Part 2 Exercise 3 Technology and engineering in the field

Focus questions

How can technology help scientists collect the data they need and protect the study area?
How can the engineering design process help scientists access study sites and carry out their research?

Performance tasks

Students will describe the process of designing and developing a technology based tool to support or facilitate sampling
Students will propose ways of protecting their own study area during sampling

Overview
In this exercise, students will consider the challenges of field studies and tackle the challenge of sampling without having a harmful impact on the site.

Time Required
One 45-minute class session.

Background

Technology and engineering help scientists ask and answer questions. In the Bringing Wetlands to Market project, the scientists chose their research questions, but needed to design some technological solutions in order to carry out the studies. In this exercise, students will learn about the innovative technology used to measure greenhouse gases and they will learn how the engineering design process was used to develop a wire mesh boardwalk to solve a sampling problem.

This overview of the engineering design process is adapted from [A Framework for K-12 Science Education: Practices, Cross-Cutting Concepts, and Core Ideas](). You may wish to share and discuss this reading with students as an introduction to the exercise.

> **How do engineers solve problems?**
>
> The design process—engineers' basic approach to problem solving—involves many different practices. They include
>
> - Defining the problem
> - Developing and using a model
> - Investigation and trials
> - Analysis and interpretation of data
> - Application of mathematics and computational thinking
> - Determining solutions
>
> These engineering practices incorporate specialized knowledge about criteria and constraints, modeling and analysis, and optimization and trade-offs.
>
> The fields of science, technology, and engineering are mutually supportive. New technologies expand the reach of science, allowing the study of realms previously inaccessible to investigation; scientists depend on the work of engineers to produce the instruments and computational tools they need to conduct research. Engineers in turn depend on the work of scientists to understand how different technologies work so they can be

improved; scientific discoveries are exploited to create new technologies. Scientists and engineers often work together in teams, especially in new fields.

Engineers must contend with a variety of limitations, or constraints, when they engage in design. Constraints, which frame the conditions under which the problem must be solved, may be physical, economic, legal, political, social, ethical, aesthetic, or related to time and place. In terms of quantitative measurements, constraints may include limits on cost, size, weight, or performance, for example. Although constraints place restrictions on a design, not all of them are permanent or absolute.

Procedure

1. Before students read about the scientists' solutions or see the videos, ask them to consider one problem as an example. Possible challenge questions are given below, or you can create a challenge question that is related to a local field study site or sampling problem..

   a. How could you observe and sample a local wetland from the edge, without actually going out on to the marsh surface?

   b. How could you find out where the level of saturated soil (soil that is full of water) is in a marsh?

Give students a couple of minutes to devise a possible solution. They can be creative - for this exercise, there are no budget constraints!

2. Discuss the proposed solutions as a class. Some points to consider might include how much the solution would cost, whether it would be practical for use in the field, how it would affect the study site, and how well it solves the problem. These considerations can also be applied to the solutions that were developed and used in the project.

3. Next, students will learn about sampling challenges faced by scientists in the Bringing Wetlands to Market project. Have students read "How do you measure something that's invisible?" (included below) about the technology for sampling gases in the field and discuss the questions as a class.

4. Show the video about the salt marsh boardwalk to find out how the project scientists approached and solved the problem of how to access the marsh with heavy equipment, but avoid damage as much as possible. Guiding questions for discussing the video are provided below. You may choose to stop and discuss the questions as you show the videos or discuss the questions at the end.

Engineering Design Challenge: After viewing the video, challenge students to develop a sampling plan for a field study at their own selected study site that would allow access for many student researchers along the wetland border, out on the surface of the marsh, or along a marsh creek without compressing the soil or increasing erosion. The solution will likely involve behaviors and procedures at the site as well as technology.

Ask students to consider the problem, then produce a diagram, picture, or model to show how the plan would work. The designs can be shared electronically, by presentation, or as a display, and can form part of the students' "Adopt a Wetland" project.

Additional engineering design challenge ideas suggested by Waquoit Bay Teachers on the Estuary 2013 participants include:

1. What is the best way to deploy data loggers so that they stay securely in the sampling location in spite of wind, rain, tides, or currents, but are inconspicuous, to prevent theft? Students could choose from a variety of materials such as string, fishing line, plastic or wire ties, bobbers and floats, sticks, meter sticks, etc. to make secure holders for loggers deployed in field studies.

2. Students could design and construct their own turbidity tube (a device to test turbidity, or cloudiness, of water). One way to do this, from Menomonie Middle School in Wisconsin, is given here

3. Students could design and construct a device to allow the user to view under water. A simple example can be viewed here .

4. Students could design and construct a device to extract core samples from a marsh or other sampling site. Note: be sure permission is obtained from the landowner or manager of the site before extracting or removing any type of sample. A video of one design in use is here and the image at right shows a homemade coring device from South Slough NERR in Oregon.

5. Students could design and construct a device to sample water from different depths

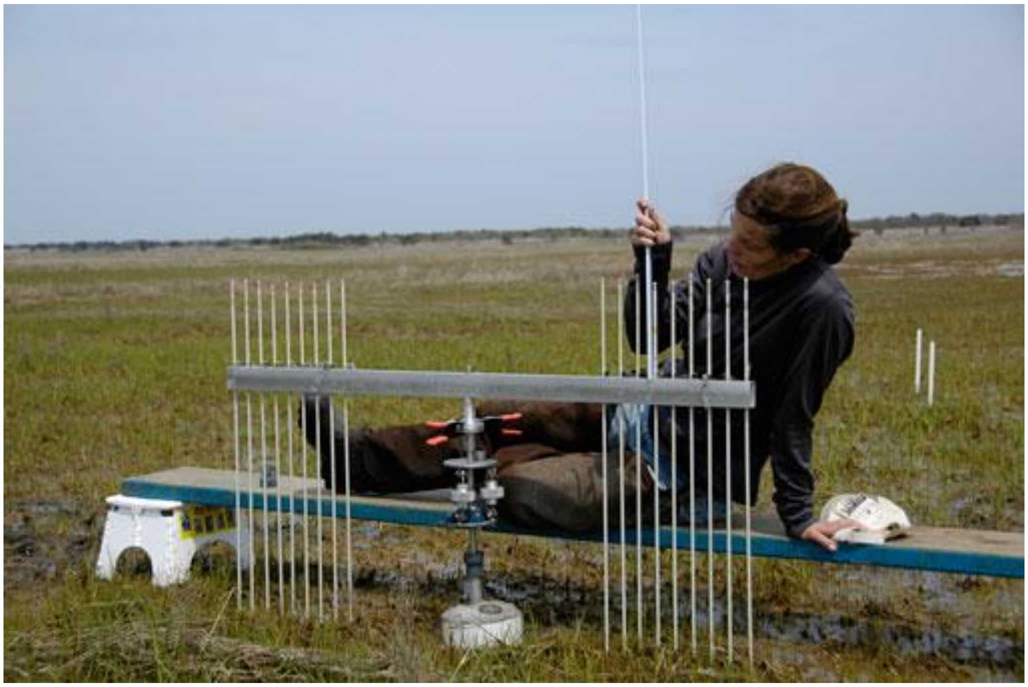
6. Students could design and construct a device to measure wind speed

7. Students could design and construct a device to measure tidal changes

8. Students could design and construct a device to measure tidal or stream current flow

9. Students could design and construct a device to collect water samples from the middle of a stream without going into the stream, since that would solve a safety issue.

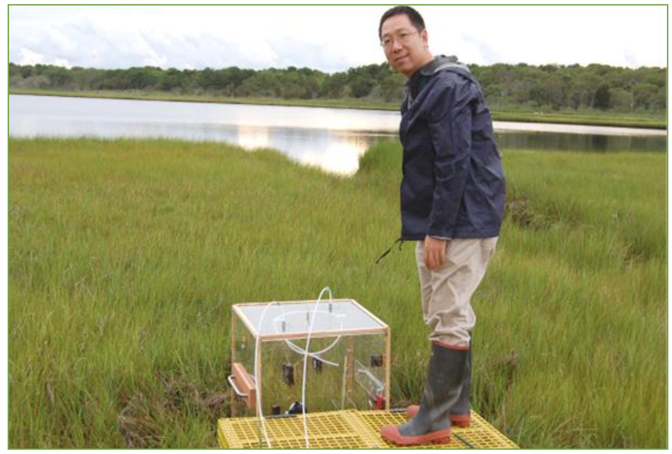
Optional exercise: The rate of sea level rise, and the ability of salt marsh wetlands to accumulate sediments to keep up with sea level, is an important area of research related to climate change. Have students view this engaging and informative 3 minute video, "Measuring marsh elevation using SET instrument" . Students will learn how scientists are measuring marsh accretion using Surface Elevation Table instruments. Discuss how sea level rise may affect the ability of a coastal marsh to sequester carbon.



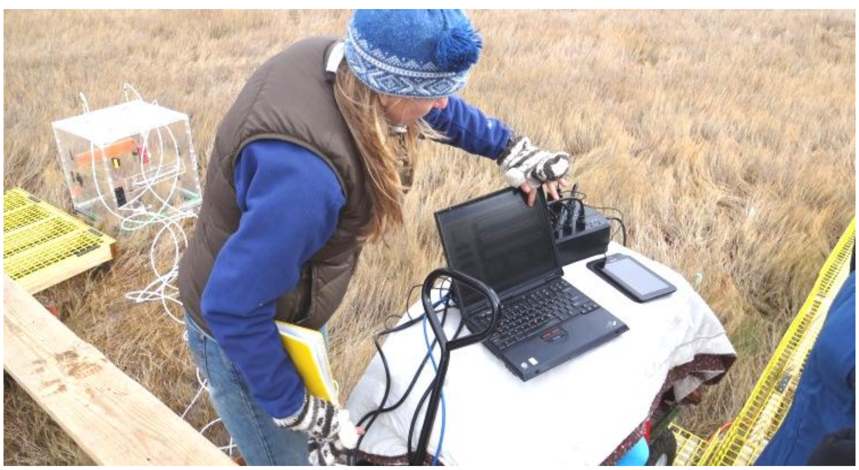
Surface Elevation Table instrument

Student reading
How do you measure something that's invisible?

Dr. Jim Tang and his team needed a way to measure the amount of several gases being taken in and emitted from the salt marsh surface. The team developed a large, transparent chamber system (a 60 cm cube, about 2 ft on a side) to measure vertical gas flux (the flow of gases into or out of the soil and plants enclosed by the cube) in salt marsh. This chamber can be connected to the state-of-the-art gas measurement system for in-situ (in place) measurement of N2O (nitrous oxide), CO2 (carbon dioxide), and CH4 (methane) fluxes.



The air inside the chamber is drawn and circulated within the analyzers, and concentration change is recorded. The team calculates the flux based on the increase of gas concentration over time when the chamber was closed. Vertical gas fluxes have been measured at Sage Lot Pond, the reference salt marsh site, since June 2012.



To compare gas fluxes in high marsh zones (spike grass, *Distichlis spicata*-dominated) and low marsh zones (salt marsh cordgrass, *Spartina alterniflora*-dominated) several sites were chosen. In the low marsh at Sage Lot Pond, a total of 9 plots were established, and in the high marsh, 6 plots were selected for these studies. These were selected to enable the team to quantify as much spatial variation as possible from the boardwalk while minimizing disturbance to the marsh. Measurements were also concentrated in low marsh zones around a tidal cycle (from dawn to dusk).

The team installed "collars," which are fixed in place but open to the air, in several sampling sites. The clear plexiglas sampling chamber can be attached to any collar temporarily to make measurements.

One of the "collars" set in the study area, where the gas collecting chamber can be attached.

Questions for discussion:

a. What are some advantages of this solution?
   The technology allows scientists to sample gases at a precise location and excludes gases from other areas during sampling.

b. What are some disadvantages?
   The device is bulky, collars for the box must be installed and remain at each sampling location on the marsh, and a heavy instrument must be brought close to each site to analyze the gases during sampling.

c. Why do you think the team did not want to leave the gas collecting chambers in place throughout the project?
   Weather, tides, and storm events, as well as possible theft, are some concerns.

Video: Innovations In salt marsh boardwalk design
http://wbnerrwetlandscarbon.net/2012/09/26/innovation-in-salt-marsh-boardwalk-design-4/
Video is 7 min 38 sec

0 – 3:15 Background and overview
Question: What are some of the factors and considerations in the technological challenge the researchers faced?
The distances are large and the equipment is heavy; the boardwalk had to prevent the wheeled vehicles form slipping off.

3:15 – 3:40 Solution to problem
Question: What was the source of the material for the solution?
The scientists used vinyl covered wire mesh from a lobster trap manufacturer

3:40 – 6:35 Process of building the boardwalk
Questions: What were some of the steps in building the boardwalk? How did the team increase the efficiency of the project?
Supports had to be installed; mesh had to be shaped, components had to be fastened together. People worked in teams on specialized tasks.

6:37 7:38 Platforms and ramp
Question: What factor helped the researchers complete the project quickly?
Many hands made light work!