VA SEA

DATA-DRIVEN DECISIONS:

SEAGRASS RESTORATION AS AN EXAMPLE OF ENVIRONMENTAL PROBLEM SOLVING

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Grade Level
High School

Subject Area
Environmental Science / Marine Science

The Virginia Scientists & Educators Alliance (VA SEA) is a project of William & Mary's Batten School & VIMS Office of Outreach and Engagement. The VA SEA project is made possible through funding from VIMS, Virginia Sea Grant, the National Science Foundation, and the MacWhorter Family.

Title: Data-Driven Decision Making: Seagrass Restoration as an Example of Environmental Problem Solving

Focus: Students will learn how environmental conditions influence the suitability of sites for seagrass restoration and practice applying ecological criteria to make restoration decisions.

Grade Level: Environmental Science, Earth Science, Marine Science

Virginia Standards of Learning:

ES.10 The student will investigate and understand that oceans are complex, dynamic

systems and are subject to long- and short-term variations. Key ideas include

a) chemical, biological, and physical changes affect the oceans;

b) environmental and geologic occurrences affect ocean dynamics;

e) human actions, including economic and public policy issues, affect oceans and

the coastal zone including the Chesapeake Bay.

ENV.1 The student will demonstrate an understanding of scientific and engineering practices by

a) asking questions and defining problems

b) planning and carrying out investigations

c) interpreting, analyzing, and evaluating data

d) constructing and critiquing conclusions and explanations

f) obtaining, evaluating, and communicating information

ENV.5 The student will investigate and understand that the Earth is one interconnected system through which energy and matter flow. Key content includes

a) Earth's terrestrial and aquatic biomes have distinct characteristics and components;
b) an ecosystem is composed of both biotic and abiotic factors;
c) biotic and abiotic factors may limit population growth in a given area (carrying capacity).

ENV.10 The student will investigate and understand that pollution and waste management affect an ecosystem. Key content includes

a) pollution and resource depletion have potential environmental implications at the local and global levels. These include air and water pollution, solid waste disposal, waste water disposal, depletion of the stratospheric ozone, global warming, and land uses

OC.2 The student will investigate and understand that ocean ecosystems support a great diversity of life.

a) Explain how biotic and abiotic factors affect biodiversity within marine ecosystems.
b) Make, support, and evaluate a claim about factors that promote and control the locations of primary productivity and its effect on ocean ecosystems.

OC.3 The student will investigate and understand that the properties of seawater enable distinct biological and physical characteristics within the ocean and ecosystems.

a) Explain how the properties of seawater (pH, dissolved oxygen, turbidity, density, and salinity) affect biodiversity in ocean ecosystems.

b) Describe the variation of the transmission of light through zones of the ocean and determine biological adaptations that allow organisms to survive within each zone.

c)

Learning Objectives:

The student will be able to:

a) Identify key environmental factors affecting seagrass growth

b) Measure or interpret site parameters and assess their suitability for seagrass planting.

c) Apply critical reasoning to allocate limited seagrass seeds to the most suitable sites.

d) Communicate their decisions and justify them using data and ecological principles.

Total length of time required for the lesson:

50-60 minutes

Vocabulary:

Ecosystem services: the benefits humans derive from natural ecosystems

Environmental threshold: The point where a small change in an environmental factor (like temperature, salinity, or light) causes a big change in how an ecosystem functions or how organisms survive.

Photosynthesis: The process where green plants and some other organisms use sunlight, carbon dioxide, and water to make food (sugars) and release oxygen.

Restoration: The process of helping an ecosystem return to its natural, healthy condition after it has been damaged or disturbed.

Salinity: The amount of salt dissolved in water, usually measured in parts per thousand (ppt) or practical salinity units (PSU). It affects which plants and animals can live in a given habitat.

Seagrass: A flowering plant that lives completely underwater in shallow coastal areas. Seagrass meadows provide habitat for marine life and help stabilize sediments.

Sonde: instrument that automatically transmits information about its surroundings from an inaccessible location

Turbidity: A measure of how cloudy or murky the water is. High turbidity means there are lots of particles in the water, which can block sunlight from reaching underwater plants like seagrass.

Background Information:

Seagrass meadows are critical coastal habitats that provide shelter and food for many marine species, stabilize sediments, and improve water quality. Many coastal habitats, including seagrass, are unfortunately declining worldwide. In order to preserve these ecosystem services, there has been a large increase in restoration attempts. Time and resources are often limited, so we must make decisions on where to focus the restoration effort. These decisions are based off local environmental conditions and the environmental thresholds for the restoration species of interest. Key factors include:

a) Temperature: Optimal ranges vary by species; extreme temperatures reduce survival. Eelgrass is a temperate species, so it cannot tolerate very high water temperatures. It will start to die off.

b) Light availability: Seagrass requires enough light to conduct photosynthesis. Without photosynthesis, seagrass would not be able to grow. And after longer periods of light limitation, it will start to lose biomass. When there are a lot of solids suspended in the water (biotic or abiotic), the water clarity decreases (increasing turbidity), and there is less light that makes it down to the bottom.

c) Depth: Plants need to be in a depth that allows sufficient light penetration. Sometimes it doesn't matter how turbid the water is, light penetration decreases as it travels through more water. This pattern is just more pronounced when water clarity is lower

d) Salinity: Different underwater plants have different salinity tolerances. Eelgrass is a fully marine species, meaning it does not do well in fresh water. It is not typically found in low salinity environments.

e) Presence of other seagrass species: the presence of other rooted plants can indicate that plants can survive there. On the other end of the spectrum, the presence of other plants, typically those in competition with eelgrass can limit the space available

Materials & Supplies:

Paper handouts (printed)

Rulers (cm is best!)

Optional demonstrations (not at all necessary or expected): refractometer, thermometers, Secchi disk

Teacher Preparation:

Handouts

a) Determine difficulty level and adjust handouts accordingly (see "Differentiation" below)
b) Print out one handout packet (6 sites, 1 Secchi key) per group
c) Option to laminate to be reused for future lessons
d) The PowerPoint slides are scaled to a traditional letter paper size (8.5 x11), so they should print one per page. The depth measurements in the answer key assume this paper size scale.
    a. It is recommended to check the depth measurements on several handouts to ensure that the print scale is accurate.

Worksheets

a) Option to have each student fill out their own worksheet for participation credit or have one per group
b) Print desired amount
c) Be sure to exclude the answer they that immediately follows

Differentiation:

Determine difficulty level of activity according to students and classroom goals/constraints, and adjust materials accordingly

a) If you want it to be a bit easier or have a time crunch during your class period, you can keep the temperature and salinity values as they are written on each site
b) If you want added difficulty to the assignment, please delete the text boxes that give temperature and salinity values. Instead, let them determine the values from the thermometer and refractometer images that correspond with each site.
c) This will give the students additional practice in reading measurements
d) Optional: You can also talk about how we know the value we can measure to based on the measurement device we have (18vs 18.5 vs 18.55)

Procedure:

Mini lecture:

Hook**:** (slides 2-4) get the students used to the idea of making decisions, based on conscious factors or otherwise. What would they choose? Why? How might they quantify these factors (5 min)

Transition into how we make these same kinds of decisions during restoration planning

(Slides 5-7) Background information on what is restoration, coastal habitats, why restoration of coastal habitats is important, and introducing the example of seagrass restoration

(Slides 8-15) Introduce the idea of site selection and optimal conditions for species specific restoration. Talk about important conditions for eelgrass (temp, salinity, light availability) and how to measure them.

(Slides 16-17) Introduce in class activity

In class activity:

1. Split class into groups of 4 (or however many is best for your classroom)
2. Hand out printed/laminated handouts, worksheets and rulers (1 each per group)
3. Allow time for students to read instructions in student worksheet
4. Students will measure depth of the water at each site using rulers, determine temperature and salinity values from thermometer and refractometer images, and estimate light availability based on Secchi disk images (key in handout)
5. Using these measurements, they will determine the best sites for seagrass restoration and allocate a certain number of their total seeds (if any) to each site (full details in student worksheet)
6. Come back together as a class and discuss and elaborate on results. (slide 18)

7. Have each group input their best and worst site rankings to a separate table (slide 19). There is also the option to put seed allocations on a separate table to discuss differences in sites besides the best and worst and to discuss their reasoning in how many seeds they chose to use per site (slide 20)
    a. Discuss how it can be easy to tell when sites are absolutely wrong for restoration, but there are a lot of tricky intermediate options that make choosing difficult. Sometimes it is subjective, and we just have to make our best guess in real life too.
    b. We can try our best using the information we have, but sometimes we emphasize the wrong thing, or there is some unknown factor having a large effect

Assessment:

Students will be assessed by their participation during the in-class activity, their groups completion of the worksheet, and their discussion at the end of the class.

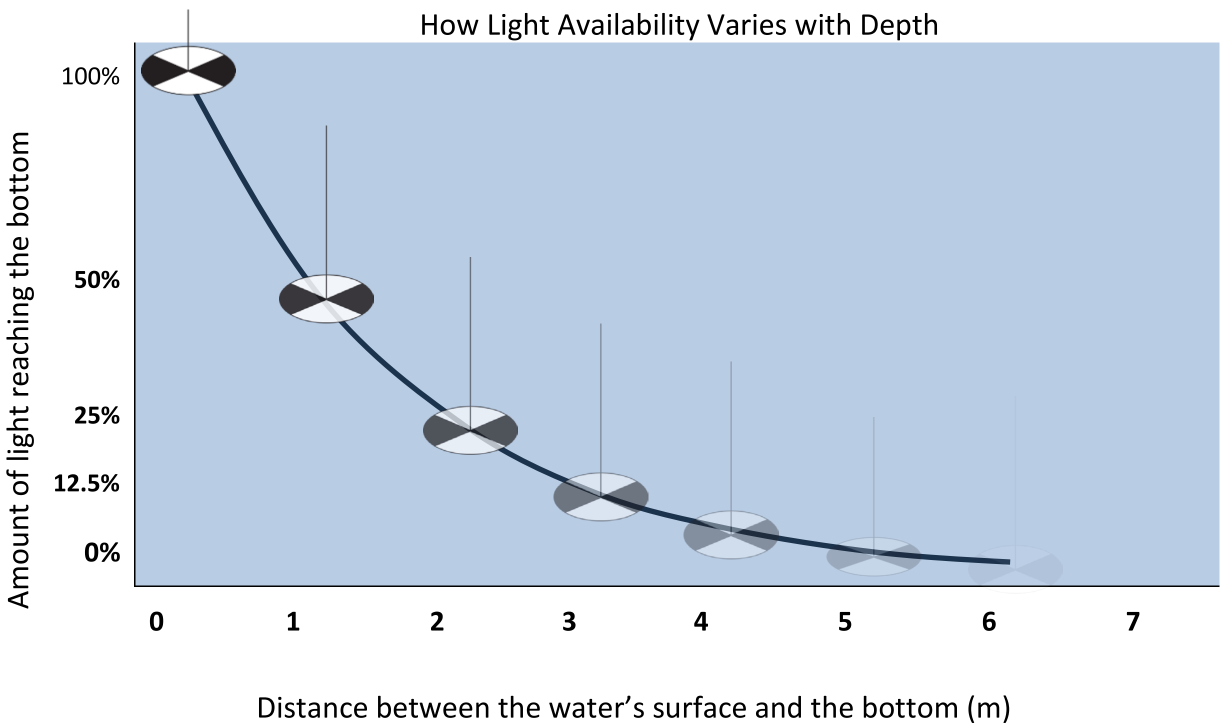
Worksheets/Answer Keys:

Name: ____________________________

Seagrass Restoration Planning in the York River

Warm-up Question:

This graph depicts the general trend of the amount of light available at increasing depths in the water column. Secchi disk visibility decreases with decreasing light availability. Please use it to answer the following questions.



a. How does the water depth affect the amount of light reaching the bottom (where seagrasses grow)? (Hint: what kind of trendline does this graph have?)

b. How would this impact your decision as a restoration manager on what depth to plant eelgrass?

Background: Your grandparents remember a time when the York River was covered in seagrass meadows, but today, there are several locations in the river that have lost their seagrass coverage. They talk longingly about how clear the water was and how many crabs and fish there were to catch. As a coastal scientist, you set out to restore these areas to their former glory. You are particularly fond of eelgrass and have access to 20,000 seeds from another project. Like many other species, it needs the right conditions to grow. Too little light, extreme temperatures, or the wrong salinity can make it hard for it to survive. Your job is to review data from several possible planting sites and decide how to use your limited resources wisely.

Instructions:

Measure and Record Depth: Use your ruler to measure the water depth at low tide by measuring vertically from the water surface (top of the blue box) to the sediment (top of brown box). Record it on your data sheet as meters with this scale: 10 cm on the ruler = 1 m of water depth. These scaled numbers are biologically accurate for the depth range of eelgrass

Estimate Light Availability: Use the Secchi disk key to determine if light availability is **High**, **Moderate**, or **Low** at each site based on how visible the lowest Secchi disk is

Analyze Site Conditions: Compare temperature and salinity to the ideal range for eelgrass

Temp: **5-28°C (tolerable); 10-20°C (optimal)** Salinity: **10-35 PPT (tolerable); 20-35 (optimal)**

Rank Each Site: After filling out the table with these four measurements for all six sites, decide whether each site is comparably **Good**, **Good-Intermediate**, **Intermediate**, **Intermediate-Poor**, or **Poor** for eelgrass restoration.

Allocate Your Seeds: Remember, you have **20,000 seeds total**. Distribute them among the six sites based on your rankings and reasoning. Each site can only hold a maximum of **6,500** seeds.

	Depth (m)	Light Availability	Temp (˚C)	Salinity (PPT)	Rank	# of Seeds
Site 1						
Site 2						
Site 3						
Site 4						
Site 5						
Site 6						

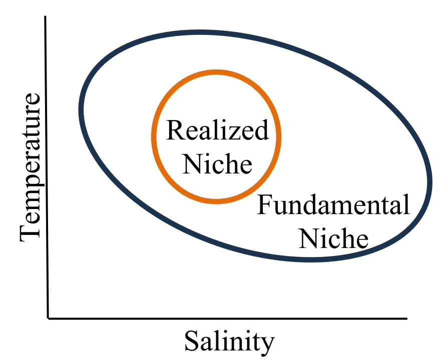
Questions:

1. Which site had the **best overall conditions** for eelgrass growth?

2. Which site had the **worst conditions** for eelgrass growth?

3. Did any sites have both good and bad qualities? How did you decide whether to plant there?

4. A fundamental niche of an organism is the full range of conditions in which an organism can survive. A realized niche is a smaller subgroup of those conditions where you actually find that organism, usually due to other limiting factors (competition, predation, etc.). **Why might this concept be important in eelgrass restoration planning? Please give one specific example of a factor that might limit the realized niche for eelgrass.**



5. What environmental factors most influenced your decisions (e.g., depth, light, salinity, temperature)? Please provide evidence to support your claim.

Name: ________________________________

Seagrass Restoration Planning in the York River: Answer Key

Warm-up Question:

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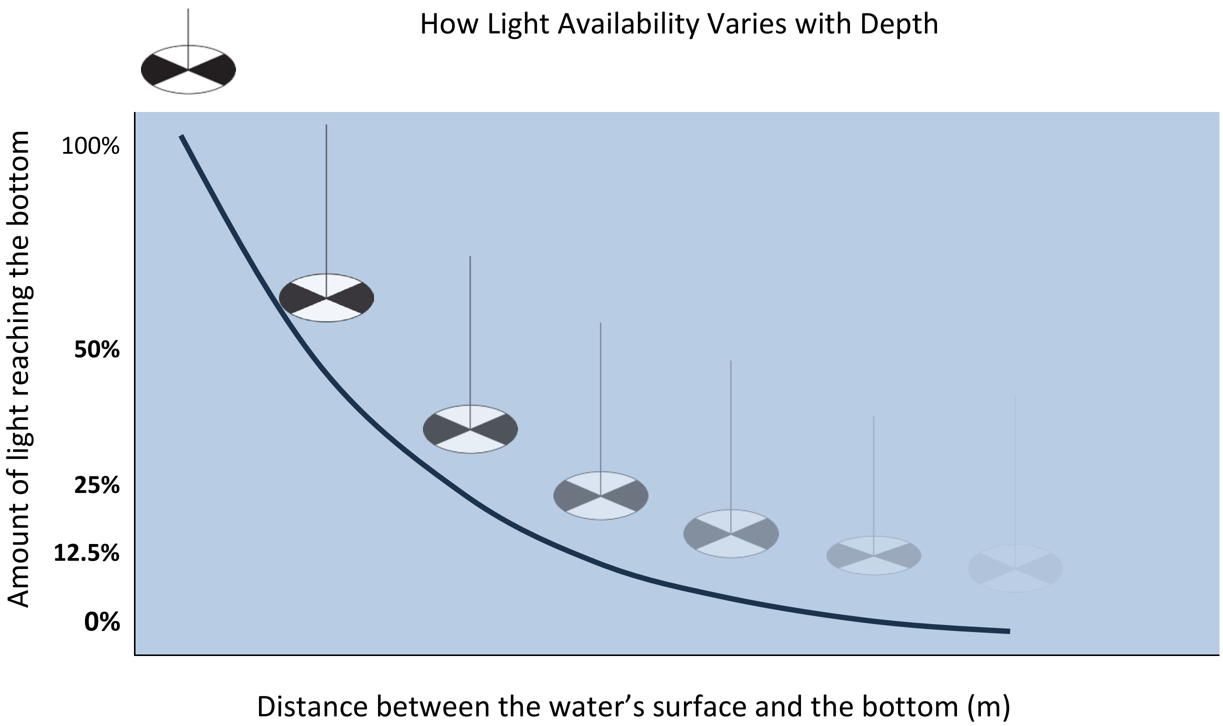

a. How does the water depth affect the amount of light reaching the bottom (where seagrasses grow)? (Hint: what kind of trendline does this graph have?)

   Light becomes increasingly less available with increasing water depth. Bonus points if they talk about there being an exponential decay!

   Optional: As a class you could discuss what makes light less available. Water by itself deflects a certain amount of light, so just by nature of having more water in between the seagrass and their light source, they will be receiving less light at deeper depths. This is magnified by the fact that most water has things in it (sediment, phytoplankton, suspended particles) that further deflect the light and compound with more water.

b. How would this impact your decision as a restoration manager on what depth to plant eelgrass?

   I would choose a site that is shallow enough where enough light can get down to the bottom for seagrass to be able to conduct photosynthesis.

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	Depth (m)	Light	Temp (C)	Sal (PPT)	Rank	# of Seeds
Site 1	1.04	high	25	10	int	3,500
Site 2	0.41	high	21	21	Int-good	6,500
Site 3	1.13	high	17	23	good	6,500
Site 4	1.12	medium	28	33	Int-poor	0
Site 5	1.18	medium	21	22	int	3,500
Site 6	1.02	Low	29	33	poor	0

Questions:

Please answer the following questions:

1. Which site had the **best overall conditions** for eelgrass growth?

   Site 3

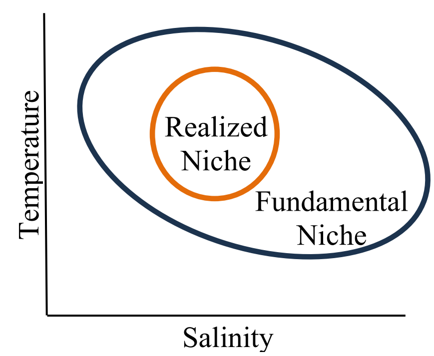
2. Which site had the **worst conditions** for eelgrass growth?

   Site 6

3. Did any sites have both good and bad qualities? How did you decide whether to plant there?

   Many sites had both good and bad qualities. It was important to check to see if these conditions were just on the edge of eelgrass' tolerance range, or fully outside of it. The combination of how many good versus bad environmental conditions is also important.

4. A fundamental niche of an organism is the full range of conditions in which an organism can survive. A realized niche is a smaller subgroup of those conditions where you actually find that organism, usually due to other limiting factors (competition, predation, etc.). **Why might this concept be important in eelgrass restoration planning? Please give one specific example of a factor that might limit the realized niche.**



   There are biological factors that also influence habitat suitability, not just chemical and physical conditions

   Competition with other seagrass species; herbivores eating the eelgrass in those locations; disease in that area; heavy boat traffic that disturbs the bottom; many right answers

5. What environmental factors most influenced your decisions (e.g., depth, light, salinity, temperature)? Please provide evidence to support your claim.

   Light and temperature. Eelgrass has a smaller range of temperature tolerances than salinity, and the sites are more often outside of the optimal range. Light is important for photosynthesis and plant growth, and it is also medium/low at more sites.