Freshwater Estuary/Wetlands Model

Exploring estuary and wetland functions

Grade Level: 3-12

Activity Duration: 60 min

Overview:

I. Building a wetland
II. How a wetland functions
III. Human impacts on wetlands
IV. Restoring wetlands
V. Managing your estuary

Summary: As the St. Louis River flows into Lake Superior, it creates a fresh water estuary. This dynamic area has components from both bodies of water. The river contributes sediment and nutrients, as well as warmer water to the mix, but can also deliver pollutants from the watershed further upstream. The lake can push and churn water back into the estuary during strong winds. An estuary can provide several important aquatic habitats; open water, sediment on the bottom and wetlands along the shoreline. Wetlands are very important in the health of aquatic systems. Students will observe the characteristics of wetlands and estuaries by using a model.

Topicsservation: Wetlands, estuary, ecology, human impact, nutrient and pollution filtering

Theme: Wetlands act as giant sponges. They filter nutrients into surrounding habitats and filter out pollution. By protecting wetlands, we are protecting surrounding habitats as well. An estuary is an important wetland that affects the health and quality of the water for plants, aquatic organisms, animals and humans who live in and around the water.

Goals: Students will understand the functions of a wetland, and explore some management issues for preserving those freshwater estuaries.

Objectives:

Students will:

1. Use a wetland model to demonstrate the filtering functions of a wetland and to understand that a wetland system functions much like a sponge.
2. Be able to explain how the river and larger body of water interact.
3. Be able to debate the importance of wetlands/estuaries.
4. Understand that human impacts have an effect on aquatic organisms in a wetland, using fish as a model.
5. Practice management and lifestyle decisions and the consequences on wetlands and estuaries.

Suggested MN Science Standards:

Grade 3:
3.1.1.2.1 – Generate questions that can be answered when scientific knowledge is combined with knowledge gained from one's own observations or investigations. *For example:* Investigate the sounds produced by striking various objects.
3.1.1.2.3 – Maintain a record of observations, procedures and explanations, being careful to distinguish between actual observations and ideas about what was observed. *For example:* Make a chart comparing observations about the structures of plants and animals.
3.1.1.2.4 – Construct reasonable explanations based on evidence collected from observations or experiments.

Grade 4:
4.2.4.1.1 – Describe how the methods people utilize to obtain and use water in their homes and communities can affect water supply and quality.

Grade 5:
5.1.1.1.4 – Understand that different models can be used to represent natural phenomena and these models have limitations about what they can explain. *For example:* Different kinds of maps of a region provide different information about the land surface.
5.3.4.1.3 – Compare the impact of individual decisions on natural systems. For example: Choosing paper or plastic bags impacts landfills as well as ocean life cycles.
5.4.2.1.2 – Explain what would happen to a system such as a wetland, prairie or garden if one of its parts were changed. *For example*: Investigate how road salt runoff affects plants, insects and other parts of an ecosystem. *Another example:* Investigate how an invasive species changes an ecosystem.
5.4.4.1.1 – Give examples of beneficial and harmful human interaction with natural systems. *For example:* Recreation, pollution, wildlife management.

Grade 6:
6.1.3.1.1 – Describe a system in terms of its subsystems and parts, as well as its inputs, processes and outputs.

Grade 7:
7.4.2.1.1 – Identify a variety of populations and communities in an ecosystem and describe the relationships among the populations and communities in a stable ecosystem.

Grade 8:
8.3.4.1.2 – Recognize that land and water use practices affect natural processes and that natural processes interfere and interact with human systems. *For example:* Levees change the natural flooding process of a river. *Another example:* Agriculture runoff influences natural systems far from the source.

Grade 9-12:
9.1.3.1.1 – Describe a system, including specifications of boundaries and subsystems, relationships to other systems, and identification of inputs and expected outputs. *For example:* A power plant or ecosystem.
9.4.4.1.2 – Describe the social, economic and ecological risks and benefits of changing a natural ecosystem as a result of human activity.

Environmental Scope and Sequence:
Benchmarks Addressed:

- Social and natural systems are made of parts. (preK-2)
- Social systems and natural systems may not continue to function if some of their parts are missing. (preK-2)
- When the parts of a social system and natural systems are put together, they can do things they couldn't do by themselves. (preK-2)
- In social and natural systems that consist of many parts, the parts usually influence one another. (3-5)
- Social and natural systems are connected to each other and to other larger or smaller systems. (6-8)
- It is not always possible to predict accurately the result of changing some part or connection between social and natural systems. (9-12)

Great Lakes Literacy Principles:

- Water makes Earth habitable; fresh water sustains life on land.
- The Great Lakes support a broad diversity of life and ecosystems.
- The Great Lakes and humans in their watersheds are inextricably interconnected.
- The Great Lakes are socially, economically, and environmentally significant to the region, the nation and the planet.

For more information about the Great Lakes Literacy Principles, visit:
http://greatlakesliteracy.net/

Next Generation Science Standard

- 3-LS4-3 Construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all.
- 3-LS4-4 Make a claim about the merit of a solution to a problem caused when the environment changes and the types of plants and animals that live there may change.
- 4-ESS2-1 Make observations and/or measurements to provide evidence of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation.
- 4-ESS2-2 Analyze and interpret data from maps to describe patterns of Earth's features.
- 5-ESS3-1 Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.

- 3-5-ETS1-1 Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
- 3-5-ETS1-2 Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
- MS-LS2-1 Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.
- MS-LS2-3 Develop a model to describe the cycling of matter and flow of energy among living and non-living parts of an ecosystem.
- MS-LS2-4 Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.
- MS-LS2-5 Evaluate competing design solutions for maintaining biodiversity and ecosystem services.
- MS-ESS3-3 Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.
- HS-LS2-1 Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems as different scales.
- HS-LS2-6 Evaluate claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.
- HS-LS2-7 Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.
- HS-LS4-6 Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.

Materials:

- 1 kit box
- 1 lesson plan
- 8 wetland models
    - Removable sponge pieces
    - Removable carpet strip
- Food coloring
- 4 Cups per group
- GIS map of local wetlands/estuary and its watershed
- Environmental action cards (Suggested for grades 3-5)
- Environmental decision cards (Suggested for grades 6-12)

Not Included:

- Water
- Syrup, molasses or vegetable oil
- Unsweetened cocoa
- Leafy dried spice, such as rosemary or parsley
- 20 Goldfish crackers per group/person

Background:

An estuary is where a river meets a much larger body of water like an ocean, sea, or very large lake. The habitat created in an estuary is unique because it has different salinity (salt content) and chemical and physical (e.g. water temperature) characteristics of the water than a river or lake alone; it is the mixture of these two that makes it special. Lake Superior near Duluth creates an estuary with the St. Louis River; because Lake Superior is a freshwater lake, it creates a freshwater estuary. The St. Louis River estuary is the largest freshwater estuary in North America at 12,000 acres.

The river flowing into the larger water body adds sediment and nutrients it receives from the land. This also means that it adds pollutants that wash into it from the land like fertilizer nutrients, industrial chemicals and litter. The lake contributes fresh water, sediments and chemicals that are churned up by storms or wind. The lake can sometimes "slosh" back up the river from strong winds or storms, or from a sloshing motion that occurs in the Great Lakes called a seiche (pronounced 'say-shh') (similar to the motion water makes when it moves back and forth in a bowl).

An estuary has several different kinds of habitats for animals and plants; these include: open water, the bottom of the estuary floor, plants growing in the water, and the shoreline of the estuary. These habitats can include wetlands. Wetlands are land that has standing water for most or part of the year. In Lake Superior, wetlands tend to be marshes, a kind

of wetland that is characterized by tall grasses like cattails and bulrushes growing in the water.

Wetlands are very important! They filter water coming from the river to keep it clean, which means they help protect the lake from pollution. They protect land from floods and storm water coming in from the lake. They cycle important nutrients like carbon and nitrogen that all living things need to grow. Wetlands are important habitat for animals; they are a nursery for baby fish, habitat for migrating birds, and home to many animals who don't live anywhere else and who are special because of their adaptations to brackish water (water that contains intermediate amount of salt, organic matter or sediment; often turbulent and muddy). Wetlands also give a lot of food to humans like fish (or elsewhere in Minnesota, wild rice).

People didn't realize how important wetlands and estuaries were for a long time. Often wetlands are drained or filled in and used as land to construct buildings. People also cut down trees and grass along shorelines which lead to increased erosion (more dirt in the water). People aren't always very careful about dumping waste from industries and sewers, fertilizer, pesticides, and oil into wetlands. Wetlands act like a sponge; they filter impurities out of the water, but they also hold those impurities. When we destroy wetlands, polluted water runs directly into the lake. This means baby fish can't grow up, animals lose their homes and the lake receives a lot of pollution it didn't before, which can make lake animals and plants, and eventually us, sick.

When people realized wetlands and estuaries are important to keep a lake healthy and clean, and therefore keep us healthy, they started to protect them. They rebuilt wetlands, create wetlands and estuary reserves, and make laws to protect the habitat.
This class activity is a synthesis of various other wetlands models that have been adapted to include the functions of an estuary. The objectives of this class activity are to: understand how a wetlands system functions; understand how an estuary functions, and how the river and larger water body interact; understand the importance of wetlands/estuary functions; practice management and lifestyle decisions and their consequences on wetlands and estuaries.

NOTE: Wetlands and estuary are the same location in this lesson. Estuary is more of a geographic location (at the intersection of a river and a lake) and ecosystem. Wetlands are a more specific ecosystem and habitat type that we are discussing within the estuary. It is important to realize that an estuary is not only made up of wetlands, and wetlands are not only found in an estuary.

Procedure:
Classroom Setup (10-15 min.)

1. At the front of the room lay out what you will need for the introduction and conclusion so it is readily accessible in the order needed.

2. Students will be working in groups of 3-5 for the lesson. If teaching indoors, group tables/desks together ahead of time for ease of starting the lesson.

3. Wet the sponges in each of the wetland models so that they are damp, but not soaking.

Introduction (5-10 min.)

1. Have students brainstorm individually or in small groups everything they know about wetlands. Use prompts if needed: What are wetlands? Are there wetlands near your home? School? What lives in a wetland? How are wetlands created? Are wetlands important? Why?

2. Today we will be learning about wetlands and how they function.

How a Wetland Functions (10-15 min.)

1. Place the GIS map at the base of the container to represent the estuary as a whole. Beyond the GIS map is the lake, and beyond the top of the container is the river.

2. Mix a few drops of food coloring in with ~1 cup of water each, so that you have 3 cups of water containing different colors. Put a teaspoon of cocoa and a teaspoon of rosemary into each cup.

    a. What could the food coloring represent? *Coloring is mainly to make the water easier to see, but can also represent dissolved material or pollution.*
    b. What does the cocoa represent in a wetland? *The cocoa represents sediment or fertilizer.*
    c. What would rosemary represent? *The rosemary represents organic matter and other nutrients.*

3. In a fourth cup, mix water with several tablespoons of syrup or oil. Have a stirrer on hand to stir the mixture together before you add it to the wetland.
    a. What would syrup or oil in water represent in the wetland? *The syrup or oil represents oil or pollution.*

4. Set the cups aside for later use.

5. Wetlands function like a sponge to clean the water. Pour part of one cup of colored water into the top of the container and watch it move through the sponges to the bottom.
    a. What do you notice about the amount of coloring and cocoa/rosemary in the top sponges versus the lower sponges? *See how the sponges take up the coloring and cocoa/rosemary, so that the sponge further down the container receives less than the sponge near the top.*

6. The water that reaches the bottom of the container is what will enter the estuary and lake.
    a. What do you think will happen with less sponges (wetlands)? *More matter will enter the lake.*
    b. What do you think will happen with more sponges (wetlands)? *With more wetlands (sponges), less matter will enter the lake. Wetlands trap nutrients, which create a lot of food for the plants and animals that live there.*

7. A lake can slosh water back up into the estuary (and the wetlands) during storms. Tilt the container to slosh some of the water at the bottom back up into the wetlands; the sponges should absorb some more water, and some of the nutrients the wetlands were holding will end up in the estuary. There is an exchange between the wetlands and lake through the estuary.

Human Impacts on Wetlands (10-15 min.)

Grades 3-6

1. The St. Louis River estuary is unique in that it is located in Duluth city boundaries. This means that it is surrounded by land that has many different uses. Look at the highlighted GIS map to see how humans have altered the land use, and thus affected the estuary.
    a. How does the way humans use land affect the health of the estuary?
        i. *Protected land, just South of the estuary allows for low runoff (less erosion), healthier water quality, and provides habitats for animals.*

    b. Locate the forested land on the map. How might this forested land affect the wetland? If there are no trees near the estuary and there is heavy rainfall, what might happen? How might forested land be used? How would that affect the estuary?
        ii. *It may lead to more erosion, and thus, lower water quality. Forested land may also mean higher development (neighborhoods) which could lead to higher nutrient levels in the form of fertilizer.*

c. Locate the commercial development area on the map. How does the commercial development sector affect estuary health? Lake health?
   iii. *Commercial development results in higher levels of tourism in the area. Because of the increase in population, pollution may be higher in these areas. The commercial development sector is located between the wetland and the lake, meaning the pollution could free flow into the lake and seiches could cause it to flow back into the wetland as well.*

Grades 7-12

1. The St. Louis River estuary is unique in that it is located in Duluth city boundaries. This means that it is surrounded by land that has many different uses. Using the GIS map of the St. Louis River estuary, and the highlighted puzzle pieces, place the puzzle pieces over the map to see how humans have altered the land use, and thus affected the estuary.
   a. How does land use relate to estuary health?
      i. *Protected land, just South of the estuary allows for low runoff (less erosion), healthier water quality, and provides habitats for animals.*
   b. The forested land is located along the Northwestern part of the St. Louis River estuary. How might this forested land affect the wetland?
      ii. It may lead to more erosion, and thus, lower water quality. Forested land may also mean higher development (neighborhoods) which could lead to higher nutrient levels in the form of fertilizer.
   c. How does the commercial development sector affect estuary health? Lake health?
      iii. Commercial development results in higher levels of tourism in the area. Because of the increase in population, pollution may be higher in these areas. The commercial development sector is located between the wetland and the lake, meaning the pollution could free flow into the lake and seiches could cause it to flow back into the wetland as well.

Humans Impacts on Wetlands Continued (All Grades) (10 min.)

1. Humans add things to water that wouldn't usually be there. Use a new color of water to represent a pollutant. Pour a little into the wetlands; the wetlands should absorb most of it, so little reaches the estuary. Pour a lot of colored water in really quickly; the sponges should fill up and be unable to hold any more, so more of the color (pollution) reaches the estuary and the lake. The more pollution we add, the less efficiently the wetlands can clean the water.

2. Remove the middle sponge to symbolize humans destroying wetlands by filling them in or draining them. When you remove a sponge, squeeze the sponge out; once a

wetland is gone, much of what it was holding is released back into the water. You can remove the entire middle section, or leave parts intact for comparison.

3. Pour a different color water into the pan.
    a. What do you notice when you remove part of the wetland habitat? *The intact wetlands will filter the water more quickly and more efficiently than the degraded wetlands. Much of the particulate matter from the pieces of the degraded wetlands will be washed into the lake; destroying one part of wetlands impacts the estuary as a whole.*

4. NOTE: The bottom of your container will begin to fill up. If it gets too full, remove some water by filling up a cup (you can even reuse the water continuously in the experiment, because humans recycle water.) The more colors you add, the water should turn brown and murky – pollution, yuck!

5. Add they syrup/oil mixture to represent oil spilled from a factory or roadway. Make sure to stir the mixture before adding it to the estuary model. You can also add it to the base of the container to represent an oil spill from a tanker on the lake, and then slosh it back up into the wetlands. Remember, the lake, estuary and wetlands are all interconnected; what happens to one will end up in another. The oil is viscous (sticky) and will move slowly. The wetlands will keep much of it; this illustrates how an oil spill can negatively impact wetlands for long after lake is cleaned because the long grasses trap and sediment the oil.

Restoring Wetlands (5 min.)

1. Humans are now restoring wetlands or cleaning up existing wetlands. Replant wetlands by adding the sponge (squeezed out) back into the container. Restore wetlands by squeezing a sponge in the container out into a cup on the side and replacing it.

2. Place the piece of turf or carpeting near the top of one sponge to represent a vegetative buffer humans planted between their homes/roads/buildings and the water. Pour the third color of water over the turf and see how much particulate matter is kept in the turf. One of the best ways to clean up an estuary is to keep pollutants from entering it.

Conclusion/Wrap Up:
Managing Your Estuary (Grades 3-6) (15-30 min.)

1. Place at least 20 goldfish crackers onto the GIS map of the estuary. These are your fish or baby fish in their wetlands nursery. Remember there are other animals that need wetlands like birds, insects and mammals, which will be impacted like the fish.

2. Either as a class or in small groups draw action cards **(Estuary Keeper Cards)** one at a time. READ THE ENTIRE CARD and follow the action listed as a class or individually. Based on the action listed, fish will be added or removed to the estuary. When they are removed, they can be removed from the map and the students' napkins and kept on the side or eaten. When added, you can add new fish or replace fish previously removed to the map.

3. How many fish are left in the estuary at the end of the game? The more fish, the healthier the estuary. What actions were taken that could be made more responsibly in the future? What actions allowed the fish population to flourish?

4. Discuss with your students what they can do to help keep the wetlands and estuary clean. Remember, we live by one! Here are some possible ways;
    a. Don't throw paint, chemicals, or dangerous things down the drain.
    b. Don't release pets like goldfish into the wild, they can become invasive.
    c. Plant a buffer strip (about 20 feet of long grass that you don't mow) between your yard and the water if you live on the shoreline.
    d. Don't use fertilizer or pesticides on your lawns or gardens.
    e. Don't use harsh de-icing salt in winter.
    f. Don't litter, keep the shorelines and beaches clean.
    g. Volunteer to clean up an estuary shoreline or wetlands.
    h. Visit a wetlands or estuary reserve to learn more.
    i. Support laws that protect wetlands and estuaries.

Conclusion/ Wrap Up:
Managing Your Estuary (Grades 6-12) (20-60 min.)

***See extension section of lesson plan to see how to differentiate this activity and to allow for different time constraints. ***

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2. Either as a class or in small groups draw decision cards **(Estuary Manager Cards)** one at a time and ask your students to make a decision based on their knowledge of wetlands. BE SURE TO READ THE ENTIRE CARD. After a decision has been made, flip the card over and preform the action listed. Based on the decision that was decided fish will be added or removed from the estuary. When they are removed, they can be removed from the map and the students' napkins and kept on the side or eaten. When added, you can add new fish or replace fish previously removed to the map.

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    f. Don't litter, keep the shorelines and beaches clean.
    g. Volunteer to clean up an estuary shoreline or wetlands.
    h. Visit a wetlands or estuary reserve to learn more.
    i. Support laws that protect wetlands and estuaries.

Watch how-to videos of making and using the model on www.youtube.com/ecoleader11.

Clean Up:

Dispose of all remaining liquid. Thoroughly wash out estuary models and sponges in the sink by soaking the sponges several times and squeezing them out to rid them of any food coloring or debris. Place sponges back into each model so all models have three rows of sponges. If using the kit, return all supplies to the kit bin and the kit to the library in a prompt manner.

Extensions:

1. Extend the Managing Your Estuary activity (grades 6-12) for an entire class period. Leave 40-60 minutes for each group of students to go through their entire stack of 18 cards and follow up with a discussion. Students could make their decisions individually or as a group and see how many fish they have left at the end of the activity.

2. To shorten the Managing Your Estuary activity (grades 6-12) students could discuss fewer Estuary Manager Cards. This will give them an idea of how to protect an estuary, while shortening the activity to anywhere between 15-30 minutes.

3. After completing the Managing Your Estuary activity have students write a paragraph or two on how they can protect the estuary through their own everyday practices.

4. A common misconception from the Managing Your Estuary activity is that only fish are impacted by estuary health, while in reality there are hundreds of plants and animals that are interconnected in a food web that are affected by estuary conditions. To exemplify this, create a classroom food web using a ball of yarn.
    a. Have students stand in a large circle.
    b. As the teacher, start with the ball of yarn and say that you are the sun. Throw the ball of yarn to student while holding onto the end of the string.
    c. This student must "connect" with you as some other estuary organism. Since you are the sun they could say they "I am wild rice that gets energy from the sun."
    d. That student then holds onto a section of yarn and throws the yarn ball to another student, who then "connects" to them. They could say "I am a snail that lives on the wild rice plant that gets energy from the sun."
    e. This cycle continues until every student is holding a piece of yarn and has had a chance to connect to the food web the class has created.
    f. Upon completing the activity, ask the students how this represents the St. Louis River estuary. What happens if a like goes missing? What if all the of the fish disappeared due to an oil leak? How would that affect the web we have created?

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