Getting to the Core of the Matter

Teaching Notes | Lesson and Answer Key

The topic of carbon sequestration in coastal salt marshes can serve as the basis of an investigation story line with plenty of authentic relevance and drama! Consider establishing the context with students as an introduction to this lesson. Many resources for teaching about carbon uptake and sequestration in coastal wetlands can be found at the Bringing Wetlands to Market website. Some of the elements of the story are:

- ***To understand and address adverse impacts of climate change, action can be taken at all levels, from local to regional to global***
- ***Climate change is linked to high levels of CO_2 in the atmosphere that can be reduced through lowering emissions or removing CO_2***
- ***Salt marsh ecosystems are especially efficient at removing CO_2 and storing it for many years, but only if the marsh is ecologically healthy***
- ***Students can learn about some ways to serve as stewards of local salt marshes or wetlands at the Bringing Wetlands to Market curriculum.***

Suggested Approaches to This Lesson

The lesson may be used in different ways, from a simple analysis of the graphs to a broader investigation on the Earth system processes at work in a salt marsh ecosystem. Some approaches are suggested below.

- Using the text in the lesson, review the background information as a class. Major points are:
  a. The research described in the reading (Bringing Wetlands to Market project) is related to climate change.
  b. The research included studies of the uptake and release of the greenhouse gases carbon dioxide (CO_2) and methane (CH_4) in a New England salt marsh.
  c. The research looked at how the processes of sediment accumulation and carbon sequestration (uptake and storage) in a salt marsh might be affected by sea level rise and temperature change.
- Depending on your students' skill level or the amount of time you have, you can provide them with the graphs or have the students make their own graphs using the raw data.
- Basic graph interpretation:
  a. Distribute copies of one of the graphs to students.
  b. Go over the basic features of the graph (what information is being visualized, scale and units, time span).
  c. Have pairs of students examine the graphs and ask each pair to generate two observations and two questions about one of the graphs.
  d. As a class, share some of the observations and questions and have students propose approaches to answering the questions.
- Digging deeper: Choose some of the students' questions for the class to investigate using the data, and/or choose some of the questions on the "interpreting the results" page.

Suggested Extension Activities

1. To help students understand how sediment cores can record past events, have them make a diagram of a core, using the data and photo included in the lesson. Sketching helps students focus on details and helps them recognize that not all layers or sections of a core are the same.
2. Students could draw a diagram showing how changes in sea level may affect the plant community and salt marsh ecosystem functioning (changes in plant species composition, low/high marsh zonation).
3. Students could make a demonstration model, using a clear plastic tube (for instance, clear tennis ball containers) and different colors of sand, to make a display introducing some of the basic concepts of salt marsh accretion and carbon sequestration to peers or younger students.
4. If you want to delve deeply into making your own cores and even roughly determining the carbon content, follow this link to find directions. Carbon content of plants

Here is a link to the data that was used to develop this activity.

Gonneea, M.E., O'Keefe Suttles, J.A., and Kroeger, K.D., 2018, Collection, analysis, and age-dating of sediment cores from salt marshes on the south shore of Cape Cod, Massachusetts, from 2013 through 2014: U.S. Geological Survey data release, https://doi.org/10.5066/F7H41QPP.

The Getting to the Core of the Matter activity was developed by Meagan Gonneea with editing and review by Chris Brothers, Nancy Church, Laura Hansen, Patricia Harcourt, and Joan Muller.

High Marsh Core

SEDIENT DEPTH INTERVAL (CM)	VERTICAL ACCRETION RATES (mm/y)	CALENDAR YEAR
0–1	2.1	2009
1–2	1.6	2003
2–3	1.3	1995
3–4	1.3	1988
4–5	1.6	1982
5–6	1.5	1975
6–7	1.6	1968
7–8	1.4	1961
8–9	1.4	1954
9–10	1.0	1943
10–11	1.2	1935
11–12	1.1	1926
12–13	1.4	1918

Photo of salt marsh core from Dr. Gonneea's study site.
Photo courtesy Stefanie Simpson.

Teacher Answer Key

Student Pages Intrepreting the Results

1) It is useful whenever you look at a data visualization (graph, chart, or diagram) to make sure you understand what the image is all about before you proceed to interpreting the story told by the data in the visualization.

Examine the graphs your teacher assigns to you. For each of the graphs, be sure you know:

a. What is the title of the graph, and what is the graph about?

Graph 1: *Vertical accretion rates in high and low marsh*
How much sediment is being deposited in the high and low marshes

Graph 2: *Carbon burial rates in high and low marsh*
How much carbon is being stored in the high and low marshes

b. What values are on the X and Y axes?

Graph 1: X *Millimeters per year*
Y *Year (each line represents 20 year span)*

Graph 2: X *Grams of carbon per square meter per year*
Y *Year (each line represents 20 year span)*

c. What do the data points represent?

Graph 1: *How many millimeters of sediment was deposited that year*
Graph 2: *How much carbon was stored that year*

2) Look at the vertical accretion graph and write down two or three notes describing how the vertical accretion rate for each of the cores changes through time.

a. High marsh core

Stays fairly constant, goes up a little in recent years

b. Low marsh core

Very variable. Has been going up in recent years, went down around 1930 and 1970

3) Which core has higher vertical accretion rates for the entire time span?

Low marsh

4) Calculate the average rate of accretion.

Dr. Gonneea measured the total depth of the core she used for vertical accretion from the high marsh to be 130 mm.
The age of the oldest layer at the bottom of the core was 95.8 years.

Calculate the average rate of accretion. To do this, use the total depth of the core over the whole time span and divide this by the total number of years (rate = depth /time).

Total depth of sediment = 130 mm
Total number of years = 95.8
Average accretion rate = *1.36 mm/year*

Dr. Gonneea measured the total depth of the core she used for vertical accretion from the low marsh to be 260 mm.
The age of the oldest layer at the bottom of the core was 100.6 years.

Calculate the average rate of accretion. To do this, use the total depth of the core over the whole time span and divide this by the total number of years (rate = depth /time).

Total depth of sediment = 260 mm
Total number of years = 100.6
Average accretion rate = *2.58 mm/year*

5) Write down two questions you have about the graph and the patterns you observe.

Answers will vary. We've listed a couple possibilities.

Graph 1:
Accretion- why is low marsh more erratic than high marsh? What happened in 1930, 1970 to reduce accretion?

Graph 2:
Why does carbon burial continue to go up in the low marsh in the 2,000s but goes down in the high marsh during that same period?

6) What factors might affect the rates of vertical accretion and carbon sequestration in the low or high marsh?

Amount of erosion or sediment in the water
Storms and other weather conditions
Plant growth

7) Is the high or low marsh system more resilient to sea level rise? Explain why.

The low marsh system would be more resilient since sediment is being deposited there more rapidly than in the high marsh.

8) Sea level rise in this area is approximately 3 mm/year. Do you think this marsh will be able to keep up with sea level rise? Explain your reasoning.

The low marsh may be able to keep up since the more recent accretion rates are greater than 3 mm/year. However, the high marsh is not keeping up with that rate of 3 mm/yr.

9) How might the salt marsh vegetation change as sea level rises?

More low marsh species such as Spartina alterniflora (cord grass) instead of high marsh species such as Distichlis spicata (spike grass).

NGSS Alignment for Bringing Wetlands to Market Lesson Getting to the Core of the Matter

Science and Engineering Practices	Asking questions and defining problems Developing and using models Planning and carrying out investigations Analyzing and interpreting data Using mathematics and computational thinking Constructing explanations and designing solutions Engaging in argument from evidence Obtaining, evaluating, and communicating information
Disciplinary Core Ideas	**HS-ESS2: Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems.** **ESS2.E Biogeology** The many dynamic feedbacks between the biosphere and other Earth systems cause a continual coevolution of Earth's surface and the life that exists on it. **HS LS2.B** Photosynthesis and cellular respiration are important components of the carbon cycle, in which carbon is exchanged among the biosphere, atmosphere, oceans, and geosphere through chemical, physical, geological, and biological processes.
Crosscutting Concepts	**Fits best:** Energy and Matter: Flows, Cycles, and Conservation Stability and Change Patterns Cause and Effect: Mechanism and Explanation

ABOUT BRINGING WETLANDS TO MARKET

This curriculum was supported by the Bringing Wetlands to Market (BWM) project. The BWM project was led by the Waquoit Bay National Estuarine Research Reserve and a multidisciplinary team of partners. For nearly a decade, the BWM team has been at the forefront of blue carbon science, creating the knowledge and tools that communities need to leverage this science to support wetlands management, restoration, and conservation goals, and help facilitate the integration of coastal wetlands into carbon markets.

Support for the project was provided by the National Estuarine Research Reserve System (NERRS) Science Collaborative. By engaging decision makers in the research process, collaborative science projects directly address community needs. Through a national network dedicated to sharing tools and knowledge, local research strengthens all 29 NERR sites and the communities they serve, leaving them better prepared to manage our changing coasts.

To learn more about BWM and access other project resources, please visit: http://waquoitbayreserve.org/research-monitoring/salt-marsh-carbon-project/