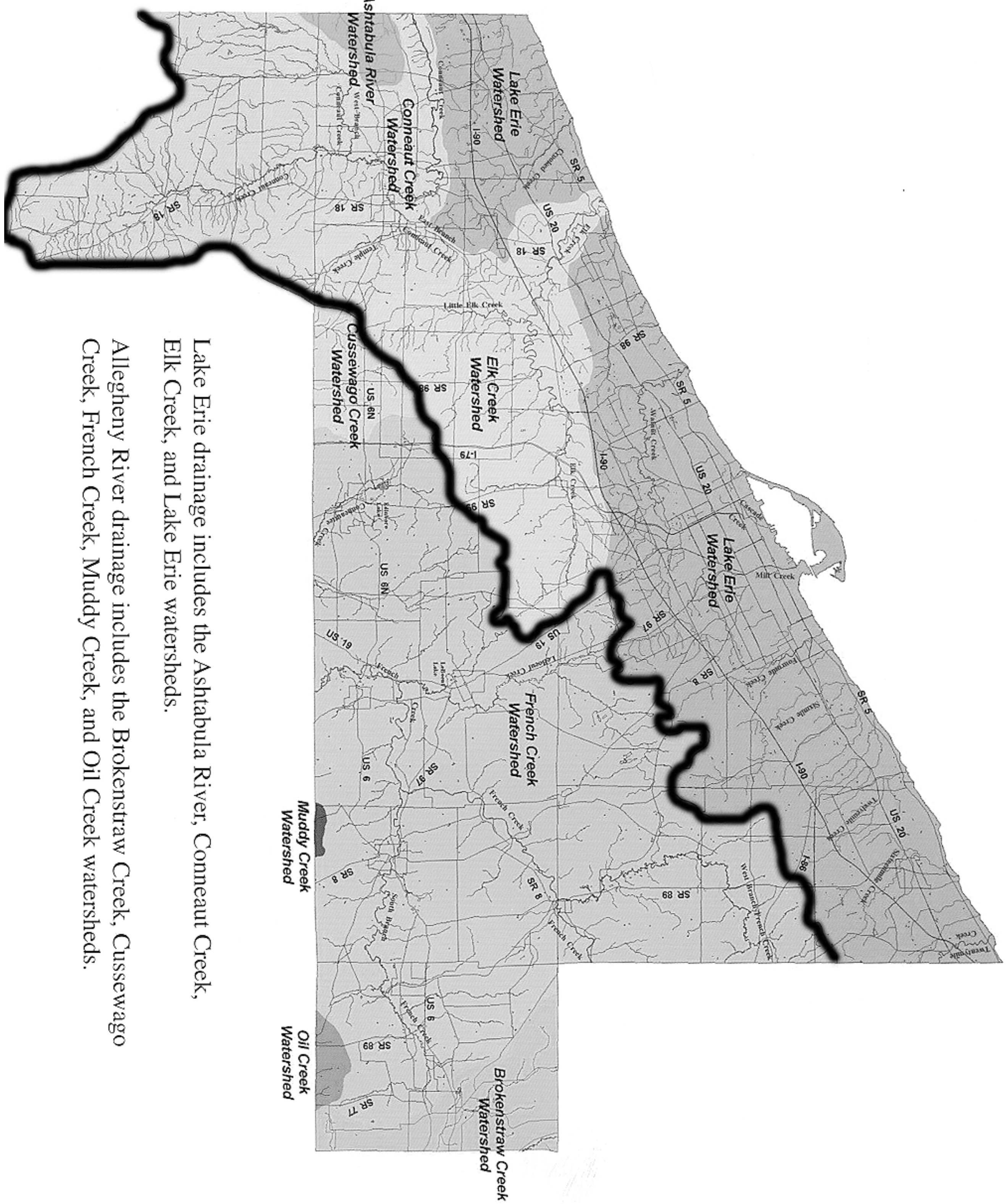
POINT SOURCE

Discharge Pipe

NONPOINT SOURCE

Runoff from Parking Lots

Map 1: Drainage Basin Divide



Lake Erie drainage includes the Ashtabula River, Conneaut Creek, Elk Creek, and Lake Erie watersheds.

Allegheny River drainage includes the Brokenstraw Creek, Cussewago Creek, French Creek, Muddy Creek, and Oil Creek watersheds.

Presque Isle Bay: AOC

Name: _____ Date: _____ Class: _____

Section I: Completion

Siltation *Mill* *Watershed* *Drainage Basin Divide* *Biodegradation*
Point source *Flushing Time* *Eutrophication* *Cascade* *Nonpoint source*

1. Presque Isle Bay is a sheltered body of water formed by a natural sand spit that has a _____of 2.5 years.
2. The_____ is a ridge that separates the Lake Erie basin drainage from the Allegheny Basin drainage.
3. A_____ is a land area drained by a river or stream. Presque Isle Bay's spans approximately 25 square miles.
4. The natural aging process of a lake is called_____. This process can be accelerated when an excess of nutrients such as phosphorus enter a lake.
5. Presque Isle Bay has been subject to both _____and_____pollution. It is because of the effects of this pollution that Presque Isle Bay was named the forty-third Area of Concern.
6. The main tributaries of Presque Isle Bay are _____Creek and _____ Creek and account for two-thirds of the bay's water supply.

Section II. Matching

Label the types of pollution as either point or nonpoint source pollution. For nonpoint source pollution write a 1, for point source write a 2.

1=Nonpoint Source Pollution
2=Point Source Pollution

REMEMBER....

1. ____Runoff from farm land
2. ____Exhaust from cars
3. ____Rainwater from parking lot
4. ____Discharge from factory pipes
5. ____Oil droplets from car engines

Nonpoint Source →

← Point Source

Section III: Critical Thinking

Remembering what you learned about the effects pollution has on the plants and animals in the Presque Isle Bay watershed, describe some action steps you can take to help prevent further pollution of your watershed. What types of changes could you make at home that would help reduce water pollution?

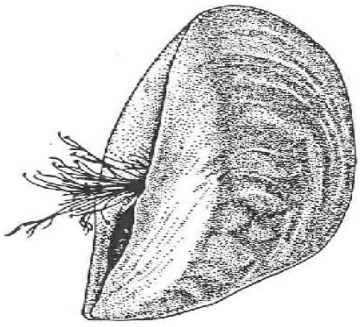
Exotic Species: Zebra Mussels & Round Gobies

GRADE LEVEL/SUBJECT

Grade 7: Ecology/ Environmental Science

TIME

One class period



OVERVIEW

Exotic species are organisms that are introduced into habitats where they are not native. They can have detrimental effects on the ecology of the environment by driving out native species and altering the biodiversity. Without natural predators, they can often displace native species and impact recreation, water quality, pollutant cycling, and habitat. In Presque Isle Bay and Lake Erie, two exotic aquatic species that are having significant impacts on these ecosystems are the zebra mussel and the round goby.

PURPOSE

The purpose of this lesson is to introduce students to invasive species and help them to understand the impacts exotic species have on ecosystems of the Great Lakes and Presque Isle Bay.

OBJECTIVES

At the end of this lesson students will be able to:

- Identify a zebra mussel and a round goby.
- List the environmental impacts exotic species have on ecosystems.
- Identify courses of action that can be taken to prevent the spread of exotics to other waterways.

PENNSYLVANIA ACADEMIC STANDARDS

Science & Technology

- 3.3 Biological Sciences

Environment & Ecology

- 4.1 Watersheds & Wetlands
- 4.6 Ecosystems & their Interactions
- 4.7 Threatened, Endangered & Extinct Species
- 4.8 Humans & the Environment
- 4.9 Environmental Laws & Regulations

RESOURCES/MATERIALS

Aquatic Exotics handout for each student
Figure 1 and 3 copied for each student
Computer with Internet access (optional)
Worksheet for each student

PRIOR KNOWLEDGE

Food web

MOTIVATION

Imagine that aliens from Mars invaded our earth. How would they affect human life as we know it? What would they eat? Where would they live? What if they lived next door to you? Now think of the same situation except in an aquatic habitat like a pond or lake. The aliens can be compared to an exotic species. Exotic species are non-native organisms that invade habitats and disrupt the natural ecological cycles of the habitat. The invasion of an aquatic exotic species is like having a new neighbor coming to live in your neighborhood, except the new neighbor forces you to move ten miles across town so they can have more space. They go to the local market and buy all of the food on the shelves so there is nothing left for anybody else. You are forced to move across town because there is no more food at the store. Eventually other families are forced to move as well, and in the end the only ones left in the neighborhood are the new resident aliens. This is what can happen in an aquatic ecosystem if a non-native species is introduced.

BACKGROUND INFORMATION

What is an exotic species?

Exotic species are non-native organisms that invade habitats and disrupt the natural ecological cycles of the habitat. They are considered a worldwide threat to **biodiversity** and are considered "biological pollutants." Exotic species introduced into new habitats often overrun their new home and crowd out **native species**. With an abundant food supply, and many times a lack of natural predators in their new community, the exotics can grow and expand their numbers very quickly. Once they are established, exotics can rarely be eliminated because their new habitat is favorable for their survival.

So how do these exotics get to where they don't belong? Most of the introductions of exotic species are done by humans. They can be introduced into a habitat intentionally or unintentionally. Those introductions that are intentional sometimes do unexpected damage. However, many of the exotic introductions are accidental. The species can be transported to other areas on animals, vehicles, ships, commercial goods, produce, and even clothing. Some exotic introductions are ecologically harmless and some are even beneficial; but most exotic introductions have a negative effect on our ecosystems. Exotics have been responsible for the extinction of native species, especially those of confined habitats such as islands and landlocked aquatic ecosystems. Aquatic nuisance species of concern in the Great Lakes region are the zebra mussel, round goby, Eurasian ruffe, sea lamprey and spiny waterflea. Two of these commonly found in Lake Erie and Presque Isle Bay are the zebra mussel and round goby.

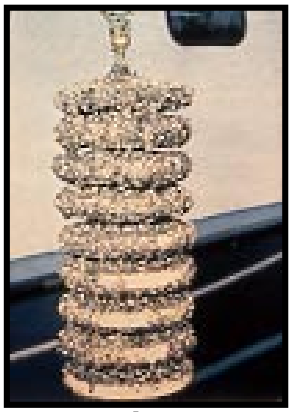
Zebra Mussels

Zebra mussels are small fingernail size freshwater **mollusks** (Figure 1) that live at the bottom of lakes and streams in freshwater and estuarine water habitats. Zebra mussels start to reproduce in Lake Erie once the water temperature reaches 13°C. One female mussel can produce up to 1 million eggs per year. Wow! The eggs are fertilized externally when both eggs and sperm are released into the water. The fertilized eggs develop into free-floating **larvae** called **veligers**. These larvae remain in this planktonic stage for 10 to 15 days and are carried by water currents which enables them to expand their distribution. After the 10 to 15 days of floating around and being carried by the current, the veligers begin to act more mussel-like and move around searching for some place to attach. They attach themselves to surfaces using very tough elastic fibers called **byssal threads** (Figure 2). This is called the settling phase during which the mussels start to form their shells.

Once the mussels begin to grow, they attach to hard substrates and tend to colonize in large clumps by growing on top of one another (see below for example of how fast zebra mussels can colonize).

May 1990

August 1990



September 1990

October 1990

Zebra mussels, like other aquatic organisms need good water quality and an abundant food source (**plankton**) to be successful in colonizing a lake or river. They need certain physical and chemical conditions of the water (pH, temperature, salinity, water velocity) in order to survive. In addition, they need appropriate biological conditions (food sources, lack of predators) to be successful. In the case of zebra mussels, a lack of natural predators has helped them expand their populations.

Zebra mussels are **filter feeders** (at right) and get their food by filtering tiny organisms out of the water. When they feed they remove microscopic aquatic plants (phytoplankton or **algae**) and animals (**zooplankton**) from the water. They have the ability to filter about one liter of water per day. It is believed that the zebra mussel colonies in Lake Erie filter the entire volume of the lake's western basin each week! This filtering increases the

clarity of the water and reduces some forms of **phytoplankton** (by as much as 80 percent). Plankton forms the basis of the lake food web. With increased clarity of the water, sunlight is able to penetrate deeper into the water, which increases the growth of aquatic plants and bottom-dwelling algae as well as some aquatic insects. It also changes the habitat for fish. Some lakes have seen a change in fish species because the increase of aquatic plants changes the habitat preference of the fish living there.

Where did they come from?

Zebra mussels originally inhabited the Caspian Sea (Map 1) and were brought to the Great Lakes region in the **ballast water** of transoceanic ships. Ballast water, taken on in a freshwater European port was discharged into Lake St. Clair, near Detroit, where the mussel was discovered in 1988. Since that time, they have spread rapidly throughout the Great Lakes and the Mississippi River System, as well as into Ontario and Quebec (Figure 1).

Impact

The effect that zebra mussels have on the area they invade can be devastating. The mussels attach themselves to the shells of other freshwater clams (right) using their byssal threads. These threads are very strong and prevents the zebra mussel from being washed away with the current. If enough zebra mussels build up on the clam's shell, the clam is unable to open and close to feed normally and it dies. This has resulted in zebra mussels eliminating most native species of clams in Lake Erie.

The native clams are not the only organisms affected by the zebra mussel. They have also been found to affect crayfish (left), snails and turtles. Since zebra mussels can filter huge volumes of water, and have a high body-fat content they can accumulate about 10 times more contaminants than native mussels. These contaminants can be transferred up the food chain to waterfowl and fish that eat zebra mussels. This can pose a threat to humans if the fish have higher levels of contaminants because of the zebra mussels in the food chain. Zebra mussels have also made impacts on commerce and industry by clogging water intake pipes and disrupting the flow of drinking water supplies in many areas.

Treatments

The most effective treatment used in preventing the zebra mussels from colonizing intake pipes is chlorination. This treatment is approved by the Environmental Protection Agency as a means of controlling the clogging of intake pipes. Poisons have been developed that kill zebra mussels but at this point researchers and scientists are still searching for a way to safely treat the zebra mussels without causing harm to other organisms in the ecosystem. We have tried to remedy the impacts of zebra mussels but most scientists believe that zebra mussels cannot be eliminated, so the goal now is to learn how to live with them.

Relationship to AOC

The zebra mussels that inhabit Presque Isle Bay and Lake Erie have made significant impacts on the ecosystem of the bay and lake. Because of the zebra mussels ability to filter plankton out of the water, they have caused an increase in the clarity of the water. As discussed before, an increase in water clarity can lead to an increase in the growth of rooted aquatic vegetation, and can also raise water temperature. The increase in vegetation can cause problems for boaters in the bay by clogging propellers and can affect fish habitat. Fisheries biologists have noticed changes in fish species because the increase in vegetation favors certain fish species. For example, in Lake St. Clair there has been a change in fish species from walleye and yellow perch to largemouth bass and northern pike.

Round gobies

The round goby (Figure 3) is a bottom-dwelling fish that perches on rocks and other substrates. Gobies have large heads, soft bodies and dorsal fins that lack spines. They can grow up to 10 inches long as adults. They are very aggressive fish, feeding on the eggs of native fish and aggressively defending spawning sites, thereby impacting reproduction of native fish species. The round goby is a multiple spawner (may nest several times a year) and produces from 300-5,000 large eggs per year! The eggs are deposited in nests on the tops or undersides of rocks, logs or cans. The male goby guards the nest. The habitat of the round goby is primarily the rocky, gravel areas nearshore, which can help protect the developing young. The goby's pelvic fin acts like a suction cup, allowing the fish to hold on to substrates when water flow is high.

In Europe, the diet of round goby consists primarily of clams and mussels and large invertebrates. Here in the United States, studies have revealed that the diet of the round goby includes insect larvae, but more interestingly, the zebra mussel. Some natural predators of the round goby include sport fish like smallmouth bass, rock bass, walleye, and yellow perch. Round gobies often are mistaken for sculpin, a native bottom-dwelling fish. The distinguishing feature between the sculpin and goby is the fused pelvic fin (Figure 4). Sculpins and round gobies are similar in coloration; however, round gobies also have a black spot on the dorsal fin (see next page).

Sculpin

Round Goby

Where did they come from?

The round goby originally came from the Black and Caspian Seas (Map 1). It was first discovered in the United States in the St. Clair River in 1990. Like the zebra mussel, they were most likely transported to the U.S. in the ballast water discharged by transoceanic vessels. Because the round goby spawns several times a year, produces numerous eggs, and aggressively protects its habitat, it was able to successfully reproduce and colonize quickly once it was introduced.

Impact

The round goby competes successfully with native fish such as the sculpin. A decrease in native sculpin populations has been reported from areas in which gobies have become established. The goby competes with the sculpin for food and also drives them from their preferred spawning areas. Gobies affect other types of native fish by consuming their eggs and young, which reduces the population of those native fishes. On the positive side, the gobies' diet consists largely of another exotic species: the zebra mussel. The zebra mussel is an important component of the goby's diet and a single goby can consume up to 78 zebra mussels a day! Although this number might seem large, it is unlikely that the goby would have a noticeable impact on the zebra mussel population; however, due to the abundance of zebra mussels, the goby population continues to increase.

Relationship to AOC

Although, the zebra mussel has done much to clear up the water in Presque Isle Bay, the ingestion of contaminants by the zebra mussel while filtering the water has created problems for anglers. Since the round goby primarily feeds on zebra mussels, the contaminants the zebra mussel uptakes while filtering the water builds up in their tissues and gets transferred to the round goby. The fish that consume the round goby such as smallmouth bass, walleye, and perch also ingest the contaminants that the round goby got from the zebra mussel. This is where humans are potentially impacted. We fish for many of the same fish that are eating the round goby. When we consume some of these fish, we could also be consuming some of the contaminants contained in the fish tissues. Fish advisories are currently issued for Presque Isle Bay and Lake Erie to inform anglers on the safe levels of consumption for certain fish. Round gobies may drive these advisories to more restrictive levels.

Control and prevention of exotics

Refer to Figure 1 and Figure 3 for "*How to stop the spread*"

Everybody can make a difference and help stop the spread of exotic species. In 1990 the Nonindigenous Aquatic Nuisance Prevention Act was passed to prevent the introduction of species into the Great Lakes via ballast water and to create a national program to prevent the entry of invasive species. This act was expanded with the Native Invasive Species Act (NISA) of 1996. Action on the local level is essential to prevent the spread of exotics. Exotic species such as zebra mussels can be picked up and transported on equipment, including boats, trailers, motors, tackle, anchors, axles and centerboards. Others species, like round gobies, waterfleas and zebra mussel veligers, can be carried in the water of livewells, bait buckets, motors, bilges, and transom wells. People should be aware that even a small cluster of zebra mussels in a bait bucket could lead to an infestation of an entire waterway. Exotics that are used as bait such as the round goby can also be transported by anglers and bait dealers into other waterways. Proper bait disposal can help reduce the spread of the round goby and zebra mussel. "Stop the Exotics" a video produced by Minnesota Sea Grant, provides an exciting approach to the control and prevention of exotic species and is available for classroom use.

PROCEDURE

1. Begin class by asking students if they have ever heard of the term exotic species before. Motivate them by reading the story about the earth being invaded by aliens from Mars. Following the story, ask the students again if they have an idea what an exotic species is. Ask for their thoughts.
   Hint: Define each word (exotic, species) with the students, and then put them together and see what you get.

2. Handout enclosed Aquatic Exotic Species of the Great Lakes Region sheet. Discuss the different organisms pictured. Why would these be considered exotics? Do they look different than other organisms? Ask for students' thoughts.

3. Discuss what an exotic species is. Refer to Aquatic Exotic Species of the Great Lakes Region sheet. Ask students to look at each organism pictured and think of how they might have been introduced into a new habitat and why.
   Hint: The round goby and ruffe are both fish. Can they swim from one habitat to another?

4. Call attention to the zebra mussel pictured in the handout.

5. Handout Figure 1 and display Figure 2. Begin to discuss the basic characteristics of the zebra mussel life cycle. Review the "how to identify it" section of the handout and discuss other noticeable characteristics that could be used for identifying the zebra mussel. Make a list of any additional characteristics that could be used to identify zebra mussels.

6. Discuss the colonizing capabilities of the zebra mussel and relate it to their reproduction.

7. Review "Where did they come from?" Refer to Map 1 (Caspian Sea) to familiarize the students with where the Caspian Sea is located.

8. Discuss what types of impacts or changes the zebra mussel has made on the ecosystem. Ask how the mussels might affect other organisms.

9. Refer to Aquatic Exotic Species of the Great Lakes Region sheet and bring their attention to the round goby.

10. Handout Figure 3. Begin to discuss the basic characteristics of the round goby. Review the "how to identify it" section of the handout and discuss other noticeable characteristics that could be used for identifying the round goby. Make a list of any additional characteristics that could be used to identify round gobies.

11. Display Figure 4. Point out the differences in pelvic fins between the sculpin and the round goby.

12. Refer to Map 1 and review "Where did they come from?" Point out the Caspian and Black Seas as the native homes of the round goby. Refer to the distribution map on Figure 3 and discuss how the goby might have arrived in the United States.

    Hint: Think about the differences between the zebra mussel and round goby in terms of their mobility. Which one would have an easier time moving around?

13. Discuss the types of impacts or changes the round goby has made on the ecosystem, both positive and negative. Critically think about how the round goby's diet potentially affects humans.

14. Wrap up: Talk with students about how they can become actively involved to prevent the spread of exotic species. Perhaps they or someone in their family likes to fish.They can help by telling them what they learned about the zebra mussel and round goby and how they impact the ecosystem.

15. Pass out student worksheet: Exotic Species.

VOCABULARY

Algae
Ballast water
Biodiversity
Byssal threads
Exotic species
Filter feeder
Larva
Mollusks
Native species
Phytoplankton
Plankton
Veliger
Zooplankton

QUESTIONS/INQUIRY

CLASS DISCUSSION:

- ✓ Why should we be concerned about exotic species? What impacts do they have on ecosystems? How can the transfer of exotic species be controlled or stopped in the Great Lakes?

CREATIVE WRITING:

- ✓ Provide a list of terms that the students can make into a story about a zebra mussel or a round goby making the trip from their original "homeland" to their new habitat.

EXTENSION:

- ✓ Use the Internet to research other geographical areas that have been impacted by zebra mussels or round gobies. What impacts have they had in those communities? What have they done to control them?

ASSESSMENT

- ✓ Students will be assessed on their ability to correctly identify both a zebra mussel and round goby using the distinguishing characteristics provided in the fact sheets.
- ✓ Students will be assessed on the completion and correctness of their worksheet.

GLOSSARY

Algae: A photosynthetic plant-like protist (single-celled eukaryotes).

Ballast water: Water stored in tanks on large ships to help maintain the ships buoyancy and balance.

Biodiversity: Measure of the number of different species and individuals in an ecosystem.

Byssal threads: Tough elastic threads formed from secretions of the byssal gland in the zebra mussel. Zebra mussels use them to attach themselves to rocks, docks, boats and the shells of other animals.

Exotic species: Organisms that are introduced into habitats in which they are normally not found.

Filter feeder: Organisms that filter the water using specialized organs such as gills to trap fine food particles for feeding.

Larvae: A free-living, sexually immature form in some animal life cycles that may differ from the adult in morphology, nutrition, and habitat.

Mollusks: (Phylum Mollusca) Examples include snails, slugs, oysters, clams, octopuses and squids. Mollusks are soft-bodied animals, but most are protected by a hard shell made of calcium carbonate. Zebra mussels are bivalves that are characterized by having shells divided into to halves that protect their soft-bodied insides.

Native species: Organisms that are residents in a habitat or naturally occur there.

Phytoplankton: Plants of the group plankton.

Plankton: The floating or weakly swimming organisms found in aquatic habitats.

Veliger: Larval stage of the zebra mussel.

Zooplankton: The animals of the group: plankton.

REFERENCES

- ✓ Minnesota Sea Grant. A Field Guide to Aquatic Exotic Plants and Animals http://www.d.umn.edu/seagr/areas/exotic/x9.html
- ✓ Griffiths R., Kovalak W., Schloesser S. The Zebra Mussel, Dreissena Polymorpha, In North America: Impact on Raw Water Users.
- ✓ Ohio Sea Grant College Program Fact Sheet; Zebra Mussels in North America: *The invasion and its implications*. 1997.

Aquatic Exotic Species of Concern in the Great Lakes Region

Zebra mussel

Round goby

Eurasian ruffe

Sea lamprey

Spiny waterflea

Map 1: Caspian Sea

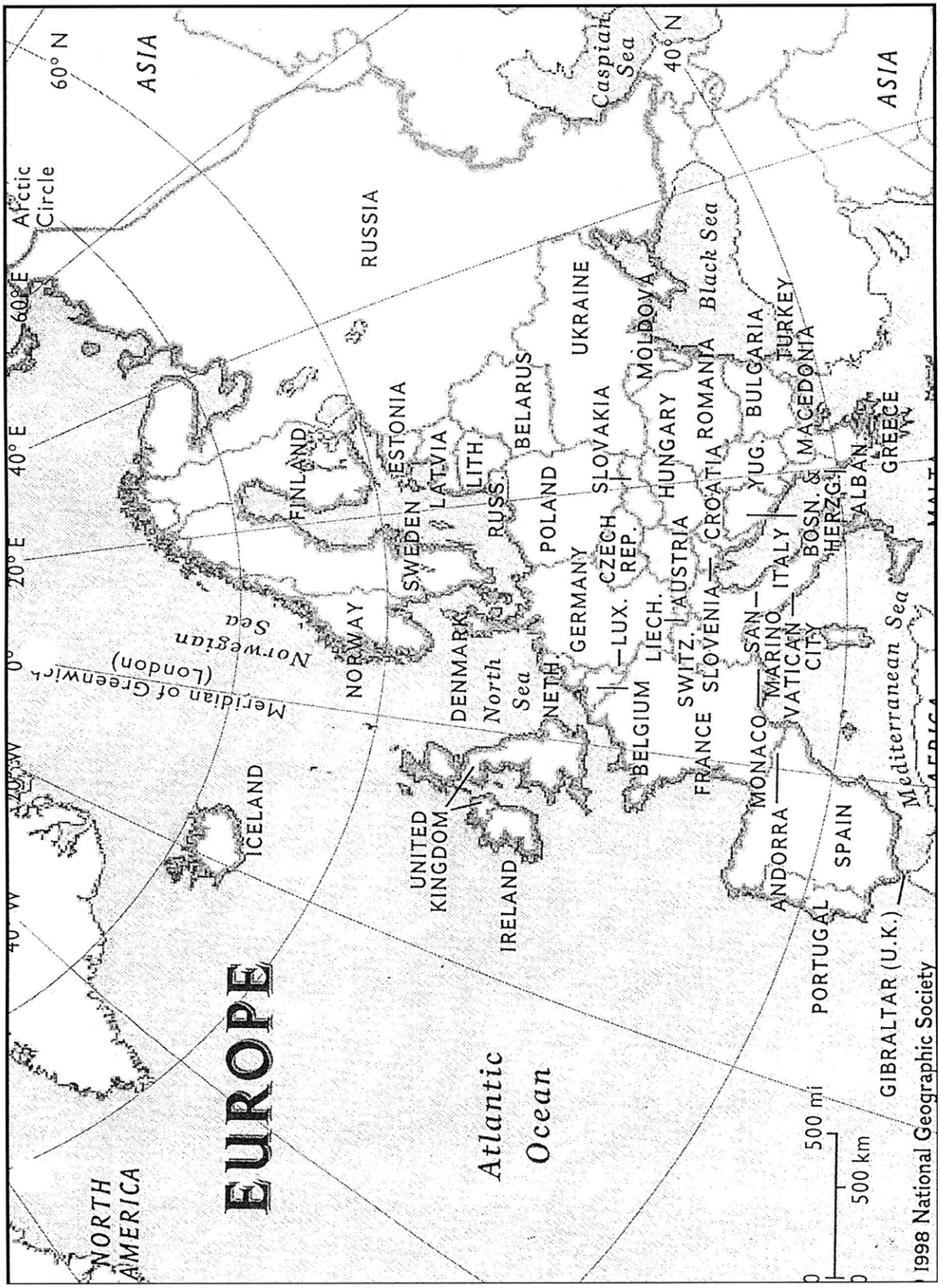


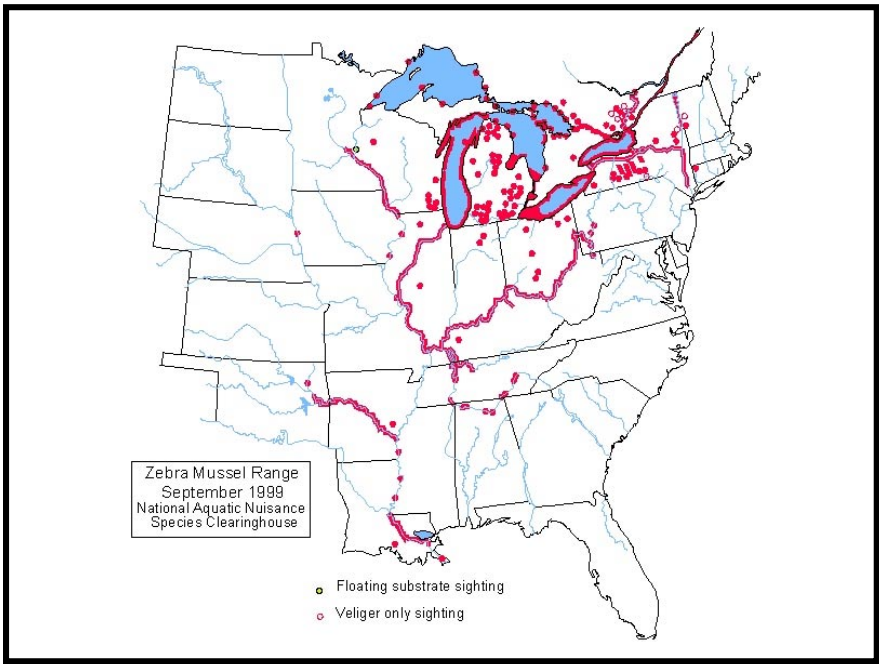
Figure 1: Zebra Mussel Facts

How to identify it:

- ✓ Look for a yellowish or brownish "D" shaped shell with dark and light colored stripes
- ✓ Average size is 1 inch, but can be as large as 2 inches
- ✓ Grow in clusters in shallow (6-30 feet) algae-rich water

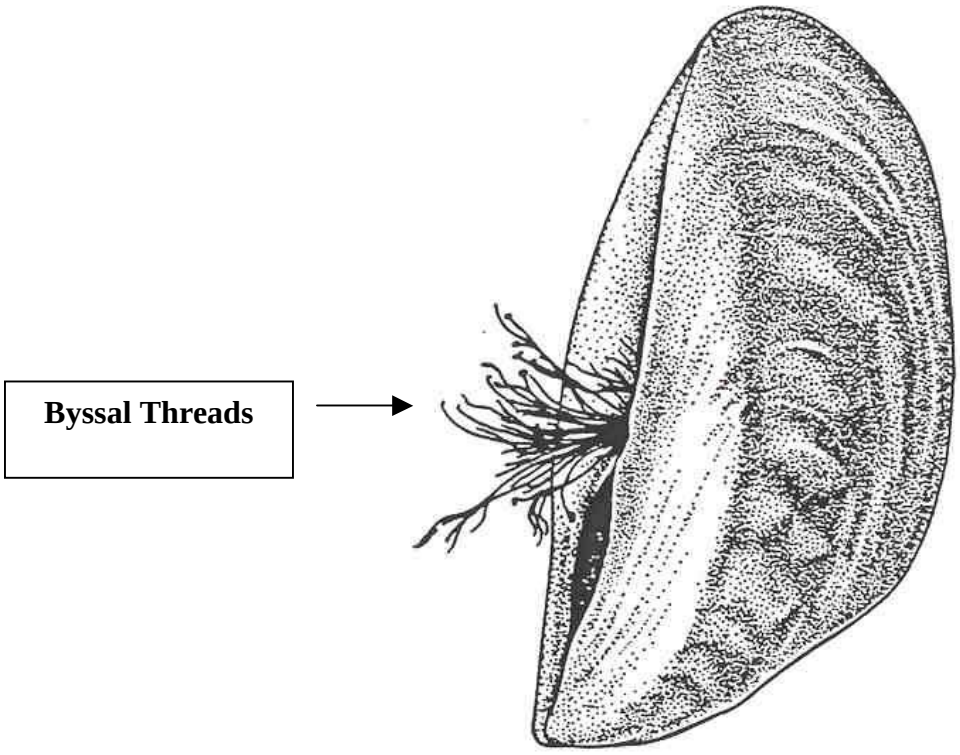
How to stop the spread:

- ✓ Inspect boat, trailer and equipment and remove any zebra mussels
- ✓ Empty bait bucket on land. Do not release live bait into a waterway
- ✓ Learn what zebra mussels look like, and know which waterways are infested



Zebra mussel range September 1999

Figure 2: Adult Zebra Mussel



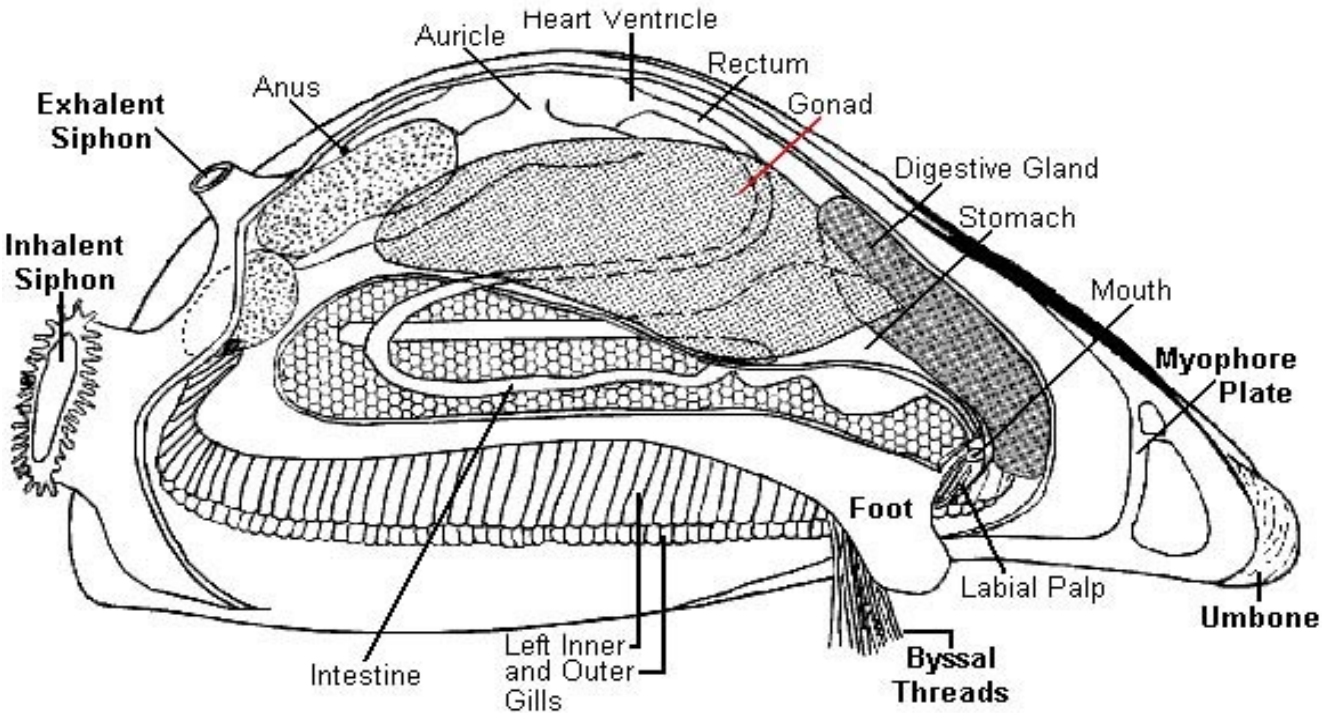


Figure 3:Round Goby Facts

How to Identify It:

- ✓ Dark blotch on dorsal fin
- ✓ Fused pelvic fins
- ✓ Frog-like raised eyes
- ✓ Thick lips
- ✓ Body mostly slate gray in color mottled with black to brown spots

How to Stop the Spread:

- ✓ Learn to identify the round goby
- ✓ Always drain water from boat before leaving any waterway
- ✓ Never dump live fish from one body of water into another
- ✓ Always dispose of unwanted bait on land

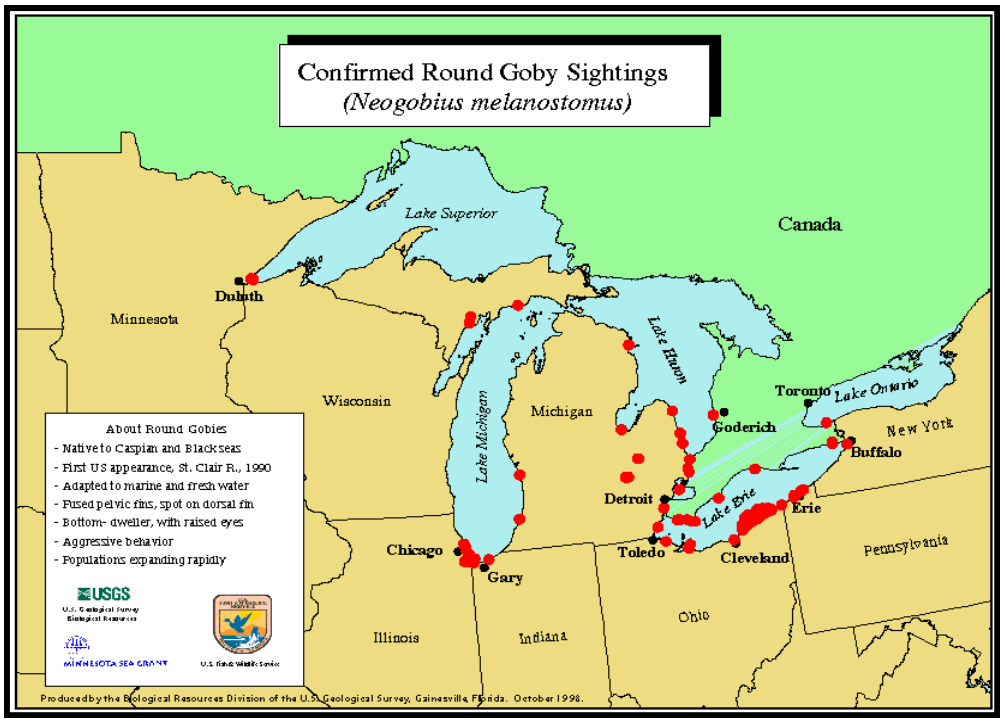
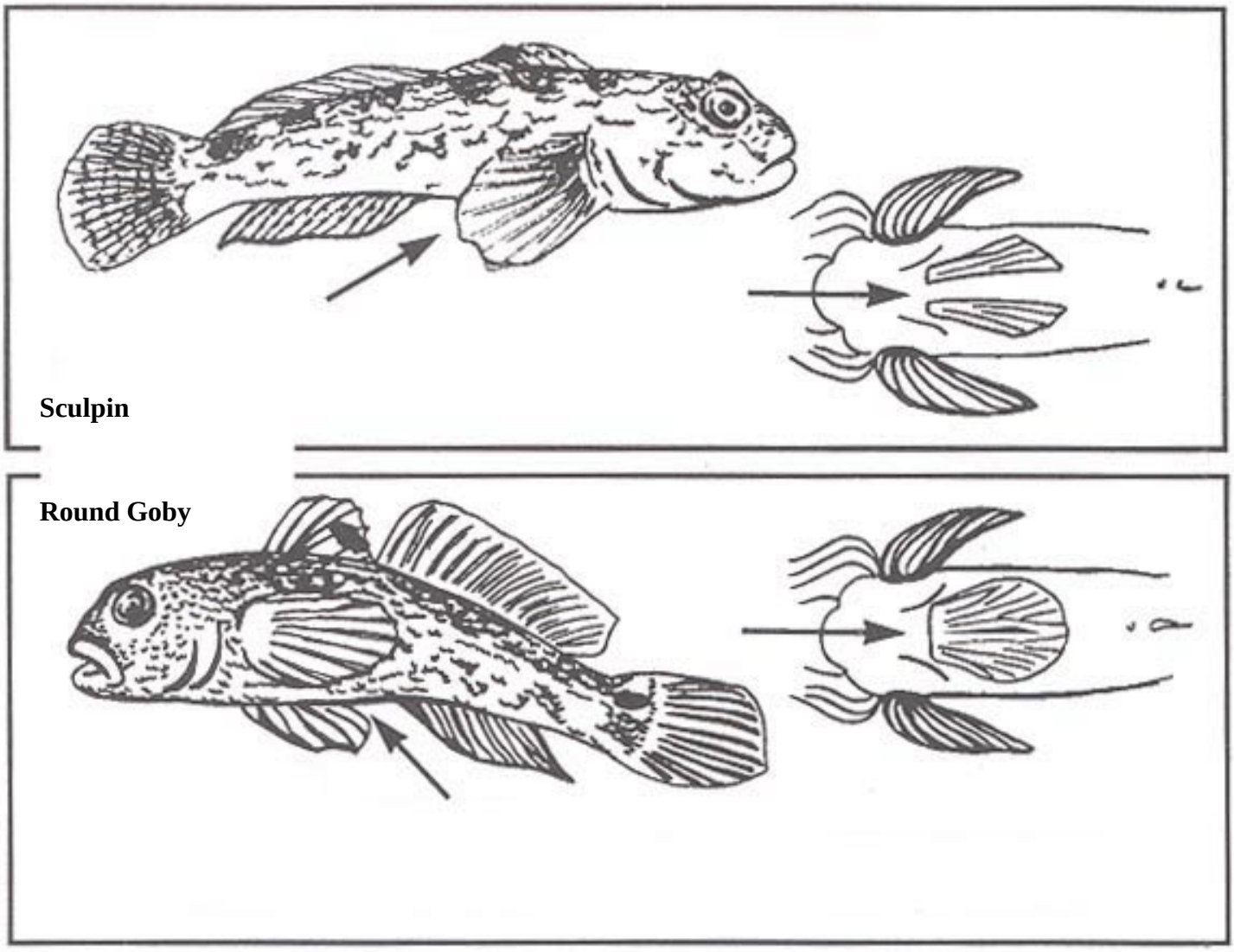


Figure 4: Round Goby and Sculpin



Sculpin

Round Goby

Exotic Species

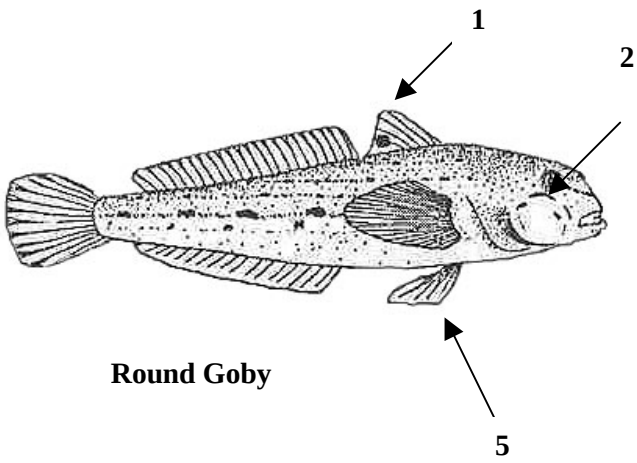
Name:_____ **Date:**_____**Class:** _____

Section I: Completion

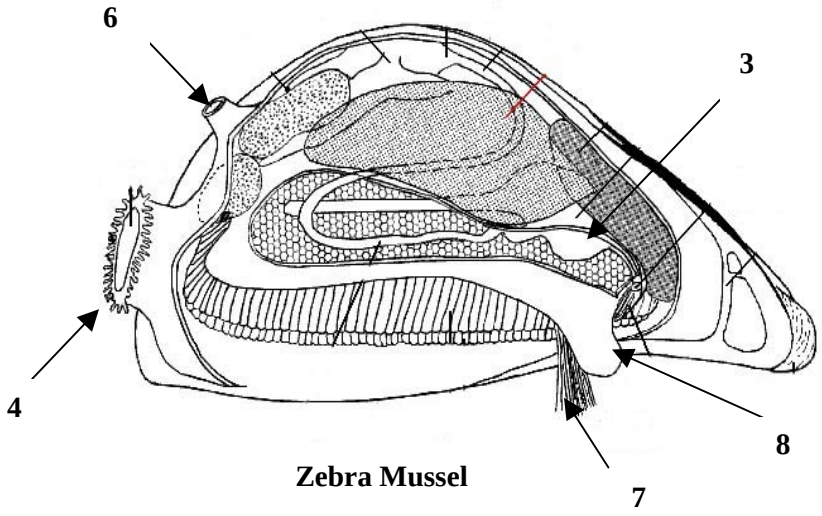
Non-native *Ballast* *Round gobies* *Zooplankton* *Native*
Sculpins *Filter feeders* *Biodiversity* *Byssal threads*

1. Exotic species are species that are_____ to their new environment.
2. Zebra mussels and round gobies came to the United States from the Caspian Sea through the _____ water of oceanic ships.
3. Zebra mussels are _____ and can filter up to 1 liter of water per day!
4. Using their _____, zebra mussels are able to firmly attach themselves to solid surfaces as well as other organisms like crayfish.
5. _____ have a fused pelvic fin, _____ do not.

Section II. Label Me!



Round Goby



Zebra Mussel

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____

Word Bank:

Byssal threads *Pelvic fin*
Mouth *Larvae*
Foot *Eye*
Exhalent siphon *Stomach*
Dorsal fin *Inhalent siphon*

Section III: Critical Thinking

Remembering what you learned about exotic species, what do you think you could do to prevent other exotic species from entering your watershed?

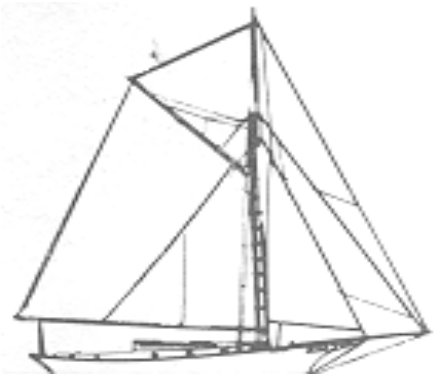
Friendship Sloop *Momentum*

GRADE LEVEL/SUBJECT

Grade 7: History/Physical Science

TIME

One class period



OVERVIEW

The ***Environmental Rediscoveries*** program creates a unique learning opportunity for area students aboard the 42-foot, traditionally rigged Friendship Sloop *Momentum*. To enhance this experience, this lesson provides historic background about the Friendship Sloop and the nomenclature associated with sailing a traditional vessel. This lesson will provide students with the knowledge and confidence to participate as members of the crew and create a memorable learning experience.

PURPOSE

The purpose of this lesson is to introduce students to the history and general nomenclature that is associated with boats and with sailing, specifically the Friendship Sloop *Momentum*. This lesson will also serve to prepare the students for their participation as part of the crew of *Momentum*.

OBJECTIVES

At the end of this lesson students will:

- Be familiar with general nomenclature associated with boats, sailing and the Friendship Sloop *Momentum* in particular.
- Understand how a sailboat sails.
- Demonstrate their knowledge of the general responsibilities of a crew member.

PENNSYLVANIA ACADEMIC STANDARDS

Science & Technology

- 3.4 Physical Science, Chemistry & Physics
- 3.5 Earth Sciences
- 3.6 Technology

RESOURCES/MATERIALS

Figures
Need a Lift? handout
Worksheet for each student

MOTIVATION

How many students have seen the US Brig Niagara? How would you describe Niagara? What type of power does the Niagara use? Has anyone ever gone sailing? Describe your experiences to your classmates. Has anyone ever flown in an airplane? Can you guess how flying and sailing are similar?

BACKGROUND INFORMATION

History

The Friendship Sloop *Momentum* was built in 1964 in Friendship, Maine. She is a re-creation of the traditional working vessel that once populated the coast of Maine. In fact, that is how the boat got her name; so many of these vessels were built in Friendship, Maine that it seemed logical to name them, Friendship Sloops. The fishermen and lobstermen along the Maine coast would use these sturdy boats to long-line for herring and cod, to set and haul lobster traps, and even for sword fishing. The Friendship Sloop has five sails and is a very versatile sailor in almost any weather. The men working onboard would often "let the boat sail herself" as they fished and tended their traps.

Momentum is certified to carry passengers on sightseeing trips around Presque Isle Bay. She is 42 feet long overall (that's counting the bowsprit) and weighs 18,000 pounds. Our captain is one of the youngest female captains on the Great Lakes and should prove to you that it's not just boys who can sail boats. There are many parts to *Momentum* and it is helpful to have knowledge of the nomenclature of the boat before attempting to sail it. Some basic terms that are essential to boat orientation are **bow, stern, port,** and **starboard.** Other general words to become familiar with are included on Figure 2.

What makes a boat move?

We now know a little about the history of our boat and what the parts of the boat are, but how does the boat actually move? The answer: wind.
For further explanation refer to handout: Need a Lift?

How do we get there?

Once we know the parts of the boat and how a boat actually sails, how do we get where we want to go? We can't just let the wind carry us along in any direction it feels like. We should be able to manipulate our direction according to where we want to go and where the wind is. As soon as the lines are released from the dock, the boat comes under the influence of one dominating force: the wind. The wind governs everything that happens to the boat, including the direction we sail and how fast we go. Wind is unpredictable and invisible, so learning how to find and feel the wind are important for sailing. The position of the boat relative to the wind will determine the course it sails and these courses are known as the **points of sailing** (Figure 3). Depending on where the wind is there will be different positions of the boat relative to it.

Once we know how to position the boat with the wind, we need to have a plan on how we are going to reach our destination. Navigation, or the practice or process of plotting a course can be helped with a number of aids such as navigational charts, compasses or a global positioning system (GPS) unit. The navigational chart represents the earth's surface on paper. Charts will have symbols, pictures and abbreviations to help the sailor

navigate the waters. The compass indicates the north direction and uses degrees to indicate location. The GPS unit is a more advanced technology that can be used to indicate direction and your position in space. GPS systems operate on a 21-satellite system that are placed around the world. The on-board satellite navigator picks up signals from the satellites and translates them to give read outs of the position of your boat in longitude and latitude.

Commands aboard the Friendship Sloop Momentum

Now that we have learned the basics about what makes a boat go and how to navigate we need to know how we can work together with the crew and successfully sail to our destination. In order to provide a safe and fun voyage, you as members of the crew must treat your ship, your crewmates, and your captain with the utmost respect. The very first thing to do is to put on your personal flotation device (PFD). No one will be allowed on the boat without a PFD. No excuses, no exceptions. Put them on and leave them on for the duration of your voyage.

Participants will serve as crew during the ***Environmental Rediscoveries*** program.

Following is a list of the terms and commands that you will hear while aboard the Friendship Sloop *Momentum.* Each student will become part of the crew while aboard and should have some knowledge of these commands:

- **"Prepare to cast off (name of dock line)"**
  "Prepare to cast off dock line"

  Your response should always be to repeat the order *as you are performing the task.*

- **"Cast off dock line"**
  "Casting off dock line"
- **"Stow fenders"**
  Fenders are the large bumpers on the side of the boat that protect the hull from damage on the dock.
- **"Prepare to raise the mainsail"**
  We will seek volunteers for this task before we leave the dock. There will be one volunteer on the **peak halyard** and one volunteer on the **throat halyard**. *Momentum's* captain will ascertain the abilities of the volunteers and may designate helpers or crew to assist. The boat will then be steered into the wind. With the wind on both sides of the sail and the sail luffing (flapping in the breeze) it is much easier to raise. If the sail were drawing (full of wind) it would be practicably impossible to raise.
- **"Ready on the throat?"**
  "Ready on the throat."
- **"Ready on the peak?"**
  "Ready on the peak."

- **"Raise away"**
  "Raise away."

- **"Hold the peak"**
  "Hold the peak."

  (stop raising the throat halyard)

- **"Hold the throat"**
  (stop raising the throat halyard)
- **"Make it off** or **make it fast"**
  This means to tie off the halyard on one of the cleats on the side of the mast. *Momentum* crew will assist your students at this point.
  The other sails are raised in similar fashion and will be at the captain's discretion.

- **"Ready to come about?"**
  Coming about is changing direction with the **bow** of the boat passing through the **eye of the wind.** As the boat prepares to turn, crew may prepare to cast off the appropriate **sheets** and haul in on the new **sheets.** Sheets will be prepared to be released on the **leeward** side of the boat (as the boat turns the present leeward side will become the new windward side and vice versa).

PROCEDURE

1. Display Figure 1. Discuss the history of the Friendship Sloop *Momentum*.

2. Handout Figure 2 to each student for them to review.

3. Discuss: **What makes a boat go?** Handout out "Need a Lift?" sheet to each student and review with them.

4. Okay, you can see wind as it acts to change the shape of the sail, but if the sail weren't there how would you know where the wind is? Let's find out.
   Optional Activity: **What is Wind?**

5. How does a sailor get from one place to another? One technique is to use the points of sailing. Discuss with students "How do we get there?" Display Figure 3.

6. Review the different types of navigational aids that are available to assist the sailor in plotting their course and reaching their destination.

   Navigation Activity: Pass out a piece of paper to each student. Have each of them draw a course they would take to get from their classroom to the lunchroom in their school. Make sure

7. Review some of the commands that will be heard aboard the Friendship Sloop *Momentum*.
   Activity: Let me hear you! This activity is a good way to practice the commands you will hear while aboard *Momentum*. Break students into several teams of 5 or 6. Each team will work together in this activity. You choose a command and say it to the class. Each team should discuss the command and then respond with the correct response and explanation of the command. The first team with the correct response will earn points. Incorrect responses will result in a loss of

points. (*Why? It is important to have the correct response to a command while aboard a ship. If a command is misinterpreted and the wrong action is taken, it could result in disaster for the ship and crew)*. The team with the most points at the end wins.

8. Pass out worksheet: Get some *Momentum!*

VOCABULARY

Boom
Bow
Bowsprit
Eye of the Wind
Gaff
Halyards
Jib
Jib Sheets
Jib Topsail
Mainsail
Mainsheet
Mast
Peak Halyard
Port
Sheets
Starboard
Staysail
Stern
Throat Halyard
Topsail
Windward
Leeward

ASSESSMENT

- ✓ Students will be assessed on their completion of the navigation activity.
- ✓ Students will be assessed for their participation in the Let me Hear You! activity.
- ✓ Students will be assessed for the completion and correctness of their worksheet.

GLOSSARY

Boom: Horizontal pole (spar) attached to mast; the *foot* of the *mainsail* is attached to the boom.

Bow: The front of the boat.

Bowsprit: Pole (spar) attached to the front of the boat.

Eye of the wind: Facing directly into the wind.

Gaff: Pole (spar) to which the *head* of the *mainsail* is attached.

Halyards: Lines (look like ropes) that are used to raise and lower the sails.

Jib: Small, triangular sail flown low from the bowsprit of the boat and controlled by *jib sheets.*

Jib sheets: Lines (look like ropes) used to control the jibs.

Jib topsail (top'sul): Small triangular sail flown above the jib.

Mainsail: Sail attached to the mast, boom and gaff, the largest sail on *Momentum.*
The mainsail is controlled by the *mainsheet*.

Mainsheet: Large block and tackle (series of pulleys) used to control the mainsail.

Mast: Large, vertical pole (spar) supported by *stays.*

Peak halyard: The halyard the raises and lowers the back section of the gaff corner of the mainsail connected to the gaff.

Port: The left side of the boat.

Sheets: Lines (look like ropes) that are used to control the sails by pulling them in or letting them out.

Starboard: The right side of the boat.

Staysail (stay'sul): Larger triangular sail flown forward of the mast from the staysail boom controlled by staysail sheets. Also known as a jumbo.

Stern: The back of the boat.

Throat halyard: The halyard that raises the forward section of the gaff, which rides on the mast.

Topsail (top'sul): Small sail flown from the *topmast,* above the mainsail.

Windward: The side of the boat that the wind hits first.

Leeward (loo'ward): The side of the boat not receiving the wind.

This combination creates a narrow channel through which the initial volume of air must pass and which is influenced by the Venturi effect! And we know that air is essentially (for our purposes) incompressible. So, in order to get the same volume of air through this narrow channel, it speeds up! And Venturi switches to Bernoulli:

Bernoulli's Principle:

An increase in airflow velocity relative to the surrounding free air stream causes a decrease in pressure where the faster flow occurs. This phenomenon literally creates a low-pressure suction field on the outer curved surface of our airfoil. What do we know about airflows? They are attracted to low pressure. Thus the new air approaching is attracted to the low-pressure area and an even greater mass of air must make its way through that same narrow channel. The result is an even greater decrease in pressure attracting more new air, creating a greater decrease in pressure…you get the picture? This low-pressure area is the greatest aerodynamic force acting on our airfoil.

What's happening on the other side of our airfoil?

Who can predict? Who is the wise guy who said, "The opposite?" Well, you're right Mr./Ms. Smarty-pants. As more air is attracted to and flows over the convex surface, less air is flowing over the concave section. There is no narrow channel so the airflow expands and slows down creating a high-pressure area. (This can be explained by examining the airflow on the outside of a Venturi Tube.)

MAKE IT MAKE SENSE

On the lee side of the sail the airflow is traveling faster (Venturi) and creating low pressure (Bernoulli) thus attracting more air and creating lower pressure, which actually creates a strong negative pressure or suction effect known as lift! A similar phenomenon is happening underwater on the keel of our boat. So Bottom Line Me: When we are sailing we are creating lift. We are not being pushed by the wind, but creating a perfect airfoil shape to pull us where we are going. And you thought it was just going to be a sunny cruise on Presque Isle Bay.

What is Wind?

Background

Wind is a result of air movement around the earth. Winds are part of a global air circulation system moving light, warm air towards the poles and heavy, cold air towards the equator. **High-pressure** areas represent heavy sinking cold air and **low-pressure** areas represent light rising warm air. Winds are caused by air trying to move from the areas of high pressure to the areas of low pressure (similar to what we learned in the "Need a Lift" lesson). The greater the difference in pressure the greater the wind velocity. There are several semi-permanent wind patterns around the globe. In the low latitudes (between the equator and 30° north and south) the earth receives much of the sun's heat. In the high latitudes and around the poles the earth receives very little of the sun's energy. The great temperature contrasts create complex air motions and form bands of high and low pressure. It is these bands that create the earth's wind patterns. Air is moving from the poles and flowing back to the low pressure areas around the equator. These winds are known as **trade winds**. The earth's rotation bends these winds. Instead of moving directly north and south, the winds in the northern hemisphere bend to the right while the winds in the southern hemisphere bend to the left. Therefore the winds moving towards the poles become **westerlies** and the winds moving toward the equator become **easterlies**.

Our local weather and wind patterns are influenced in much the same way. The difference in temperature between the land and that of Lake Erie create the same movement of air as we see on a global scale. Air rises as it is heated up over the land. As it rises, it is replaced by cooler air from the lake. This is known as a **sea breeze** or **lake breeze**. In the evening as the land cools, the opposite occurs. The warm air over the water rises and is replaced by the cooler air from the land. This is known as an **offshore breeze**.

Activity

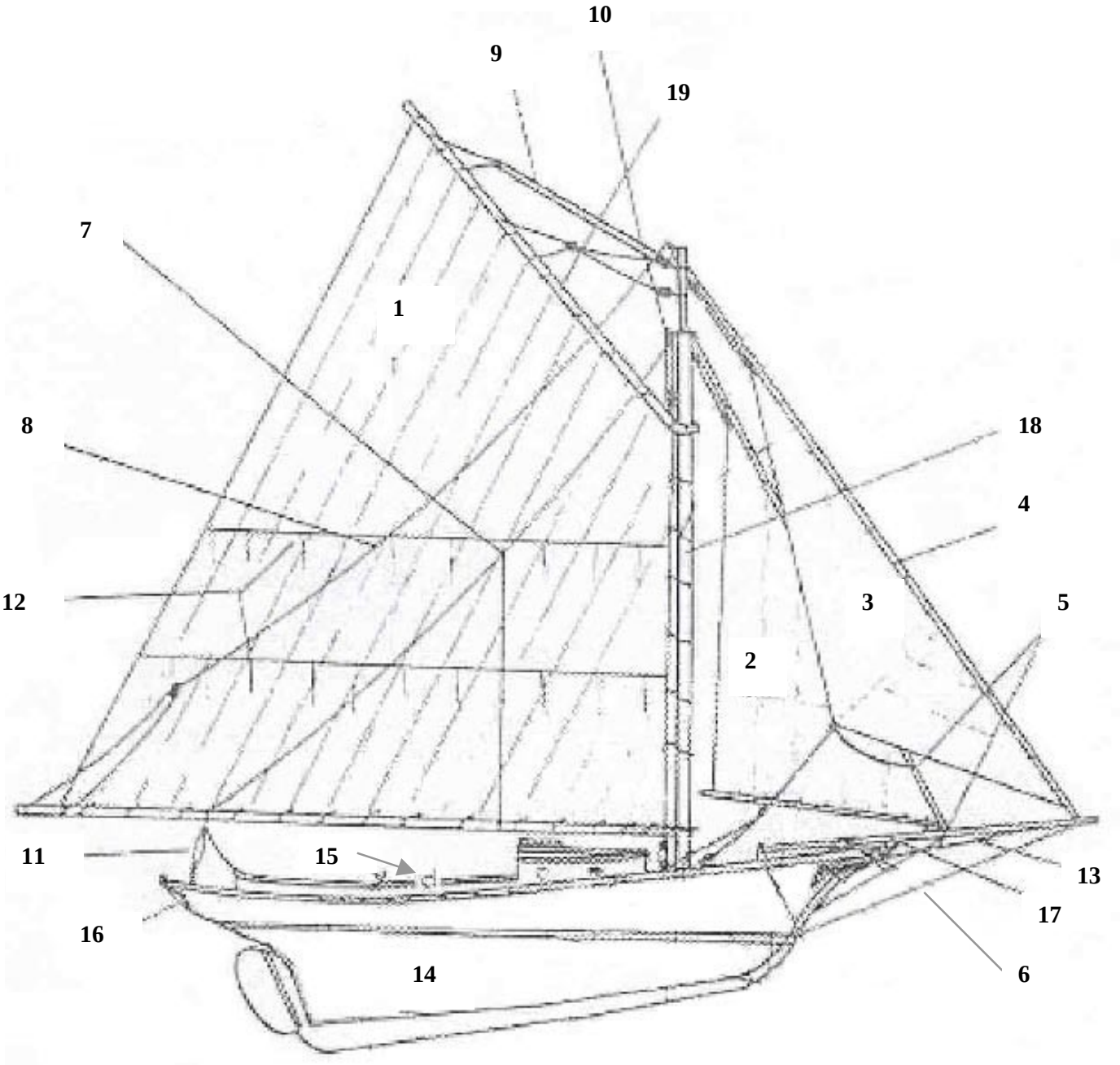
The best activity to prepare your students for sailing aboard the Friendship Sloop *Momentum* is to encourage them to "feel", characterize and categorize the wind using the Beaufort Scale (see below). Take your students outside and encourage them to feel the breeze on their face. Have them look for clues as to what direction and strength the wind is blowing. Smoke from smokestacks can be a good indicator of wind direction and velocity. The leaves and branches of trees can be good wind strength indicators. This would be the ideal time to introduce your students to the points of the compass. Students can chart and graph their observations. Students can also visit the BCMS website www.goerie.com/bcms and view live weather conditions from the bayfront. Click on "The Weather Right Now" and follow the prompts. This is a great opportunity to compare and contrast the weather along the waterfront with that at your school.

The Beaufort Scale

The Beaufort Scale (Figure 4) is a system for estimating wind strengths without the use of instruments, based on the effects wind has on the physical environment. The behavior of smoke, waves, trees, etc., is rated on a 13-point scale of 0 (calm) to 12 (hurricane). The scale was devised in 1805 by the British naval Commander, later Admiral Sir Francis Beaufort (1774-1875). A further set of numbers (13-17) for very strong winds were added by the US Weather Bureau in 1955. Check out www.stormfax.com/beaufort.htm for some excellent graphics that will help your students interpret their observations.

Figure 1: Friendship Sloop *Momentum*

Figure 2: Friendship Sloop Nomenclature



1. Mainsail
2. Staysail
3. Jib
4. Headstay
5. Forestay
6. Bobstay
7. Lazy Jacks
8. Topping Lift
9. Peak Halyard
10. Throat Halyard
11. Main Sheet
12. Reef Points
13. Bowsprit Shrouds
14. Hull
15. Cockpit
16. Elliptical Transom
17. Bowsprit
18. Mast
19. Gaff

Figure 3: Points of Sailing

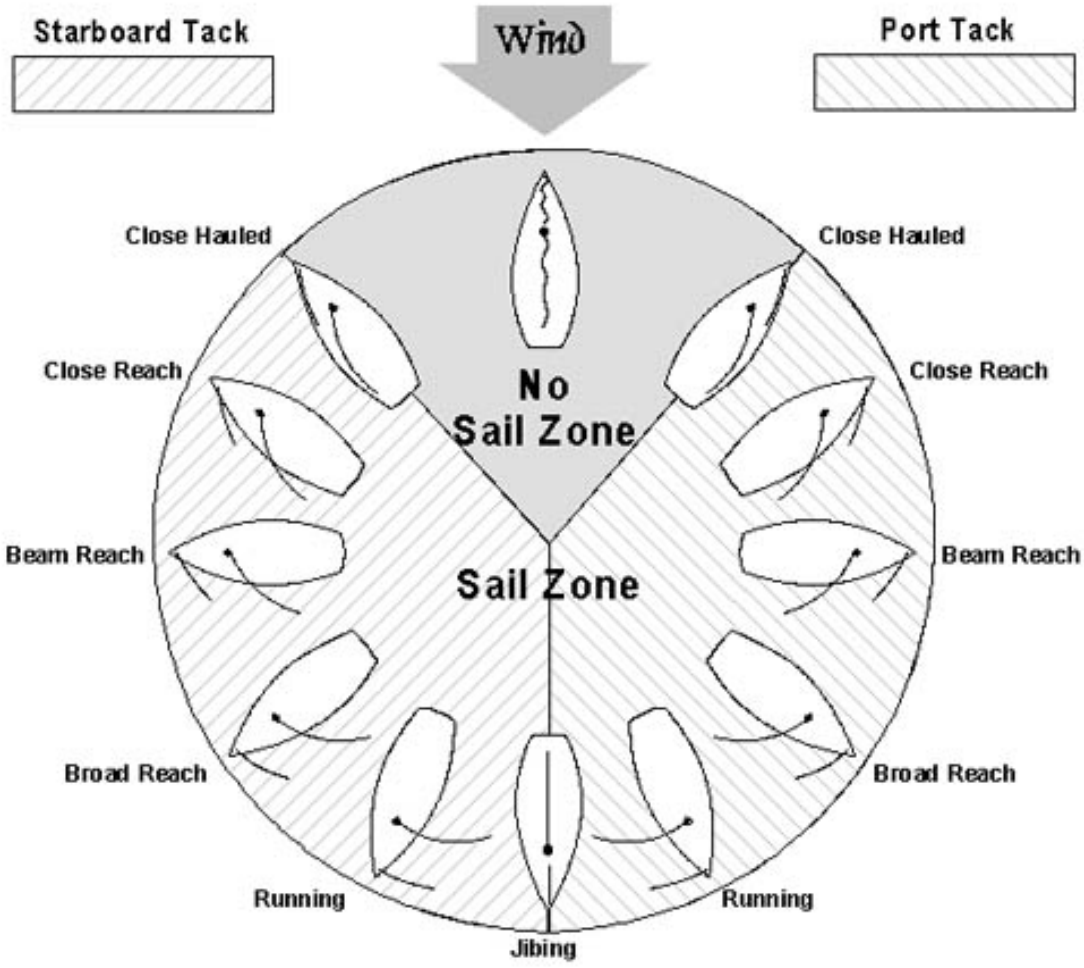


Figure 4: Beaufort Scale

Beaufort Scale	Wind Speed	Land Signs	Sailing
0	Calm less than 1 knot	Smoke rises vertically	Bobbing, boat does not make headway
1	1-3 knots	Smoke will drift	Ripples or "cat's paws" appear on water
2	4-6 knots	Wind felt on face, small leaves rustle	Sails fill small wavelets appear
3	7-10 knots	Leaves and small branches move, wind extends small flags	Sail boats will heal slightly as they make way
4	11-16 knots	Raises dust and loose paper, leaves and branches constantly in action	Good working breeze for *Momentum*
5	17-21 knots	Small trees will sway	Leeward rail may be in the water, may reduce sail area
6	22-27 knots	Large trees sway whistling heard in wires and rigging	Large waves form, sailing is very wet from spray, reduce sail area
7	28-33 knots	Difficulty felt when walking towards the wind	Large waves form and break, foam is blown along the direction of the wind, too much breeze to work on the water
8	34-40 knots	Great difficulty felt when walking	Moderately high waves of greater length; edges crests begin to break into spindrift; the foam is blown in well-marked streaks along the direction of the wind
9	41-47 knots	Slight structural damage occurs (chimney post and slates removed)	High waves; dense streaks of foam along the direction of wind; crests of waves begin to topple, tumble and roll over; spray may affect visibility
10	48-55 knots	Seldom experienced inland; trees uprooted; considerable structural damage occurs	Very high waves with long overhanging crests; resulting foam in great patches is blown in dense white streaks along the direction of the wind; on the whole, the surface of the sea takes a white appearance; tumbling of the sea becomes heavy and shock-like; visibility affected
11	56-63 knots	Very rarely experienced; accompanied by widespread damage	Exceptionally high waves (small and medium size ships might be for a time lost from view behind waves); sea is completely covered with long white patches of foam lying along the direction of wind; everywhere the edges are blown into froth; visibility affected
12	64 knots and greater	Very rarely experienced; accompanied by widespread damage	The air is filled with foam and spray; sea completely white with driving spray; visibility very seriously affected

Get some Momentum!

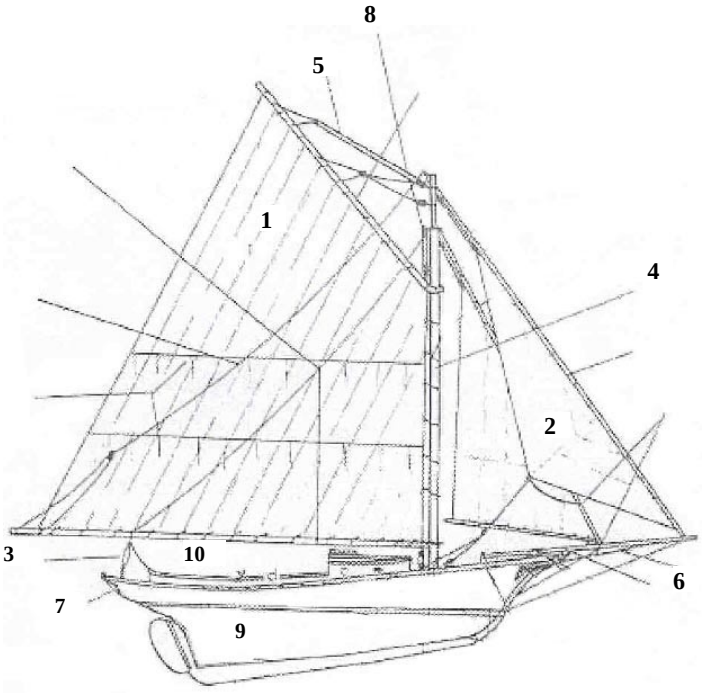
Name:_____ **Date**:_____ **Class**: _____

Section I: Completion

Friendship *Compass* *Fishing* *"Hold the peak"* *Mainsail* *"Raise away"*
Momentum *Personal flotation device*

1. The Friendship Sloop_____ has five sails and weighs over 18,000 lbs!
2. So many sloops were built in _____Maine, that it seemed logical to name them Friend ship Sloops.
3. Navigation is an important skill for sailors to learn. One type of navigational tool they can use is t the _____.
4. Everyone must wear a PFD or a _____ while they are sailing aboard *Momentum*.
5. If you hear a crew member call out: "Raise away" you would say: _____.

Section II. Label Big Mo!



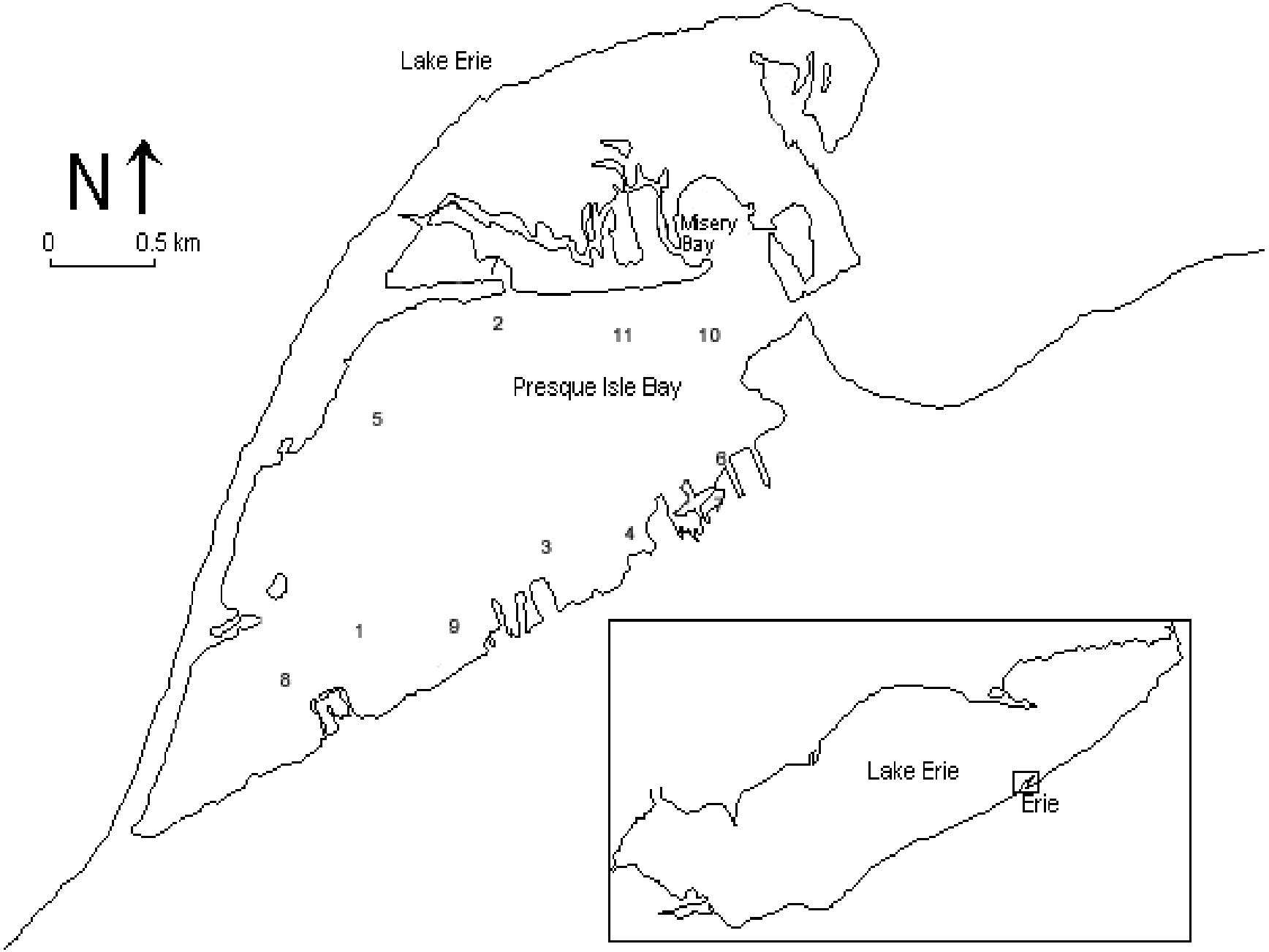
Word Bank

Bow *Cockpit*
Peak Haylard *Stern*
Mainsail *Hull*
Trailboard *Throat Halyard*
Jib *Transom*
Mast *Main Sheet*

1. _____ 2. _____ 3. _____ 4. _____
5. _____ 6. _____ 7. _____ 8. _____
9. _____ 10. _____

Section III: Critical Thinking

Remembering what you learned about the wind and navigation techniques, if you were out sailing on Lake Erie and suddenly realized that you were lost, describe how you would find your way home.


N
0
0.5 km
Lake Erie
Misery Bay
Presque Isle Bay
2
11
10
5
6
4
3
1
9
8
Lake Erie
Erie

Benthos Sampling Procedure: *Look What We Found!*

INTRODUCTION

The following procedure is a step-by-step description of the sampling process that will be carried out while on board the Friendship Sloop *Momentum*. One sample of the benthos will be collected from a specified site on Presque Isle Bay and brought back to shore to be analyzed by the students. Benthos are the organisms that inhabit the bottom substrate of lakes, ponds, and streams. Many benthic insect larval forms are a major food source for small fishes. Before you begin, there are a few things you will need to know. Please read.

THE PONAR DREDGE

We will be using a Ponar dredge that is mounted to the boom. A Ponar dredge (at right) allows the user to collect samples from the bottom (or benthic) layer of sediment in a body of water. The jaws of the dredge consist of a spring-loaded trigger mechanism that will close when the dredge hits the bottom, thereby collecting the samples. The dredge is then pulled back to the surface and the contents emptied into a plastic container.

Safety Note: It should be noted that this dredge has a trigger mechanism that can catch loose clothing, fingers or any other body part if it happens to get in the way.

THE DREDGING TEAM

1. One sample will be taken from the designated site.
2. Students will be assigned to control the lowering and raising of dredge and empty the samples into the container. Students will help hold the line as it raised and lowered. Students may rotate positions throughout the process.
3. Preparing the dredge:
    a. Once the dredge is properly secured, the dredge is lowered into the water.
4. Lowering the dredge:
    a. The dredge should be lowered slowly and consistently.
    b. Once the dredge hits the bottom, the lines should be given some slack to allow the dredge to close.
    c. At this time, the students who are monitoring the line should begin to raise the dredge.
5. Raising the dredge:
    a. As the dredge is being raised, it is important that it is lifted slowly and consistently to prevent the loss of any sample.
    b. Once the dredge is at the surface it should IMMEDIATELY be positioned directly above the plastic container on the deck and the contents emptied.
    Note: To prevent losing some of the smaller organisms it is important that the dredge remain out of the water for as little time as possible.
6. Emptying the Samples
    a. Once the dredge is over the plastic container, the contents should be emptied directly into the container.
    b. Once the dredge is emptied, the dredge should be cleaned and stored properly.

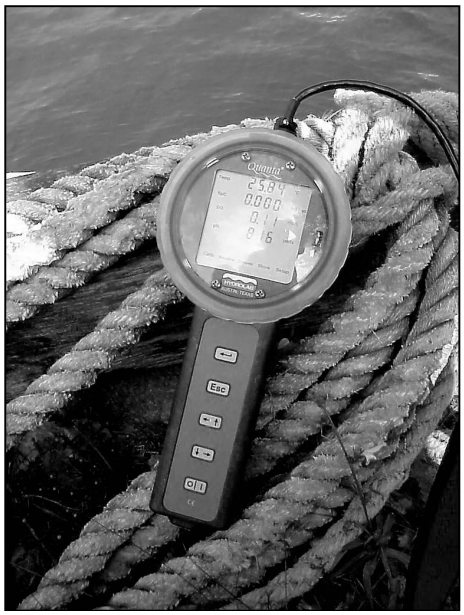
Hydrolab® Sampling Procedure

INTRODUCTION

Students will use a Hydrolab unit to assess water quality parameters while aboard the Friendship Sloop *Momentum*. They will learn how to operate the Hydrolab. as well as learn about how each parameter relates to the health of the water in Presque Isle Bay. The parameters being recorded are: temperature, pH, dissolved oxygen and conductivity. Each student will have the opportunity to use the Hydrolab and record the data collected.

THE HYDROLAB UNIT

The Hydrolab is an electronic instrument that is used in monitoring water quality. It consists of a digital display with an attached cord and probe (at right). When the probe is placed in the water it can measure several different water quality parameters depending on the model. The parameters we will be concerned with are dissolved oxygen (D.O.), pH, temperature and conductivity. Each parameter's value is recorded on the digital display unit. The operation of the unit is straightforward. Once the unit is calibrated the user places the probe in the water and allows a few seconds for the reading on the digital display to stop fluctuating. The readings are recorded and the process repeated.



WATER QUALITY PARAMETERS

Each parameter (temperature, dissolved oxygen, conductivity and pH) we will be sampling tells us something important about the health of Presque Isle Bay. Each of these factors are limiting, that is, each has a maximum and minimum value, above or below which life for many species cannot continue.

Temperature directly affects the rate of biological activities. Every organism has an upper and lower tolerance limit for temperature and a certain temperature range that they prefer. Most organisms will try and remain near the center of their range. Water forms temperature layers at different depths through a process called thermal stratification; however Presque Isle Bay does not stratify and the temperature is relatively uniform throughout. Lake Erie does stratify. The upper, warmer layer is the ***epilimnion;*** the layer of transition from warmer to colder waters is the ***thermocline*** (represented by a drop in temperature of 1°C for every increase in depth of 1 meter); and the lower, colder layer is the ***hypolimnion***, which has a relatively uniform temperature. A rapid increase or decrease in temperature can have a negative impact on aquatic life.

Dissolved oxygen: Oxygen is one of the most important environmental factors in aquatic systems. The atmosphere contains approximately 20 percent oxygen in the gaseous state but is typically found in lower amounts in aquatic environments. The oxygen found in the water is dissolved in solution and therefore is less available to the organisms. The relative amount of dissolved oxygen in aquatic environments is measured in parts per million (ppm). The amount of dissolved oxygen in the water can potentially become a limiting factor for many organisms. For example, most fish need dissolved oxygen levels of 6 ppm to survive, however, some species like carp and catfish can survive at levels as low as 4 ppm. However some sensitive insects require 8-10 ppm of dissolved oxygen.

Conductivity is directly related to the amount of chemical ions in the water. Dissolved solids present in the water exist as ions and their solution can conduct an electrical current. A high conductivity reading implies that there are a lot of ions present in the water and is associated with fertile lakes; a lower conductivity implies fewer ions present and is associated with relatively infertile lakes. Metals such as aluminum, copper, magnesium and mercury exist as ions in the water. The higher the conductivity reading, the higher level of metals that will more likely be found. The conductivity does not say which metals are present, simply that there are metal ions in the water.

pH expresses the concentration of hydrogen ions in an solution on a scale that runs from 0 to 14. On this scale 7 is neutral; below 7 is acidic; and above 7 is basic. The scale is exponential; i.e., the concentration of hydrogen ions at pH 6 is actually 10 times that of pH 7. An example of a basic solution is Alka-Seltzer dissolved in water. It has a pH greater than 7.0 since it is composed of sodium bicarbonate, a basic substance. It is used to neutralize the acid in your stomach which has a pH well below 7.0. Aquatic organisms can be very sensitive to pH fluctuations, with most aquatic organisms preferring a pH around 7. Some fish species can tolerate pH levels as low as 5.0; however, most do best in ranges of 6.5 to 9.0. Mayfly nymphs are very sensitive to pH, if the pH were to drop as low as 5.0 it could wipe out their entire population.

Sieving Procedures: *Out! Come Out! Wherever You Are!*

INTRODUCTION

The following procedure is a step-by-step description of the sieving and sorting process to be completed shoreside following collecting samples aboard the Friendship Sloop *Momentum*. Students will have the opportunity to become biological detectives by searching through their samples looking for any organisms that may be hiding in the mud and gravel. They will also have the opportunity to use the microscope to further analyze and identify the organisms they found using the enclosed dichotomous key. Students will also categorize and record their results. Before beginning there are a few things you will need to know. Please read.

THE SIEVE

A sieve is an apparatus used to separate sediment and water from organic debris such as rocks, plants and organisms. The photo at right depicts a sieve screen containing organic debris. In this activity, round plastic sieves with four different screen (or mesh) sizes will be used. Sizes range from a no. 5 mesh size used to separate larger organisms to a no. 230 mesh, a finer mesh used to separate the smallest organisms.

THE SIEVING PROCESS

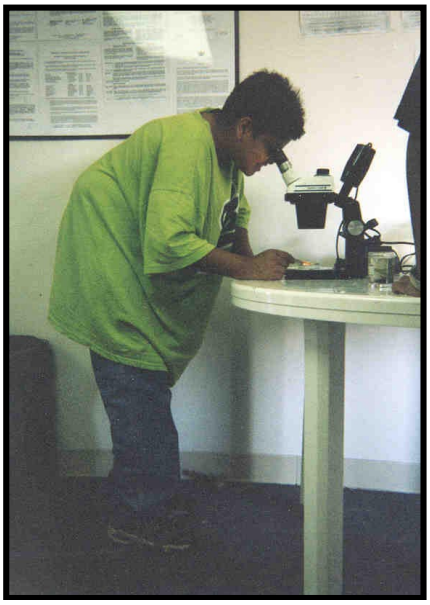
NOTE: Five students and one supervisor will be placed at each sieving station. Each group should have a white plastic sorting pan, one-gallon bucket, a pair of forceps, and gloves for each student.

1. The first step is to add water to the samples to break up any large clumps of mud that are present. All students will assist in this process.
    a. Using the garden hose, gently spray water into the plastic container.
    b. Using your hands, combine the water and the mud and break up any large clumps.
    c. Once mixed, one student from each group will grab a one-gallon bucket, scoop a portion of the water/mud mixture into the bucket and return to his/her station to begin sorting.
2. A small portion of the contents of the one gallon bucket should be gradually emptied into the sieve. *It may take several tries to empty your bucket.*
3. If necessary, a small amount of water should be sprayed on the sample to further separate any gravel or debris from the organisms.
4. The hunt begins! Carefully examine the contents on the first screen. *(You may notice that most of your sample falls through to the next screen. Don't worry you'll catch them later!)*

6. Once all organisms are removed from the first sieve screen, remove it and go on to the next screen. Each time you remove a screen you will need to look harder and harder to find organisms. *Make sure you look closely!*
7. After removing all organisms from the last sieve screen, rinse the sieve and repeat steps 1-6 until all samples are sorted!
8. CLEAN UP!
    a. All equipment should be rinsed and properly stored.
    b. Each student MUST wash his or her hands before doing any other activity.

Identification and Processing: *Who Are You?*

INTRODUCTION



The identification process is the final phase of the field experience. This gives the students a chance to become "biological detectives" and find out exactly what types of organisms live in the sand and mud of Presque Isle Bay. Correctly identifying and classifying these samples is important in the overall assessment of the benthic invertebrate community of Presque Isle Bay. This portion of the field experience will be one of the most challenging but also one of the most eye opening experiences for your students. Using the microscopes, your students will be able to explore a world that they may never known existed! Students will definitely need to use their x-ray vision to catch some of these critters under the microscope! This will be exciting for you and your students.

PROCEDURE

Once your students have had the opportunity to sort through their samples they will use a microscope and the enclosed dichotomous key (next page) to categorize and classify their samples. Using the microscopes, students will have the opportunity to examine their specimens in detail. Each student will draw his/her interpretation of their specimens. Each team of five students will be assigned to a microscope and have one container full of specimens they found while "playing in the mud." Students will work together taking turns retrieving samples, classifying them, and recording their findings. All findings will be recorded on the provided data sheet. The data will be made available online through the ***Environmental Rediscoveries*** website.

Key to Phyla, Classes, and Orders of Benthic Invertebrates

1. Without jointed thoracic legs---------- 2
   With jointed thoracic legs---------- 8

2. Wormlike---------- 4
   Not wormlike----------3

3. Covered with a hard calcareous shell of two parts----------PELECYPODA (clam, Figure A)
   Covered with a hard calcareous shell of one part----------GASTROPODA (snail, Figure B)

4. Flat and solid----------PLATYHELMINTHES (flatworm, Figure C)
   Round----------5

5. Unsegmented----------NEMATODA (roundworm, Figure D)
   Segmented----------6

6. Head rather undifferentiated----------ANNELIDA (segmented worms, Figure E)
   Head with distinct structures or their remnants----------INSECTA----7

7. Free living; maggot like----------Larvae of Diptera (flies, Figure F)
   Parasitic----------Larvae of Hymenoptera

8. Legs (more than three pair)----------CRUSTACEA----9
   Legs (three pairs or less)----------INSECTA----12

9. More than 20 body segments----------Phyllopoda (fairy shrimp)
   Body segments of 20 or less----------Malacostraca----------10

10. Carapace present, eyes stalked----------Decapoda (crayfish, Figure G)
    Carapace absent, eyes sessile----------11

11. Body flattened dorsi-ventrally----------Isopoda (sowbug, Figure H)
    Body compressed laterally----------Amphipoda (scud, Figure I)

12. With long segmented, filamentous appendages at the posterior end----------13
    Posterior filamentous appendages absent, or if present, not long, nor segmented----------14

13. With two posterior filamentous appendages; two tarsal claws; usually with finger-like tracheal gills on ventral side of the thorax----------Naiads of Plecoptera (stonefly)
    Usually with three, filamentous posterior appendages; one tarsal claw; with tracheal gills on lateral margins of abdominal segments----------Naiads of Ephemeroptera (mayfly, Figure J)

14. Large hard of leathery forewings covering abdomen, biting mouthparts----Adult Coleoptera (beetle)
    Wings, if present, of a different type----------15

15. Small insects, less than 3mm long; wingless; spring-like appendage beneath abdomen----------
    Collembola (springtails)
    More than 3mm long; wings present or absent; no spring-like appendages----------16

16. With wing pads (rudiments) or functional wings; naiads and adults----------17
Without wing rudiments or functional wings; larvae----------18

17. Sucking mouth parts in the form of a long jointed beak----------
Nymphs & Adults of Hemiptera (True Bugs)
Chewing mouth parts, labium (long and scooplike); with or without platelike caudal gills----------
Naiads of Odonata
a. Abdomen terminating in 3 caudal lamelle more than 1/3 length of abdomen----------
Zygoptera(damselflies, K)
b. Abdomen terminating in 3-5 stiff, pointed valves, longest less than 1/3 length of abdomen---------
Anisoptera(dragonflies,L)

18. With five pairs of abdominal prolegs----------Lepidoptera (aquatic caterpillars)
Prolegs absent, or confined to the last abdominal segment----------19

19. No hooks on tip of abdomen----------20
Hooks on tip of abdomen----------21

20. Tip of abdomen elongated to form a long tube----------Megaloptera (alderfly, Figure M)
Type of abdomen without a tube----------Coleoptera larvae (beetle)

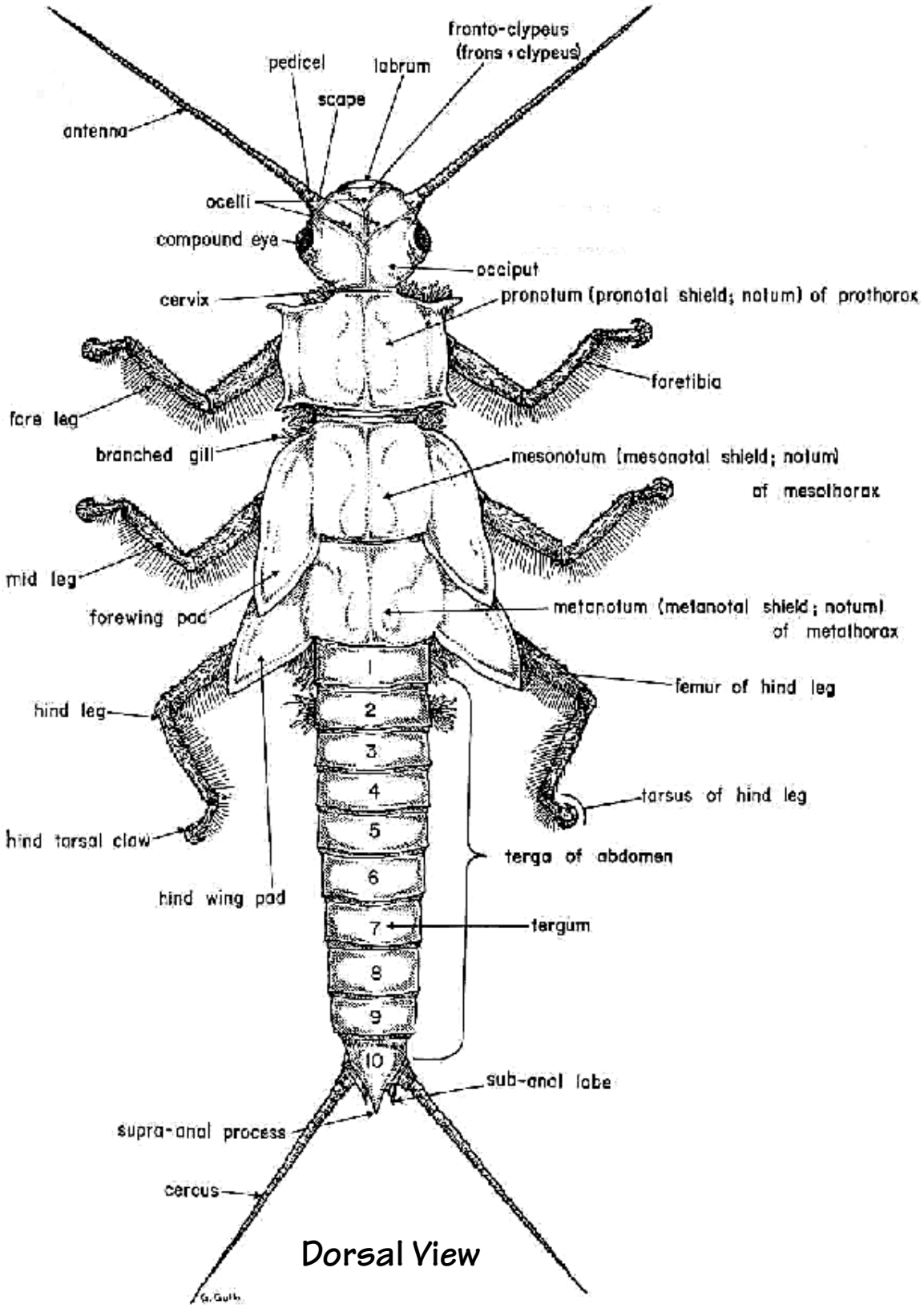
21. Hooks on central unpaired projection----------Gyrinidae (Coleoptera) whirligig beetle
Hooks on paired projection----------22

22. Each hook single (sometimes reduced)----------Trichoptera (caddis fly larvae, Figure N)
Each hook double----------Megaloptera (hellgrammite, fishfly larvae, Figure O)

VOCABULARY WORDS

Head-the first body region
Thorax-the middle region of the body
Abdomen- the last body region
Wing pads- The external undeveloped wings
Tracheal gills-The flattened or hair-like processes through which oxygen is absorbed from the water
Labrum- the movable "upper lip"
Femur- usually the largest part of the leg
Tibia- the fourth part of the leg a little more slender than the femur
Tarsus- the "foot" consisting of several segments
Claws- arise from the last tarsal segment
Labium- lower lip
Lamellae-leaf-like tail

Note: Refer to figures on pages 115 and 116 for diagrams of general anatomy.


fronto-clypeus
(frons + clypeus)
pedicel
labrum
scape
antenna
ocelli
compound eye
occiput
cervix
pronotum (pronotal shield; notum) of prothorax
foretibia
fore leg
branched gill
mesonotum (mesonotal shield; notum)
of mesothorax
mid leg
forewing pad
metanotum (metanotal shield; notum)
of metathorax
femur of hind leg
hind leg
tarsus of hind leg
hind tarsal claw
terga of abdomen
hind wing pad
tergum
sub-anal lobe
supra-anal process
cercus
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2
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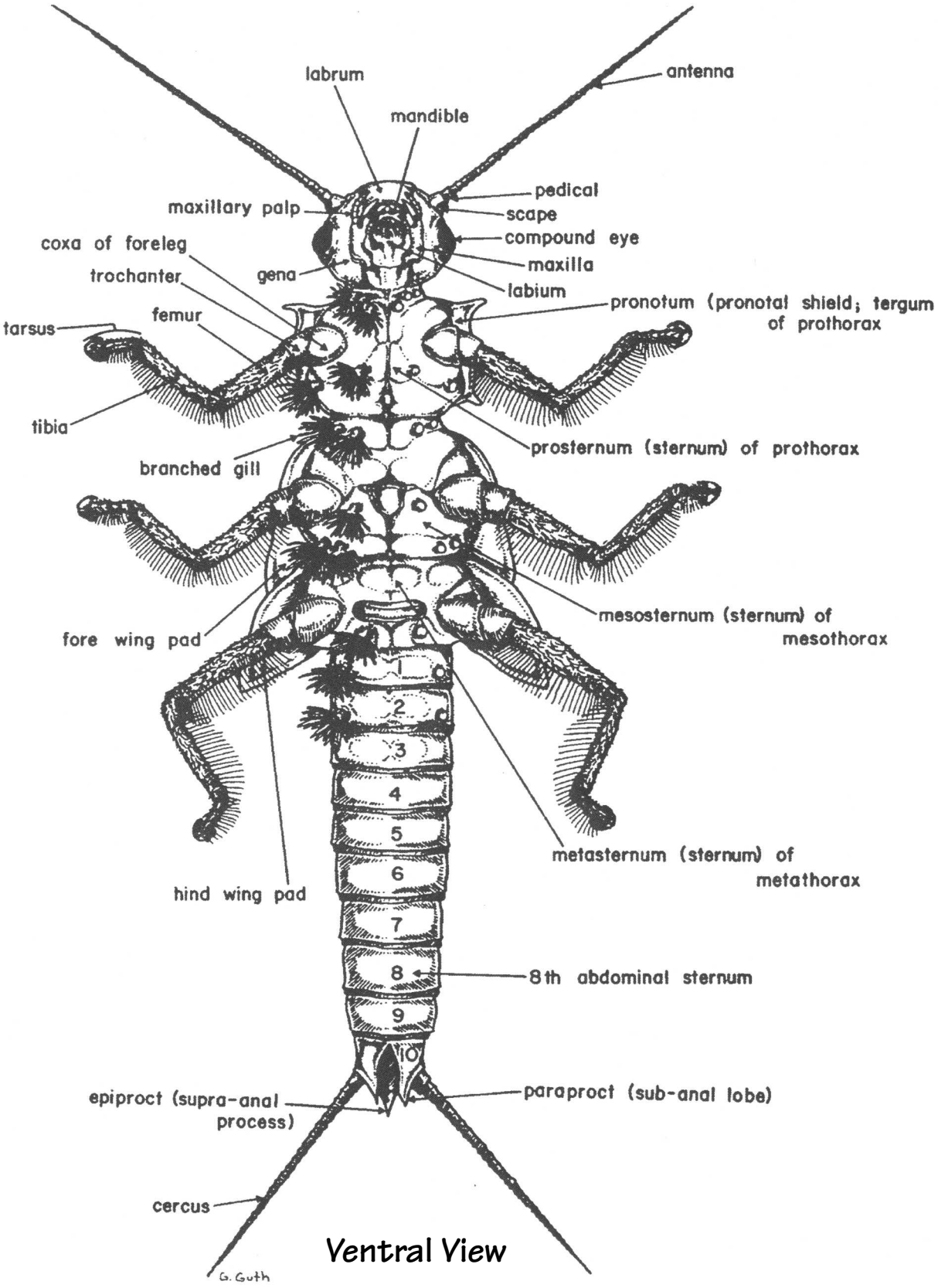
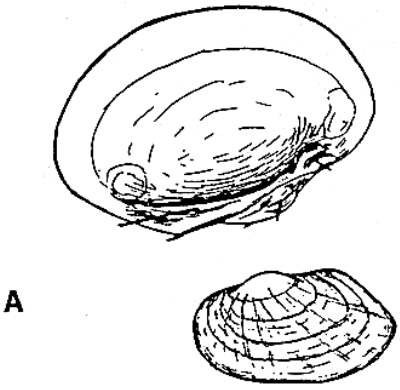
4
5
6
7
8
9
10

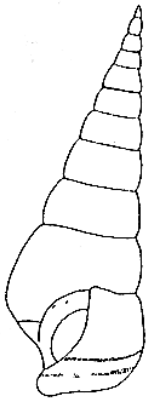
Dorsal View



Ventral View



A



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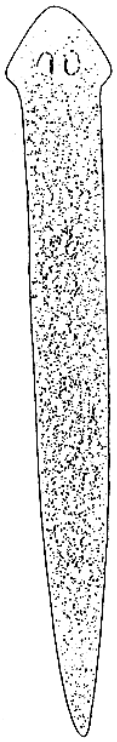

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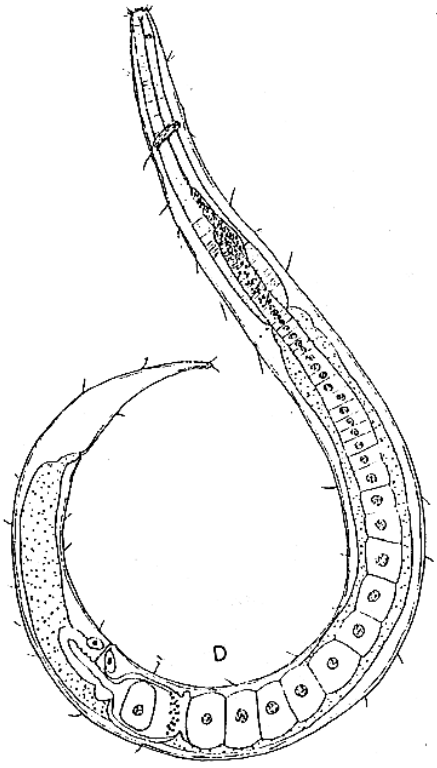

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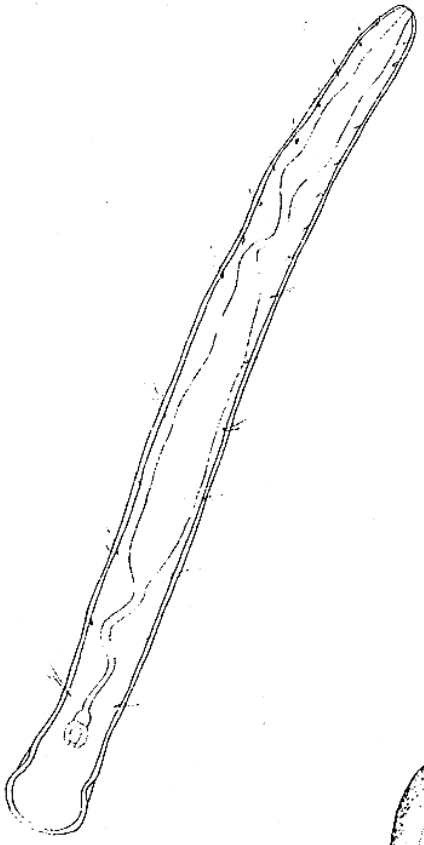

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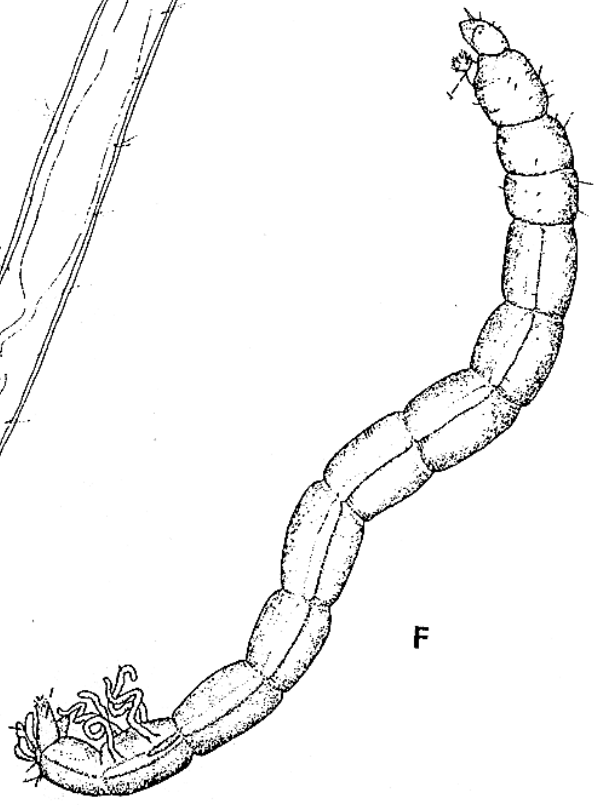

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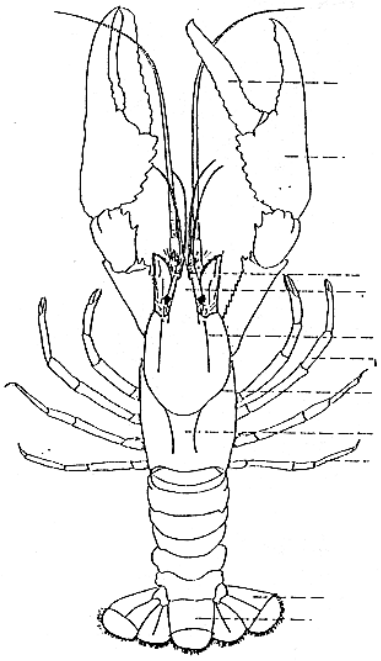

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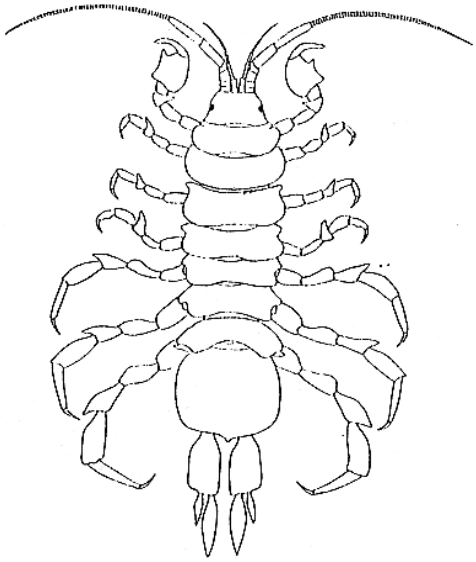

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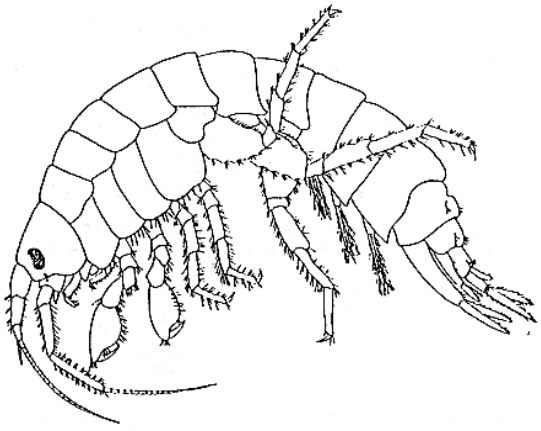

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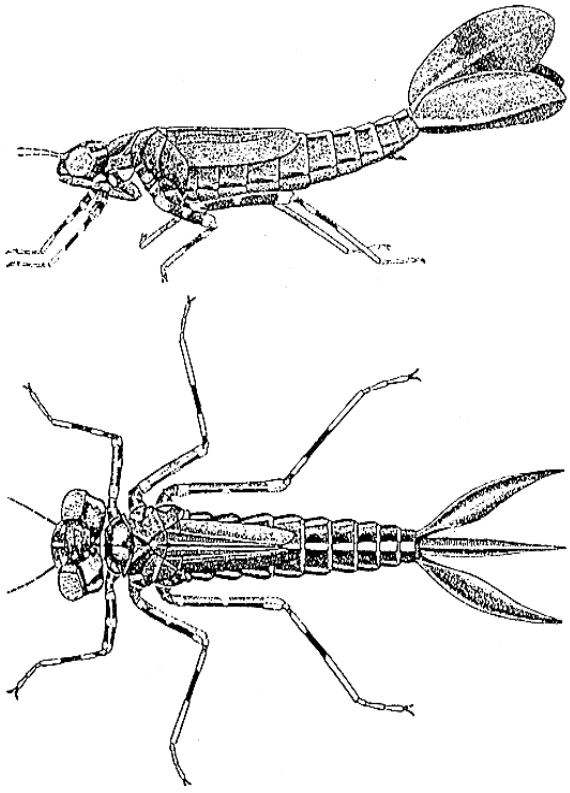
J



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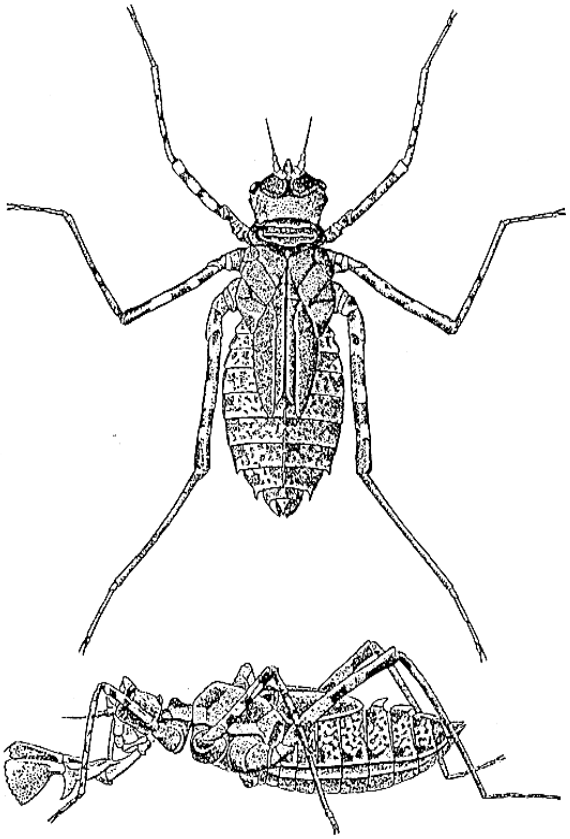

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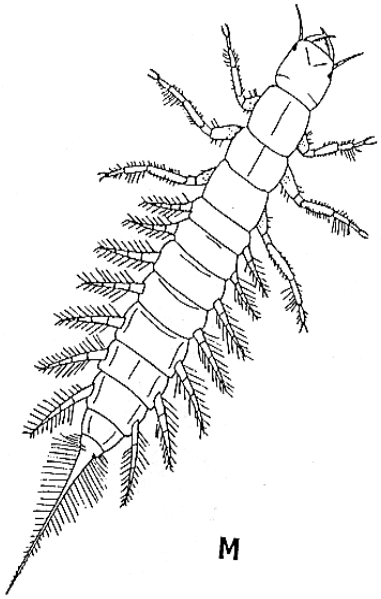

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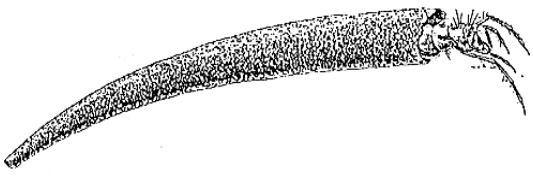

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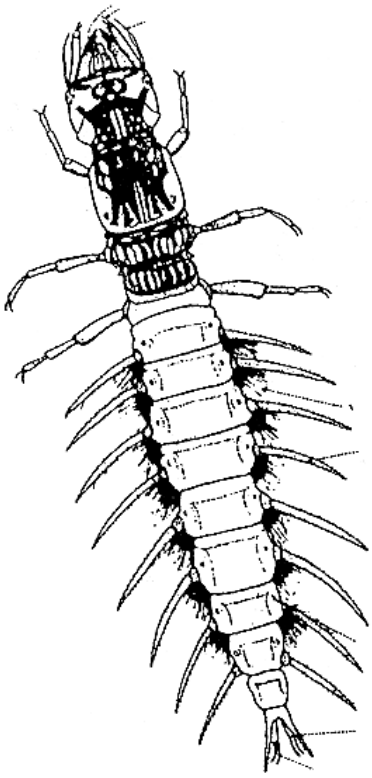


o

FOLLOW-UP ACTIVITIES

OVERVIEW

Following your experiences aboard the Friendship Sloop *Momentum*, you may want to take the opportunity to provide some closure for your students and to discuss their experiences with them. Some of these activities can be done in the classroom or on the bus ride back to school.

ACTIVITY LIST

1. Creative Writing:
   - ✓ Encourage students to reflect on their experiences. What did they see? What did they hear? What did they do? What did they smell? Have each student write his or her thoughts on paper. Encourage them to be as creative as possible by writing a story, poem or drawing a picture.

2. Quiz: Remember *Me?*
   Test your student's memories of what they collected in the field!

3. Computer Applications:
   Through the ***Environmental Rediscoveries*** website students can view their data online and make inferences and predictions from their data.
   Note: *If students do not have access to the Internet, hard copies of their data can be provided by contacting Anne Danielski.*

   A. Data Analysis Questions
      1. Relative to their sampling position on the map of Presque Isle Bay, how could the surrounding environment affect their results? Example: Are there any streams emptying into the bay near your site that could contribute runoff or other pollutants? How would other streams in the Presque Isle Bay watershed affect your results?

      2. Looking at the number and types of invertebrates collected, use Microsoft Excel or other spreadsheet program to create graphs and charts displaying your findings. Did you find any mayfly nymphs? Why or why not?
         Note: *If students do not have access to a computer, have them draw their graphs and charts by hand using markers and construction paper*.

   B. Microsoft Power Point Presentation
      Your students may want to summarize their experiences and experimental results by creating a presentation they can share with other classes or their entire school. Pictures and data will be available online for downloading to use in the presentation. Creating a presentation is a great way to give your students a chance to be creative and also assess what the students learned through their ***Environmental Rediscoveries*** experience.

TAKE HOME LESSON

It is our hope that the ***Environmental Rediscoveries*** experience:

- ✓ Exposed your students to their environment.
- ✓ Taught them about the components (both living and nonliving) of their environment.
- ✓ Gave your students an understanding of how they affect their environment.
- ✓ Helped your students become more aware of the issues affecting their environment and encouraged them to become stewards of their environment.

Remember Me?

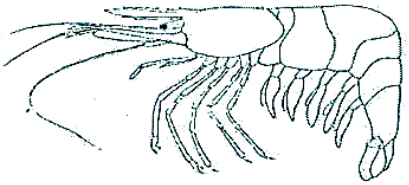
Name:_____ **Date:** _____ **Class:** _____

Word Bank

Mayfly nymph	Scud	Fairy shrimp	Dragonfly	Flatworm
Crustacean	Damselfly	Sowbug	Roundworm	

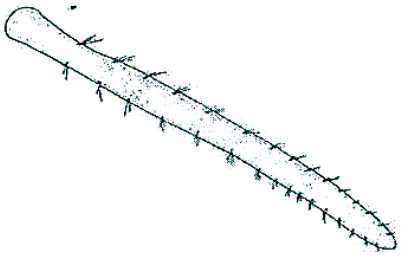
Common Name:_____

Common Name:_____



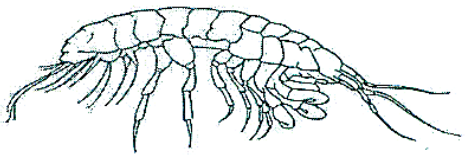
Common Name:_____

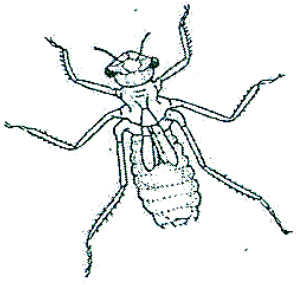
Common Name:_____



Common Name:
_____

Common Name:_____





Common Name:_____

BONUS: Name the ORDER of any of the above invertebrates

REFERENCES

Biological Resources Division of the U.S. Geological Survey, Gainsville, FL 1998.

Borror & Delong. An Introduction to the Study of Insects. Holt, Rinehart and Winston. 1964.

Burks, 1953.

Enviro 2000. A Curriculum for Presque Isle State Park.

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U.S. Army Corps of Engineers and Great Lakes Commission. Living with the Lakes.1999.

Wetzel & Likens. Limnological Analyses. W.B. Saunders Company. 1979.

National Geographic. www.nationalgeographic.com. Caspian Sea Map.

Photo Credits
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Adult Mayfly: Dr. Edwin C. Masteller
Zebra Mussel Growth Progressions: Eric Obert
Zebra Mussels on Native Clam: Wisconsin Sea Grant
Mussels on Crayfish: Ontario Ministry of Natural Resources
Aquatic Exotics:
- Zebra Mussels-Ohio Sea Grant
- Round Goby-Shedd Aquarium
- Eurasian Ruffe-Minnesota Sea Grant
- Sea Lamprey-U.S. Fish & Wildlife Service
- Spiny Waterflea- U.S. Fish & Wildlife Service

Round Goby: D. Jude
Friendship Sloop *Momentum:* Jim Stewart
Sieve Box: Jim Stewart

WEB RESOURCES

General Information Websites

- Environmental Rediscoveries: http://www.pserie.psu.edu/seagrant/rediscoveries/index.html
- Pennsylvania Department of Environmental Protection: http://www.dep.state.pa.us/
- Pennsylvania Sea Grant: http://www.pserie.psu.edu/seagrant
- National Sea Grant Program: http://www.nsgo.seagrant.org/
- Bayfront Center for Maritime Studies: http://www.goerie.com/bcms
- Living Classrooms Foundation: http://www/livingclassrooms.org

Mayflies on the Move!

- Area Of Concern (AOC): http://www.epa.gov/glnpo/aoc/presque.html
- Walleye: http://www.seagrant.wisc.edu/greatlakesfish/LakeErie.html
- Sturgeon: http://www.seagrant.wisc.edu/madisonjason9/sturgeon.html
- Whitefish: http://www.seagrant.wisc.edu/greatlakesfish/LakeErie.html
- Lake Herring: http://www.seagrant.wisc.edu/madisonjason9/herring.html
- Silver chub: http://www.state.ia.us./dnr/organiza/fwb/fish/iafish/minnow/card/sic-card.htm
- Pennsylvania Sea Grant Mayflies on Doppler Radar: http://www.pserie.psu.edu/seagrant/mayflies.htm

Presque Isle

- Erie Triangle: http://erie.net/~chamber/eriehist.html
- Anthony Wayne: http://www.tristate.pgh.net/~bsilver/WAYNE.htm
- Niagara: http://www.brigniagara.org/niagara.htm
- Restored: http://www.brigniagara.org/museum.htm
- Discover Presque Isle: http://www.goerie.com/presqueisle/
- Atlantic Flyway: http://www.fws.gov/r7enved/sssp.html

Presque Isle Bay: Area of Concern (AOC)

- Surf your Watershed: www.epa.gov/surf
- Topographical Maps Online: http://www.topozone.com

Sailing

- Mark Rosenstein's Sailing Page: http://www.apparent-wind.com/sailing-page.html
- Mystic Seaport Maritime Museum: http://www.mysticseaport.org/

Exotic Species

- Zebra Mussels: http://www.sgnis.org/www/zebra.htm
- Round Goby: http://www.sgnis.org/www/goby.htm
- Eurasian Ruffe: http://www.sgnis.org/www/ruffe.htm
- Sea Lamprey: http://www.sgnis.org/www/lamprey.htm
- Spiny Waterflea: http://www.sgnis.org/www/spiny.htm
- Photos of Zebra Mussels: http://www.wes.army.mil/el/zebra/piclist.html
- Comprehensive Info on Zebra Mussels: http://www.wes.army.mil/el/zebra
- Fish Advisories: http://www.state.pa.us/Fish/fishadvi.htm

WORKSHEET ANSWER KEYS

Mayflies on the Move!

Section I: Completion
1. Nymph
2. Walleye
3. Nonpoint source
4. Water quality
5. Potable

Section II: Label Me!
1. Head
2. Wings
3. Caudal filament
4. Legs
5. Antennae
6. Thorax
7. Gills
8. Tusks

Section III: Critical Thinking
Answers will vary. Students should mention something about pollution from untreated sewage or runoff contributing to the disappearance of the mayfly in the 1950s. The reappearance of the mayfly in the 1990s is most likely linked to an improvement in water quality.

Presque Isle

Section I: Completion
1. Recurved sand spit
2. War of 1812
3. Niagara
4. Succession
5. Biodiversity
6. Atlantic Flyway

Section II: Matching
1. A
2. E
3. C
4. B
5. F
6. D

Section III: Critical Thinking
Answers will vary. Reference should be made to how Presque Isle has migrated in the past due to wind and wave erosion. This erosion causes new habitats to be formed, which creates more habitats for many plants and animals.

Presque Isle Bay: AOC

Section I: Completion
1. Flushing time
2. Drainage basin divide
3. Watershed
4. Eutrophication
5. Point source and nonpoint source
6. Cascade and Mill

Section II: Matching
1. 1
2. 2
3. 1
4. 2
5. 1

Section III: Critical Thinking
Answers will vary. Some possible steps students can take include properly disposing of oil and paint cans and by limiting the amount of fertilizer applied to their lawns.

Exotic Species

Section I: Completion
1. Non-native
2. Ballast
3. Filter feeders
4. Byssal threads
5. Round gobies, sculpins

Section II: Label Me!
1. Dorsal fin
2. Eye
3. Stomach
4. Inhalent siphon
5. Pelvic fin
6. Exhalent siphon
7. Byssal threads
8. Foot

Section III. Critical Thinking
Answers will vary. Among the ideas the students may have can be taken directly from *"How to stop the spread"* on the zebra mussel and round goby fact sheets. Many of the same actions that are used to prevent the spread of zebra mussels and round gobies can be applied to other aquatic nuisance species.

Get some Momentum!

Section 1: Completion
1. Momentum
2. Friendship
3. Compass
4. Personal flotation device
5. Raise away

Section 2: Label Big Mo!
1. Mainsail
2. Jib
3. Main sheet
4. Mast
5. Peak halyard
6. Bowsprit
7. Transom
8. Throat halyard
9. Hull
10. Cockpit

Section 3: Critical Thinking
Answers will vary. Students should be as creative as they can. Students should mention something about how the wind would affect the direction they are sailing and any navigational tools they would use to help them

REFERENCES

Biological Resources Division of the U.S. Geological Survey, Gainsville, FL 1998.

Borror & Delong. An Introduction to the Study of Insects. Holt, Rinehart and Winston. 1964.

Burks, 1953.

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