Bringing Wetlands to Market Part 2 Exercise 2
Variability in an Estuary

Overview
In this exercise, students will access, graph, and interpret data from the National Estuarine Research Reserves

Time Required
One or two 45-minute class sessions

Focus questions
How do conditions in estuaries vary over different periods of time and in different places?
What factors influence conditions in estuaries?

Performance tasks
Students will access, download, and graph data from the National Estuarine Research Reserve System
Students will propose explanations for the patterns that appear in the data.

Background for teaching
To visualize the normal range for some of the measurements in the Bringing Wetlands to Market project and learn how they vary over time, students will look at conditions and variability in Waquoit Bay or another estuary using data from the NERRS System Wide Monitoring Program.

Students can do this using the on-line data graphing tool to view measurements over a variety of time scales, and they can compare the patterns of two parameters on the same graph. They can also take real time "snapshot" measurements of several water and weather parameters and monitor the variability over a single class period.

Procedure

1. Ask students to suggest some factors that might affect the amount of carbon dioxide taken up or emitted from a salt marsh.
   Factors might include tide level, sunlight, temperature, and precipitation

2. Have students take a few minutes to look at the graphs of conditions in Waquoit Bay included below, and discuss the questions as a class. Students can refer to the Water Quality Parameters Information Sheet included below for information about factors that influence the different parameters.

   a. What patterns do you notice?

   b. Do the patterns for different parameters appear to be related? How?

   c. What factors or conditions can you think of that could explain the patterns in the graph?

   d. How might each factor be related to plant growth and carbon uptake in a salt marsh?

   e. What questions do you have, and what information would you need to answer them?

3. To investigate the tremendous variability in estuaries, the students will compare conditions in several estuaries around the country. They will make graphs using data from the National Estuarine Research Reserve System. Ask students to choose a particular time period, such as a week in June, and have all the students use the same time period, but access data from different locations.

   Have the students access NERRS data online, construct graphs with one or two parameters, and answer the questions above for their own graphs. Included below are some example graphs from the on-line graphing tool. You may choose to use these to introduce the graph interpretation activity, or use them if students do not have access to the internet.

   Resources for graphing and interpretation:
   The online graphing tool is here Graphing tool for NERRS data
   Instructions for using the graphing tool are available in a brief video here
   Information about factors that influence many of the parameters is available in this tutorial designed especially for students
   This online table of information about water quality parameters is also included below

   Instructions for a simpler graphing tool for NERRS data are here
   This site provides a real-time "snapshot" of present conditions

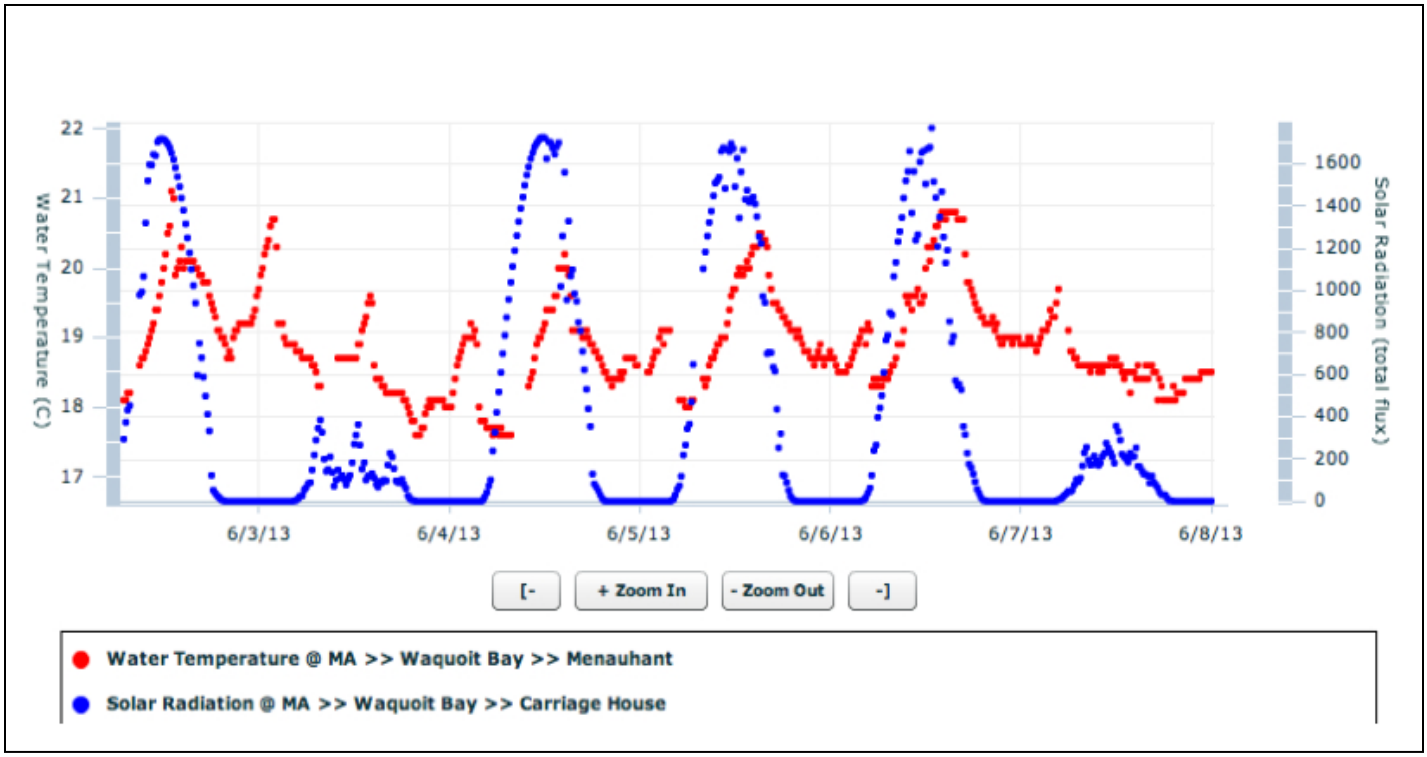
4. Discuss the results with students. Did anything surprise them? What aspects were confusing? How might the variability in an estuary affect a research or sampling plan there?

Optional activity: Students can investigate the process of choosing study sites and setting up research questions for field studies using examples from the Bringing Wetlands to Market project. The activity, “Study sites and sampling locations,” is included below.

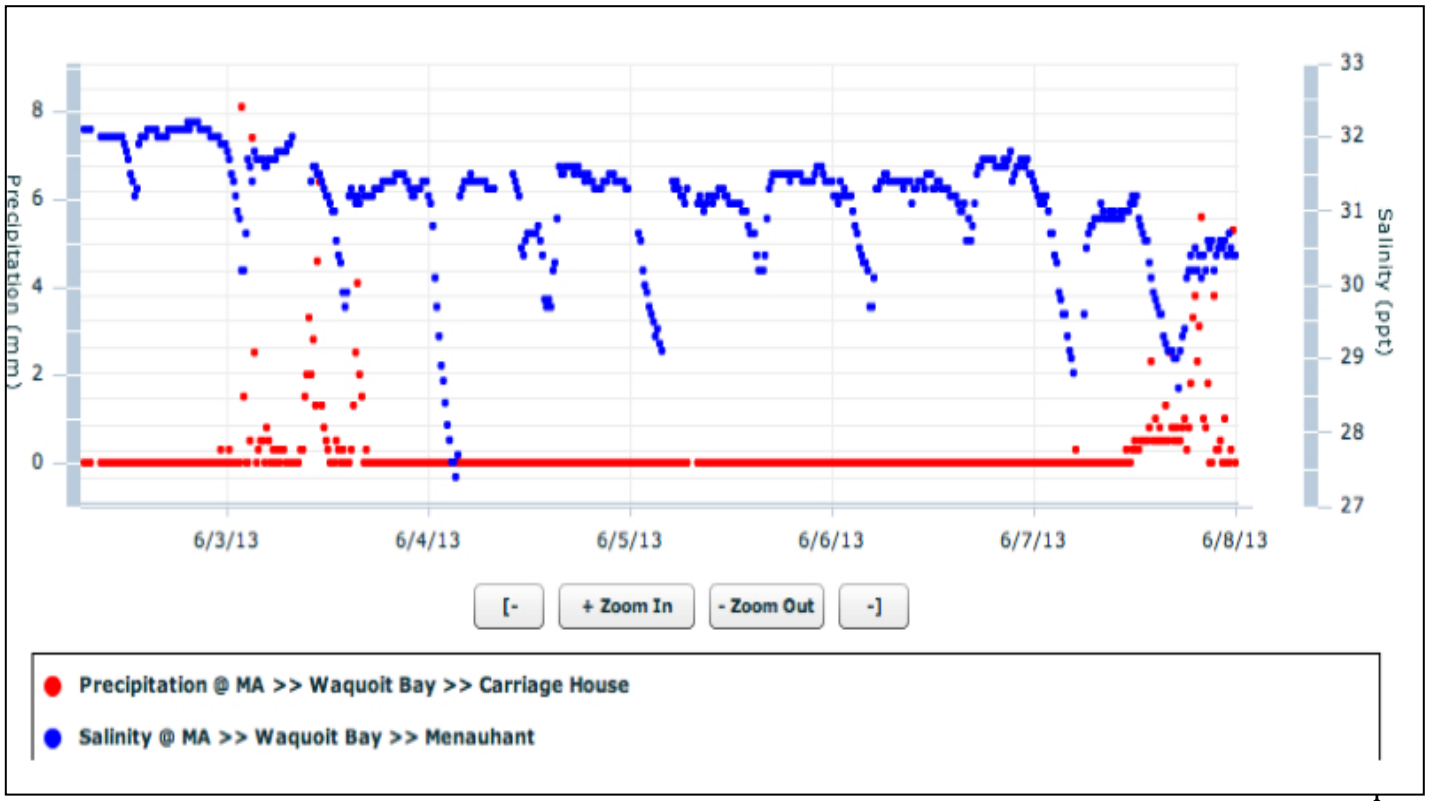
Water Quality Parameters Information Sheet

Water Test	What It Measures	Natural Reading	Danger Reading	Influenced by	Comments
Water Temperature	Amount of heat in water	0° - 30° C	Generally above 27 C (81 F)	-- solar heat -- groundwater --industrial cooling	Many estuarine organisms have a narrow temperature tolerance range
pH	Acidity or alkalinity of water,	Freshwater is typically between 6 and 8; salt water generally 8 or higher	Below 6 or above 8.5; some freshwater areas may have natural pH of 5 - 6	-- local plants and soils -- acid rain -- atmospheric CO_2 -- chemical spills	Low pH levels affect the ability of organisms to incorporate calcium carbonate
Turbidity	Clearness of the water (NOT color)	0-10 NTU, Nephelometric Turbidity Units	Above 20 NTU	-- sediment -- excessive algae growth -- storms	Turbidity determines how much light can penetrate to reach seagrasses. It is an indicator of the level of phytoplankton or silt in the water and is closely linked with eutrophication.
Dissolved Oxygen	Amount of available oxygen in water (in between water molecules)	5-12 ppm (parts per million)	Below 5 = stress 1-3 = poor 0 = anoxic (no oxygen)	-- photosynthesis -- wind -- waves -- running water	D.O. is vitally important to estuary organisms. Warmer temps allow less O_2 to be dissolved. Decomposers may deplete d.o.
Dissolved Oxygen Percent Saturation	Amount of oxygen in water relative to calculated saturation level	0% (anoxia) to 200% (supersaturation)	Below about 70% = stress Below 50% = poor 0% = anoxic, fatal for many organisms Supersaturation, > about 120% can be harmful	~ photosynthesis ~ respiration ~ temperature ~ salinity ~ wind and wave action	A wide variation in d.o. saturation over the course of a day is a sign of eutrophication. Warm water holds less d.o. than cold; salty water holds less d.o. than fresh.
Salinity	Amount of salt in the water	0 ppt (parts per thousand) for freshwater; about 5 – 30 ppt for estuaries; about 35 ppt for oceans	Salinity can be 40 ppm or higher in salt marsh tide pool on a hot day; lethal for most estuary creatures.	--tide level -- rain events -- evaporation -- local geology & soils	Most marine and aquatic organisms are adapted to either fresh water (0 ppt) or sea water (35 ppt). Some estuarine organisms and anadromous fish can tolerate a wide salinity range
Water level	Depth of water	0 m (meters) if uncovered at low tide; up to tens of meters in estuaries	Depends on location; if normally submerged, 0 m is danger reading.	-- tides -- wind direction -- wind speed -- storms -- atmospheric pressure	Estuaries have wide variation in water levels. Some organisms must be able to survive both salt water inundation and exposure to air.

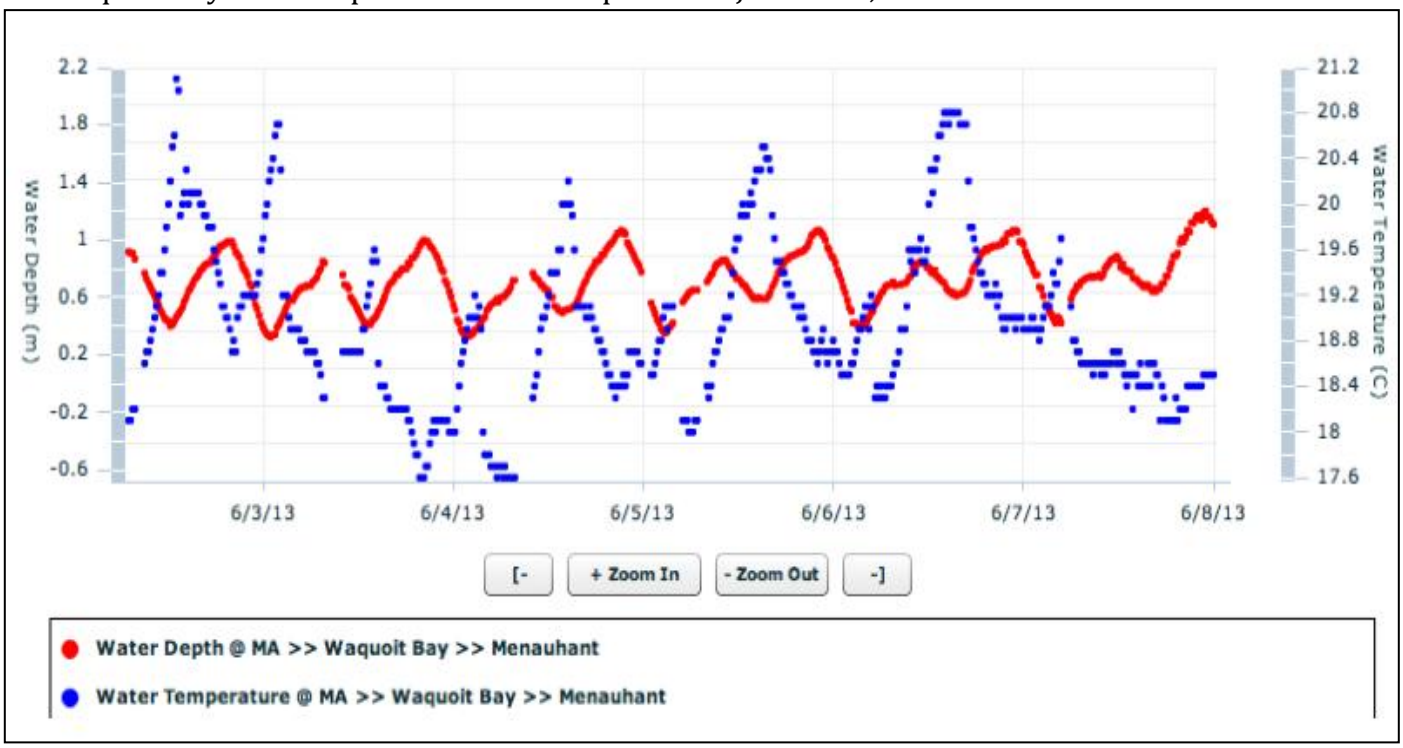
Waquoit Bay water temperature and sunlight June 2 – 8 2013



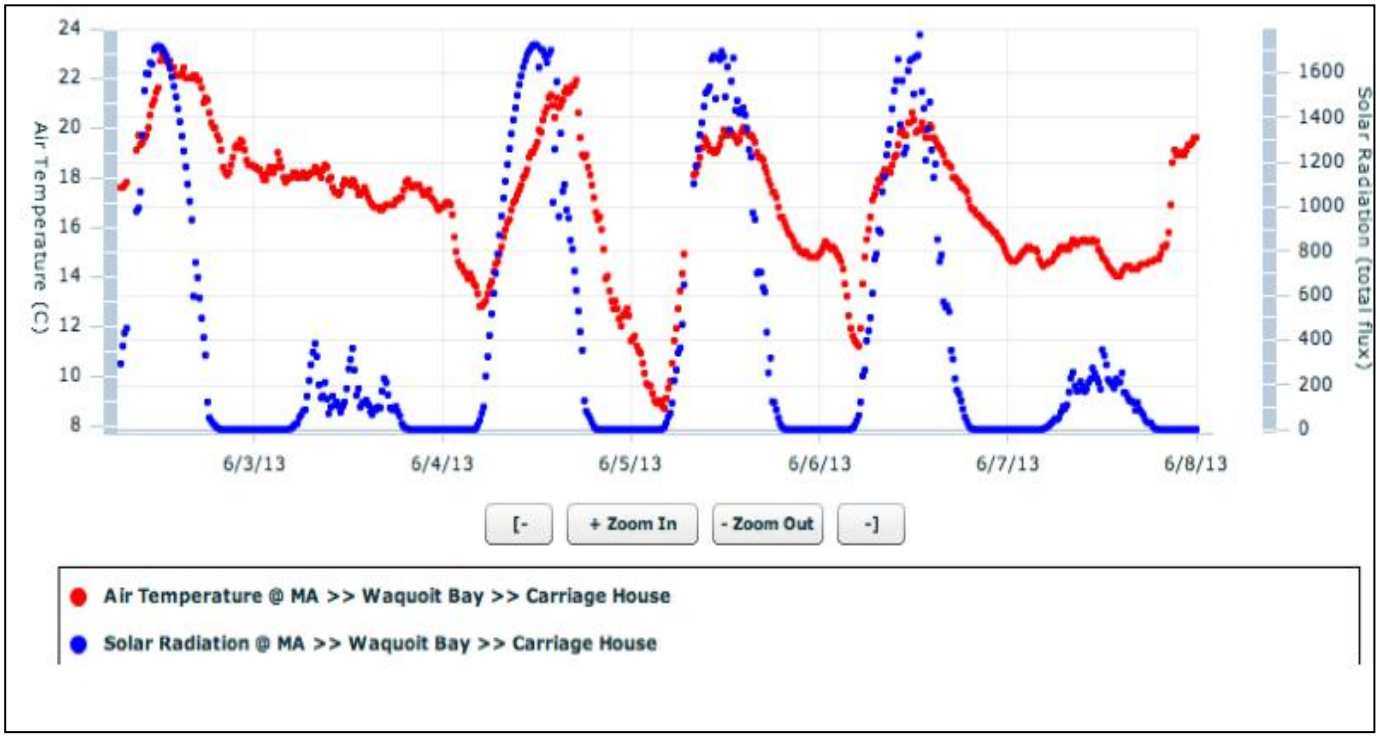
Waquoit Bay precipitation and salinity June 2 – 8, 2013



Waquoit Bay water depth and water temperature June 2 – 8, 2013



Waquoit Bay air temperature and sunlight June 2 – 8, 2013



Study sites and sampling locations

Students can investigate the factors that must be considered when choosing study sites, and discuss some of the challenges of finding answers to research questions in the field.

Materials
"Study Sites for Bringing Wetlands to Market" document
A map server, either Google Maps, Google Earth, or the NOAA CSC Land Use Change Atlas

Background
Study sites and sampling locations
Scientists carry out field studies when they want to sample or observe a process or condition in a natural system. They must consider many factors when choosing a study site. For example, is the site representative of a more general area or process, so that results at the site may be used to help understand other locations? What factors might make the measurements inaccurate or unrepresentative? Is the site safe for people to use, and how much will the sampling process harm or impact the site? Can heavy or bulky equipment be used at the site?

Early in the Bringing Wetlands to Market project, the team of researchers discussed the type of field sites needed to allow examination of nitrogen loading effects on greenhouse gas fluxes, and about 40 potential sites were selected within the larger Waquoit Bay system and neighboring estuaries. These sites were analyzed based on certain physical and biological criteria during a meeting held in February 2012, and the list was narrowed to eleven. These eleven sites were compared based on channel drainage characteristics (including water depth, temperature, salinity, and pH during high and low tide), nitrogen load (both in terms of groundwater input and tidal water input), and plant community.

A site at Sage Lot Pond (see map of study sites) was selected for intensive study. In addition to the Sage Lot site, the team selected three other sites along a nitrogen gradient after visiting nearby salt marshes three times. These sites were selected using a list of criteria developed by the team, such as plant species and diversity, water channel depth and width, salinity, accessibility, etc. With the help of WBNERR staff, the team acquired landowner permission to measure at all salt marsh sites along the nitrogen gradient in August 2012. The field sites now include Sage Lot Pond (no N loading where measurement has been started), Hamblin Pond (low N loading), Great Pond (intermediate N loading), and Eel Pond (high N loading). The team will start to take measurements at all four sites by the end of August.

Procedure

Study Sites for the Bringing Wetlands to Market Project

1. Using the background information, tell the story of how scientists selected the study sites for the Bringing Wetlands to Market project.

2. Hand out or display copies of the map "Study Sites for Bringing Wetlands to Market." Ask students to work with a partner and write three observations about each study site.

3. If desired, have students use Google Maps, Google Earth, or the NOAA CSC Land use change atlas http://www.csc.noaa.gov/ccapatlas/ to look at the land use and amount of development for each of the study sites.

4. Ask students to propose descriptions of each site based on the selection criteria: plant species and diversity, water channel depth and width, salinity, and accessibility. Which of these criteria might be different at the different sites? Which might be similar?

5. One of the main factors for selection was that the sites should be in locations with different levels of nitrogen input. Based on your interpretation of the maps and the information form the reading, what is likely to be the main source of nitrogen in the study sites?

Bringing Wetlands to Market Sampling Map

1.Distribute copies or project a copy of the Bringing Wetlands to Market Sampling Map.

2. Explain that this is a GIS map with a great deal of coded information. Work as a class or have students answer the questions on their own or in teams.

3. Remind students that they can use this sampling plan to guide their discussion on where to sample in their own field study.

Questions:

a. What does the small blue and white map in the upper right corner represent?
The inset shows the region where the study site is located

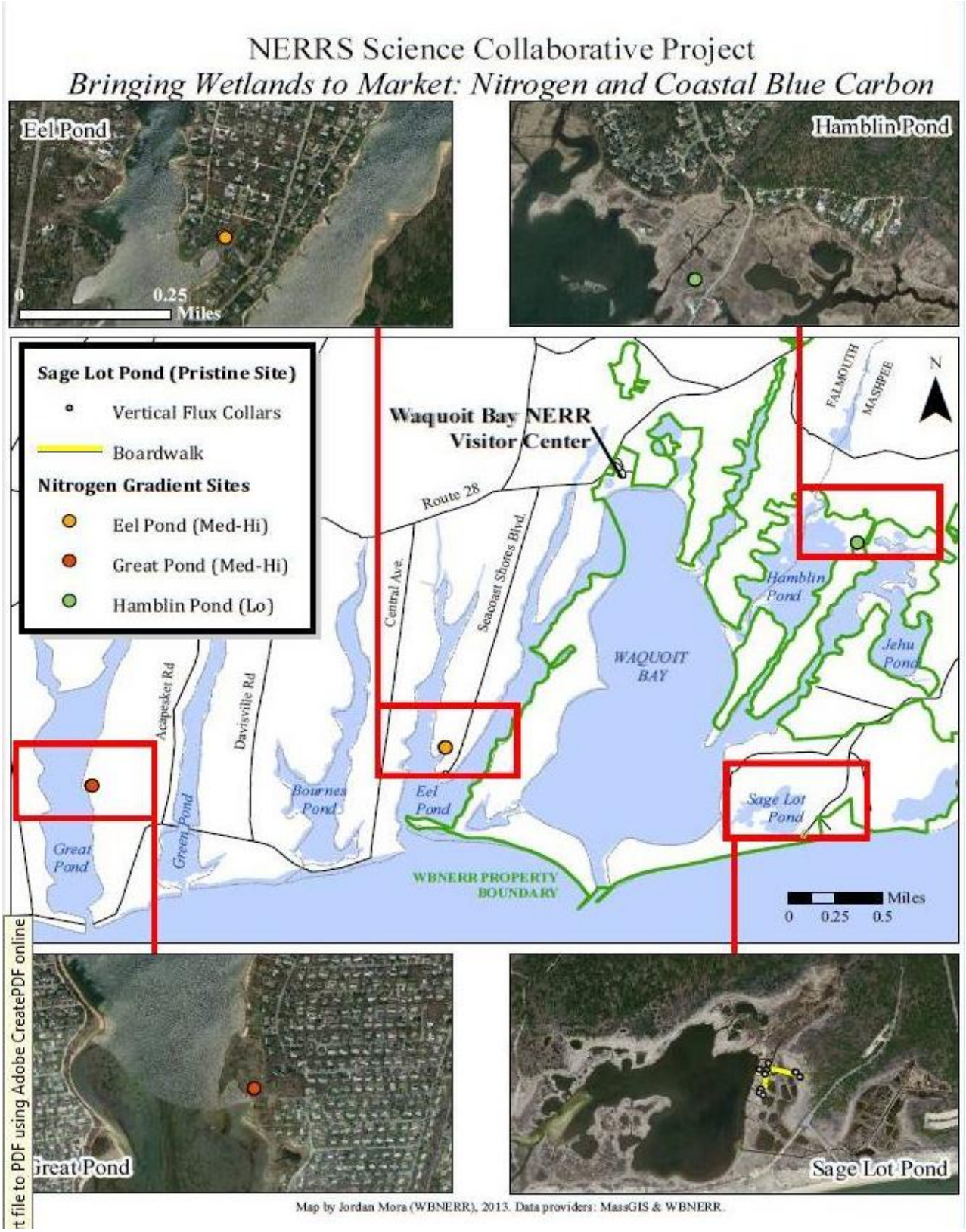
b. What do the brown, orange, green, and yellow colors represent? If you were at the study site, what would look different to you in each of the different colored regions? (Refer to the salt marsh zonation diagram below)
The colors denote higher elevations above sea level

c. What do the dark green squares represent and what type of sampling is done there?
These mark the sites for sampling vegetation for species and density of plants

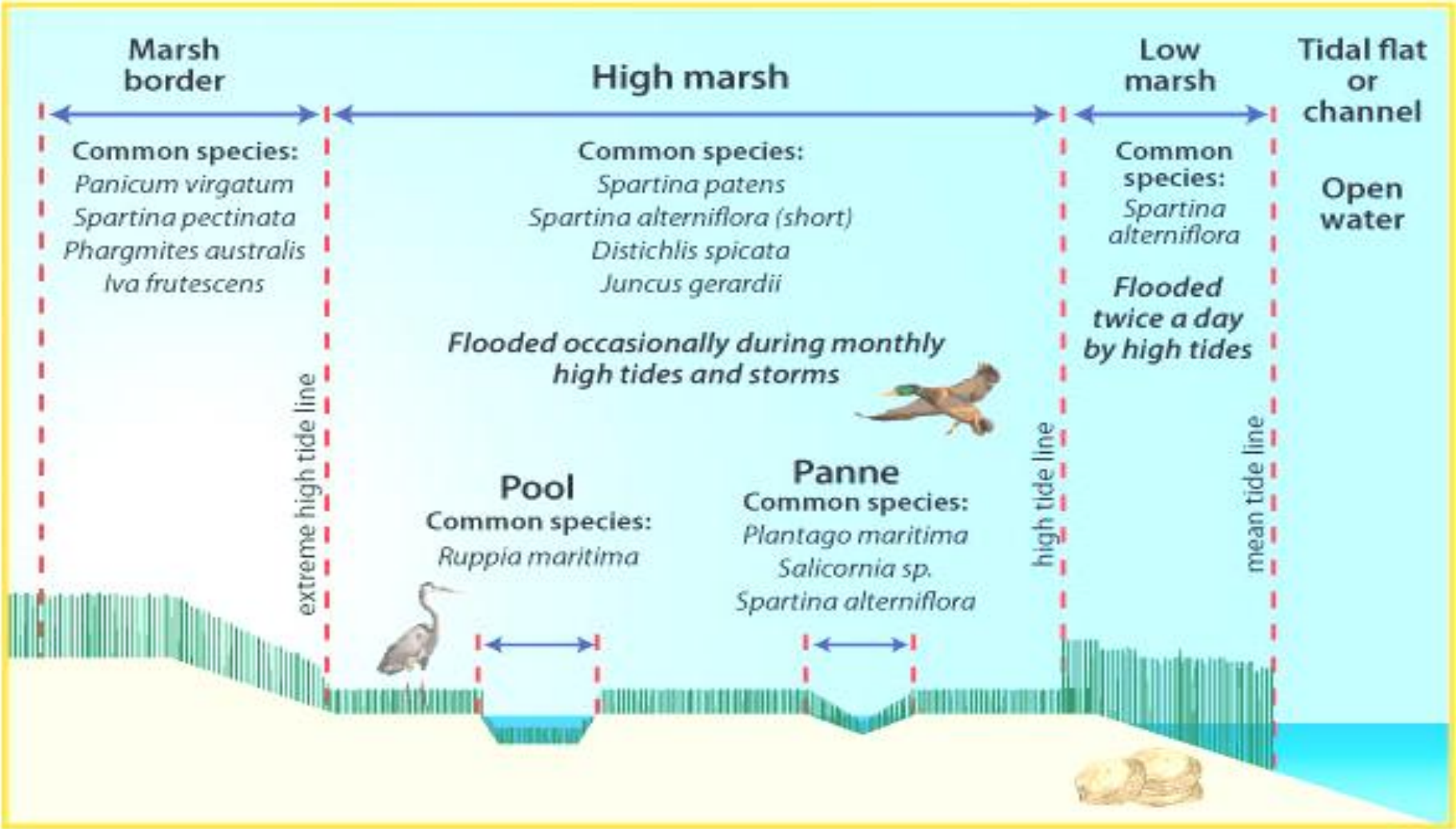
d. Why are the dark green squares in long straight lines?
They are transects following an elevation gradient

e. Why is the weather station measuring photosynthetically active radiation (PAR) at this location
It is placed to collect data that is representative of conditions out on the marsh.

Map of Study Sites



Salt marsh zonation diagram from UMaine Sea Grant



Bringing Wetlands to Market: Nitrogen and Coastal Blue Carbon

Primary Field Site:
Waquoit Bay NERR, Sage Lot Pond

Research Access

- Boardwalk
- Cleared Trail

Pre-existing Biomonitoring Design

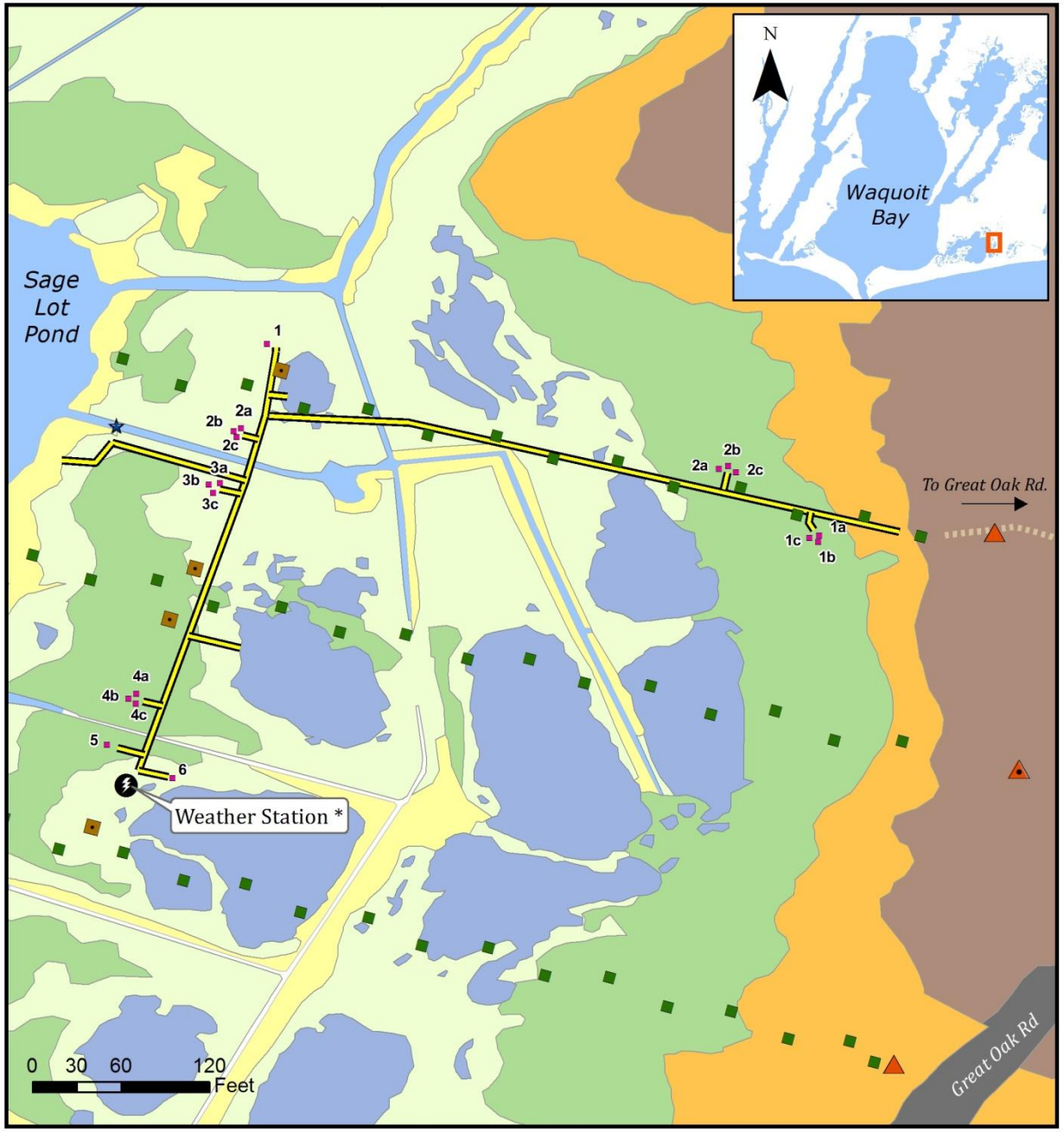
- Vertical Control: Concrete Monument
- Vertical Control: Deep-driven Rod
- Surface Elevation Tables
- Vegetation Plots

Greenhouse Gas Measurement Sites

- Vertical Flux Collars
- Lateral Flux

Land Cover

- Upland Forest
- Roadway
- High Marsh - High
- High Marsh - Low
- Low Marsh
- Marsh Border
- Salt Marsh Pools



* Weather Station Parameters: PAR, Solar Radiation, Rain Gauge, & Wind Speed/Direction

Project funded by NERRS Science Collaborative
Map Created by: J. Mora, updated April 2013
Habitat data (2004) source: Waquoit Bay NERR
USGS orthos (2009) source: MassGIS