Artificial Floating Islands: Creating artificial ecosystems for habitat restoration

Artificial Floating Islands (AFIs) are human-made floating structures capable of supporting aquatic vegetation. The idea originated in Canada and has since been commercially applied in many water bodies throughout Japan. In the last decade, many European countries and United States have widely recognized AFIs as a successful tool for habitat restoration (Winston, Hunt, and Kennedy 2012). These AFIs create near-shore mini ecosystems on the water without occupying any shoreline space. Because AFIs use floating platforms to support vegetation, they can move up and down with fluctuating water levels. They can be mobile (nonanchored) or anchored, depending on the different types of water bodies (rivers, streams, ponds, lakes) they serve. AFIs serve various functions, such as water purification through absorption; habitat for fishes, birds, and other organisms; breaking waves; and landscape improvement.

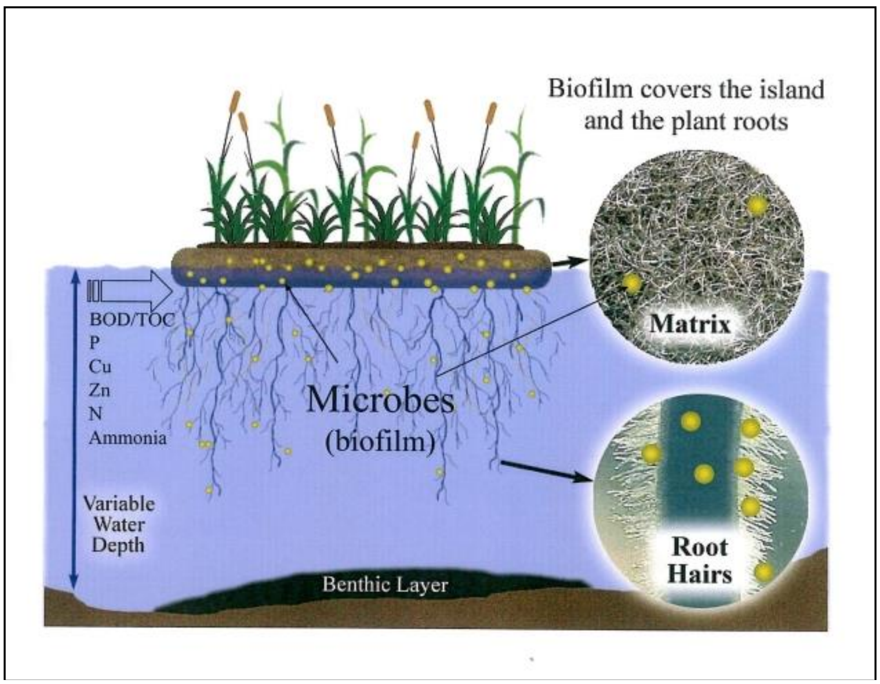

Image showing absorption of nonpoint source pollutants using AFIs
Image courtesy of Midwest Floating Islands

References

Somodi, I., and B.D. Zoltan. 2004. Determinants of floating island vegetation and succession in recently flooded shallow lake, Kis-Balaton (Hungary). *Aquatic Botany* 79: 357–66.

Winston, R., W. Hunt, and S. Kennedy. 2012. Evaluation of floating wetland islands as a retrofit to existing stormwater detention basins. World Environmental and Water Resources Congress: 274–84.

Resources
Artificial floating island (AFI) method—
www.pwri.go.jp/team/rrt/eng/img/report/contentnew2.pdf
Artificial islands mimic nature's way of cleansing water—
http://ensia.com/articles/artificial-islands-mimic-natures-way-of-cleansing-water
Floating island will restore life to Minnesota's Spring Lake—
http://inhabitat.com/floating-islands-will-restore-life-to-minnesotas-spring-lake
How to build a floating trash island—www.lowtechmagazine.com/how-to-build-a-floating-trash-island.html
In Minnesota: Artificial islands made of recycled plastic bottles—
www.mnnature.org/minnesota-artificial-islands
Making a Styrofoam watershed—
www.iwla.org/index.php?ht=a/GetDocumentAction/i/2194

Unit plan: Artificial floating islands

Overview: The objective of this lesson is the creation of AFIs as a context for STEM integration in the curriculum. Embedded in the context of habitat restoration, the AFI presents an engineering-design challenge that integrates meaningful application of math and science.

Standard: MS-LS2: Ecosystems: Interactions, energy, and dynamics		
Performance Expectation(s) MS-LS2-5: Evaluate competing design solutions for maintaining biodiversity and ecosystem services		
Dimension	Name and *NGSS* code	Matching student task or question taken directly from the activity
Disciplinary Core Idea	MS-LS2.C. Ecosystem Dynamics, Functioning, and Resilience	Students investigate the biodiversity and water quality of the habitat where AFIs will be placed and discuss the features of healthy and polluted lakes.
Science and Engineering Practice	Constructing explanations and designing solutions	Students design several AFI prototypes and evaluate them to choose the best prototype to build, test, evaluate, and improve.
Crosscutting Concept	Stability and Change	Students model point and nonpoint source pollution. Students are asked, “How does pollution in a specific area cause changes in another area?”

Big ideas and activities	**Lesson summary**	**Learning objectives**	**Assessments**
Introduction to the context Activities: Reading the	Lesson 1: Introduces the context of a polluted lake. Students discuss what constitutes pollution, what it means to be a “polluted lake,”	Objectives: 1. Read the initial newsletter communicating the problem with the community lake. 2. Discuss the elements of the	Critical reading, vocabulary check

newsletter	what the potential sources of water pollution could be within the context provided.	communication. What is it saying about the water system?	
A lake ecosystem/lake ecology Activities: 1. Testing water quality: abiotic factors (turbidity, pH, temperature, nitrogen, phosphorus) 2. Testing water quality: biotic factors 3. Habitat analysis	Lessons 2: Water quality. Students explore the sources of pollution and pollutants for the lake system identified in the context.	Objectives: 1. Explain why water quality is or is not important for organisms that live at least part of their lives in the water. 2. Use various water-quality parameters to measure the water quality. 3. Illustrate how tolerance to water quality conditions varies among macro invertebrate organisms. 4. Explain how population diversity provides insight into the health of an ecosystem. 5. Students will determine the habitat characteristics of the lake for which they will design the floating island.	Assessment of water quality
Use of EnviroScape model for point and nonpoint source pollution activity Activities: EnviroScape demo	Lesson 3: Students demonstrate how everyone contributes to the pollution of a lake within a watershed and recognize that through a change in individual and group practices and behavior, a difference can be made.	Objectives: 1. Students will differentiate between point and nonpoint source pollution. 2. Students will recognize that everyone contributes to and is responsible for the pollution of a lake's water quality. 3. Identify best management practices to reduce water pollution.	Have students express their opinions about individual contributions to protect water quality. Write a paragraph to identify the sources of water pollution. Differentiate these

			sources into point and nonpoint sources.
Understanding the context of AFIs, "Calling Wetland Rangers"	Lesson 4: Introduces the context of an AFI. Students discuss what AFIs are and what services they provide.	Objectives: 1. Students search online for information on AFIs	Critical reading, vocabulary check
Engineering design for habitat restoration Activity: Design the prototype for the AFI	Lesson 5: Engineering challenge. Students design and create a prototype for the AFI.	Objectives: 1. Students will determine the design of their floating island. 2. Students will list the properties of materials available for their design. 3. Students will choose materials, select plants, and estimate plant positioning for the construction of the floating island prototype. Mathematical analysis: Students will be given a predetermined perimeter for their floating island designs and need to determine the design that will result in the maximum area for the floating island. Students will then need to calculate area to determine the number of plants that will fit	

		on the floating island.	

Lesson 1

Big question: What do we mean by “water pollution”?

Newsletter: Students read that swimming and fishing has been suspended at a nearby lake. Introduced to the context of a polluted lake, students discuss what constitutes pollution, what it means to be a “polluted lake,” and what the potential sources of water pollution could be within the context provided.

Activity:

1. Read the initial newsletter communicating the problem with the community lake.
2. Discuss the elements of the communication. What is it saying about the water system?
3. Brainstorm the plan of action.

Lesson 2

Big question: What does water quality tell us about the health of a lake system?

Objectives: By the end of the activity, students will be able to:

1. Explain why water quality is or is not important to humans, as well as organisms that live at least part of their lives in the water.
2. Explain how pH, dissolved oxygen, phosphorus, and nitrogen affect lake organisms and humans.
3. Make a prediction based on the data that the instructor provides regarding how the ecosystem will change if the water quality is getting worse each year.

Introduction

Nitrogen (N) and phosphorus (P) pollution, also called nutrient pollution, is a common impairment of lake water quality and is responsible for slimy green algae blooms that are a familiar sight on our lakes in the summer. Excess algae growth damages drinking-water supplies, endangers the organisms that live in lakes, and degrades the recreational and aesthetic values of lakes.

In this activity, students will examine the water samples from the identified lake to determine the natural range of factors that indicate the health of water (see the table below for more details).

Water quality is determined by three major means:

- Chemical analysis “water quality” (pH, oxygen, carbon dioxide, nitrates, ammonia, phosphates)
- Biological indicators (invertebrates/fish change in response to the changing chemicals)
- Physical measurements of color, clarity, and conductivity of the water (Secchi disk, conductivity meter)

Normal water quality changes are based on a number of factors:

- Water source (i.e. river, lake, well, swamp)
- As lakes age over geological time, they change from oligotrophic (low productivity) to eutrophic (high productivity) with corresponding changes in the bio-indicators and chemicals
- Pollution sources
    - Nutrients from sewage and agricultural sources
    - Thermal pollution
    - Stormwater runoff
- Natural cycles within the ecosystem (e.g., natural decomposition and decay)

Part A: Physical and chemical analysis

Chemical/test	Sources	Levels	Oligotrophic conditions	Eutrophic conditions	Pollution and unnatural sources
Oxygen Needed for cellular respiration	Rivers: water turbulence in air Lakes : some from air, most produced by plants	5 ppm: good for most gill breathers 10 ppm for trout	High oxygen levels from bottom to surface	High oxygen at the surface, low oxygen at the bottom	Thermal (heat) increase in heat reduction in amount of oxygen Sewage: encourages bacteria which use up the oxygen
pH Measure of acidity	H+ ions in the water	6.7–8.6 supports a variety of organisms	Start basic and become acidic	Start acid and become more basic	Acid precipitation Sewage may increase acidity
Alkalinity Ability to neutralize acids Sum of all bases mostly carbonates and bicarbonates	Closely linked to the abundance of CO_2 and respiration $CO_2 + H_2O = H_2CO_3 =$ bicarbonates + carbonates	50 ppm is low 200 ppm is high	50 ppm less productive	200 ppm more productive	Household cleaners Sewage: increases the number of bacteria which increases the CO_2 and therefore alkalinity
Hardness Measure of calcium and magnesium essential micronutrients	Calcium and magnesium are dissolved in runoff as water flow over the minerals	Soft: 0–60 ppm Moderate: 61 – 120ppm Hard: 121–180 ppm Very hard: > 180 ppm	n/a	n/a	n/a
Nitrogen (ammonia and nitrates)	Released through natural decay of organic matter	Total N for lake < .3 ppm > .3 ppm = algal bloom Ammonia > .5 ppm harmful to gill breathers			Decay of human sewage Decay of waste from farm feedlots Fertilizer runoff from farms and lawns
Phosphorus needed for cellular respiration	Natural decay, faeces, and erosion of soils	Lake should contain < 0.015 ppm or algal bloom will result		n/a	Human sewage Feedlot faeces Detergents *Not fertilizer
Chloride (Cl) needed for cell functions	Natural salt (NaCl) deposits are the most common natural sources	20–50 ppm normal level in rivers and lakes	n/a	n/a	Road salt in the winter Sanitation of sewage with chlorine (300–1500 ppm)
Total Dissolved Solids (TDS)	A measure of all the nutrients and minerals dissolved in the water. A good single measure of productivity.	Lake and rivers vary between 5–200 ppm	< 100 ppm	> 100 ppm	All of the above sources could contribute Treated sewage 300 –400 ppm
Total Suspended Solids (TSS)	A measure of all the undissolved solids in the water.	Levels are used in comparisons only.			Large increases in TSS is an indication of sewage or erosion

Source: Developed by Toronto and Region Conservation Authority's Education Services

Water samples should be collected on the day of the study in sealable jars and kept refrigerated until tested. Glass or clear plastic bottles with airtight lids are considered suitable for the storage of water samples. Each sample bottle should be filled to the top with no air remaining in the jar. Samples should be collected from the center of streams, if possible. Water collected from the natural environment should be handled with care. The quality of the water is unknown and it may contain contaminants. The surrounding land use should be recorded at each site as it may have a direct effect on the water quality. It is not reasonable or economically feasible for all students to do all chemical tests. To ensure consistency, teams of two or three students should test each water sample using the same chemical test. These data can then be shared with the other students. Some tests take up to 15 minutes to complete.

Debrief

Did any of the water samples have higher than acceptable levels? Is this normal (i.e., due to natural processes or is there a potential water pollution problem?) What levels would change with an increase in fertilizer use? What water quality variables would change if there was a sewage leak into the stream or river? Did you detect any of these changes?

Materials

• Water-quality testing kits
• Tests for pH, oxide-reduction potential, dissolved solids content, and temperature

Safety issues

• Care must be taken when collecting the water sample (i.e., slippery surfaces, steep slopes, high or fast water)
• Dispose of wastewater from the tests in an appropriate manner
• Careful handling of water test kits

Lesson 3

Students demonstrate how everyone contributes to the pollution of a lake within a watershed and recognizes that through a change in individual and group practices and behavior, a difference can be made.

Big question: How is each individual responsible for the water quality of a river or a lake?

Activities:

Use of EnviroScape model for student led demonstration of point and nonpoint source pollution.

An EnviroScape model is a three-dimensional, self-contained miniwatershed. It allows students to observe and simulate in real time the interactions of precipitation with various land-use practices and the impacts they have on streams, lakes, water supplies, and ground water. Each model comes with a kit containing cocoa, cooking oil, powdered drink mixes, felt vegetation swatches, clay berms, and props such as miniature vehicles, trees, and cows. These kits are available with the Department of Natural Resources Project Wet Coordinators in every state. They can be borrowed for classroom use free of cost.

Students worked in groups of three or four, set up the models as a watershed, simulated a rainfall using water sprinkler, and then observed sources of nonpoint source pollution. Students were very involved in this activity and were able to identify various sources such as salt on the roads, pesticides, insecticides in gardens, and pet waste.

Lesson 4

Lesson 4 introduces the context of an AFI. Students discuss what AFIs are and what services they provide. Big question: What are AFIs?

Activity:

1. Read the AFI newsletter communicating the use and design of the floating island in the context of Spring Lake in Minnesota.
2. Discuss the elements of the communication. What is it saying about the water system?
3. Students finalize their plan of action.

Lesson 5

Big question: How can we design the prototype of a floating island?

Introduction: This activity will help students to determine the design of their floating island. They will choose materials, select plants, and estimate plant positioning for the construction of the AFI prototype. Students will follow the engineering-design process for creating their prototypes. The five steps of an engineering design process are:

1. Ask: What is the problem? (newspaper article)

2. What have others done? (reuse the floating island newsletter)
   a. What are the constraints?
3. Imagine: What could be some solutions?
   b. Brainstorm ideas.
   c. Choose the best one.
4. Plan: Draw a diagram.
5. Make a list of the materials you need.
6. Create: Follow your plan and create it.
7. Test it out.
8. Improve: Make your design better and test it out.

Activity 1
Ask: Designing a floating island

Students write descriptive answers to the following questions, keeping in mind the givens:

Givens: The perimeter for the floating island must be 66 cm. Students will need to determine the shape that would provide the most area for plant growth. Students record each shape on their worksheet. Students will also need to consider the number of plants the floating island can hold given that one plant can be planted every square inch.

1. What is the goal?
2. What criteria do we need to think about when designing the island?
3. What does a floating island need?
4. What materials are most important for our design?

Plan: Floating island measurements
Use the space below to draw possible shapes for your floating island. Record information about each drawing in the spaces provided.

Drawing 1

Perimeter _____________ Area ______________ Number of plants ___________

Drawing 2

Perimeter _____________ Area ______________ Number of plants ___________

Drawing 3

Perimeter _____________ Area ______________ Number of plants ___________

Drawing 4

Perimeter ___________ Area ___________ Number of plants ___________

Activity 2
Imagine: Designing a floating island

Students are encouraged to think individually and then exchange ideas with a team.

- Brainstorm some ideas for the floating island design.
- Write or draw your ideas in the boxes shown below.
- Keep in mind the criteria for your island design.
- After you have brainstormed, meet with the rest of your team.
- Circle the ideas that are common to all the team members.

Idea #1	**Idea #2**

Activity 3
Design: Designing the prototype for a floating island

Directions: In the box below, draw a diagram of your floating-island design. Label the parts.

1. Shape (circle one)	Circle	Square	Triangle
2. Base material (circle one)	Plastic	Cardboard	Foam
3. Substrate for growth (circle one)	Moss	Plastic grass	Soil
4. Floatability	Empty bottles	Floaters	Ping-Pong balls
5. Plants	Grass	Trees	Plants from the habitat around the lake

Activity 4a
Create: Designing the prototype for a floating island

Directions: Complete the chart below by circling the scores for your design of the floating island. Write your scores in the "Score" column and add them all together to get the total score of your design.

Criteria				**Score**
Buoyancy (Does the prototype float?)	Give yourself a 0 if your island does not float. Give yourself a 1 if your island floats.			
Durability	0 The structure breaks over a short time, within five minutes of floating in the tub.	1 The structure does not break, but shows damage after one or two hours of being in water.	2 The structure is resistant to water. No water damage is seen.	
The island stays horizontal	0 The structure became damaged or tipped over.	1 The structure was somewhat protected or partially tipped over.	2 The structure was entirely protected and did not tip over.	
Plants can grow on the island	0 There is no space for roots to reach water.	1 There is very little space for roots to reach the water.	2 The roots have ample space to reach the water.	
Cost of materials	1 $20 or more	2 $7.01 to $19.99	3 $7.00 or less	
Easy maintenance	1 Do the materials need to be replaced often?	2 Do the materials need to be fixed (glued, taped) often?	3 Materials do not need to be replaced or fixed for a long time.	

Activity 4b
Create: Calculating the cost for the prototype for a floating island

Materials price list:

1 piece of plastic: $4.00

1 piece of cardboard: $3.00

1 piece of foam: $3.50

1 cup of moss: $3.00

1 cup of plastic grass: 2.00

1 cup of soil: $2.00

1 empty bottle: $2.00

1 Ping-Pong ball: $1.00

1 seed: $.33

Cost scoring chart

Cost of floating island	**Score**
$20 or more	1
From $7.01 to $19.99	2
$7.00 or less	3

Cost calculation sheet

Use the table below and the materials price list to calculate how much your floating island will cost to make.

Material	**Cost per unit**	**Units needed**	**Total cost**
Plastic	$4.00	1	$4.00

		Total cost =	________________

Use the “Cost Scoring Chart” to determine your cost score:

The cost score for this package design is: ______________________________

Activity 5
Improve: Designing the prototype for a floating island

1. The total score for our design is: ______
2. Circle the functions or criteria that you will try to improve:

    Buoyancy (Does the prototype float?)
    Durability
    The island stays horizontal
    Plants can grow on the island
    Cost of materials
    Easy maintenance

3. How will you try to improve your design? What will you change?
4. Draw or write ideas for your improved design for the floating island.