
Summer on the Marsh

Sampling Protocol

Developed by Dr. Tom Trott,
2014 Science Advisor

Revised by Dr. Meagan
Gonnea, 2015 Science Advisor

“To stand at the edge of the sea, to sense the ebb and flow of the tides, to feel the breath of a mist moving over a great salt marsh, to watch the flight of shore birds that have swept up and down the surf lines of the continents for untold thousands of years, to see the running of the old eels and the young shad to the sea, is to have knowledge of things that are as nearly eternal as any earthly life can be.”

— [Rachel Carson](#)

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SUMMER ON THE MARSH

PROJECT GOAL AND OBJECTIVES

Goal

Enhance the capacity of marine science centers to engage youth ages 9-12 in field-based citizen science for protection of coastal waters.

Objectives

- 1.) Develop/disseminate a replicable model for education-focused citizen science.
- 2.) Facilitate mutually beneficial collaboration between scientists and educators.
- 3.) Provide young people with context, tools and follow-up to understand the significance of monitoring salt marsh health, especially as it relates to human health.
- 4.) Provide career development to scientists and educators through joint professional development and to participating youth through contact with those practitioners.
- 5.) Increase awareness of connections between human health and the environment.

SAMPLING RATIONALE AND PROTOCOL

Rationale

The educational experience gained through using this protocol will be enhanced by general observations of the marsh and its inhabitants. This will impart an appreciation of a precious ecosystem as essential to the health of our society through its aesthetic, recreational, and economic values. The purpose of this protocol is to provide a standard procedure for gathering information that will show some general features of salt marshes. For example, temperature can be shown to generally decrease and pore water salinity increase when marsh elevation gradually declines as the sea coast is approached. These relationships are largely due to the influence of tidal flooding. Upon this backdrop of the physical environment, changes in vegetation reliant on temperature and salinity can be associated. For example, plants that are less salt tolerant are located in the high marsh where lower salinities and higher temperatures occur. At lower elevations, living conditions for many organisms become harsh where salinity increases since the marsh is inundated by tidal waters. Here the types of plants change and their diversity decreases. Similar changes in the distributions of animals occur. For instance, ribbed mussels are found at the lowest elevations in the low marsh near creeks where they are regularly flooded by high tides for prolonged periods of time. In contrast, the gill-less coffee bean snails “breath” air and are generally more abundant at higher elevations where the marsh is briefly flooded by high tides.

General Description of the Protocol

Upon arrival at the marsh, a period of quiet time will be spent at the entrance point to seek and record birds and animals yet to be disturbed by the presence of the team. Minnow traps should be deployed near this point in time so they are submerged a maximum period before retrieval and inspection prior to leaving the marsh. After this instructional phase, sampling will take place along a line transect stretching from the point the marsh is entered to the sea coast (or major body of water). Elevation, temperature and salinity will be measured at specified points along its length. In addition, three sample quadrats (1m²) will be positioned along the line-transect at mid-distance within each marsh zone (high, mid, and low marsh). Within each quadrat, vegetation will be characterized by % cover of dominant species and their canopy height. The presence of animals will be recorded and insects collected with a sweep net for coarse identification and counting. The locations of pannes that are both intersected by the transect and located within a 10-m radius of a quadrat will be recorded and their dimensions measured. Other general observations will be made while on the marsh including sight and sounds of animals and birds, presence of plastics and other materials of human origin (fishing gear, rope, nets) and the presence and general composition of rack (drift) lines.

This protocol is divided into two major sections: pre-sampling exercises and sampling exercises. Each is further divided into subsections with a narrative describing the procedure to be followed.

PRE-SAMPLING EXERCISES

The first step in achieving the goals of (1) teaching an understanding of the significance of monitoring salt marsh health, especially as it relates to human health, and (2) increase the connection between human health and the environment, is the selection of marshes that have received minimal impact from human activities. An indirect benefit of making selections this way is the resulting degree of similarity among marshes sampled during the project. Marshes need to be selected prior to sampling both to meet expectations of low impact and to plan where to make measurements on the chosen marsh. In addition, knowing the location of features of interest prior to sampling will facilitate group activities and minimize impact on the marsh by the sampling team by reducing search time.

Marsh Selection

Sampling sites need to be selected well in advance of sampling day in conjunction with the Summer on the Marsh project Science Advisor. In general, selected marshes should not be located close to any major industrial complex, roadway, or artificial coastal barriers that would restrict tidal flow through the marsh. These barriers include bridges, culverts and dams.

This protocol was developed to show basic trends in abiotic and biotic features of marshes. These will be measured along a line transect extending from high to low marsh. The line transect should begin near an undisturbed woodland and end in a marsh river, creek, bay, or salt pond. If your camp employs the protocol over multiple weeks, the transect line should bisect a different part of the same marsh in each subsequent week. Thus, the number of transects should

equal the number of times the camp visits the marsh. This serves to increase the spatial sampling on the marsh and better characterize vegetation, elevation and salinity. The transect locations should be distributed evenly across the marsh prior to the first sampling.

Here are a few basic elements to consider when selecting the marsh and positioning line transects for summer field work.

1. Optimally, the marsh should have experienced minimal anthropogenic impact. Activities such as mosquito ditching, haying and similar activities should be historical and not currently occurring where line transects will be positioned.
2. The marsh should be located a good distance away (100 yards minimum) from development, industrial complexes, roads and other anthropogenic influences that could influence biodiversity, hydrology, and marsh zonation.
3. Since fish traps will be deployed to estimate biodiversity, access to planned sampling locations is necessary either by foot or boat.
4. Since measurements (pore water salinity, elevation, temperature) will be taken along the line transect, the marsh surface will need to be accessible.
5. The line transect should not cross any man-made structures.
6. If the line transect crosses creeks or ditches, safe access across these features is needed.
7. Each line transect should be positioned where ocean/shore affects along its long axis are minimized. In other words, if it is parallel to the shore the transect should be far enough away so that ocean water will not disturb the expected slight salinity gradient measured from high to low marsh. For example, if the line transect is near and parallel to dunes, then most of the transect could run through high marsh with little low marsh represented.
8. Multiple transect lines should be parallel to one another and evenly distributed across the marsh.

Surveillance of the Selected Marsh

Once a marsh has been selected, some marsh features will be surveyed remotely and later ground-truthed to confirm their validity prior to the day of sampling. These steps will be completed using two methods: Google Earth (GE) imagery and visiting the sample site before sampling day for reconnaissance.

Why do this exercise? One of the objectives (#3) of the project is to help young people to understand the significance of monitoring salt marsh health. Dieback and marsh collapse are two erosion problems currently observed in tidal marshes. By comparing time-stamped GE images

with real time ground observations, changes in the number and size of pannes (bare surfaces caused by vegetation loss, among other things) can be documented. In addition, marsh scarps which cannot be seen in GE images can lead to collapse of the low marsh. Marsh collapse can be seen in GE images as recessed marsh shoreline.

Google Earth Exercises

Marshes can be divided into high, mid and low marsh, each distinguished by their plants and physical characteristics. These zones will be visualized and the location of the sample transect will be planned using Google Earth (GE). Find your marsh using GE and mark down the date that the image was taken (not the date that you are looking at the image) on **Data Sheet A**. The image date appears on the bottom margin of the screen you are looking at. Next, draw your line transect from the upper limit of the high marsh to the lower limit of the low marsh. Record the GPS coordinates in decimal degrees of the start and endpoints of the transect and estimate its total length. **It is very important to use consistent formatting of coordinates throughout the protocol.** Aim for a transect length between 50 and 100 m to facilitate communication between groups (longer distances will require walkie-talkies). Record the coordinates of any major features intersected by the transect (ditches, pannes, creeks) plus any other physical marsh features to be sought in the field (wrack line, boulders, access routes). Depending on the date of the image you are looking at, some of these features may have changed in present-day. That these features are still there will be validated later during the pre-sampling day visit to the marsh. Repeat for each planned transect.

Plan the locations of three, 1m² sample quadrats, one positioned mid-way in each of the marsh zones along the line transect, and record their GPS coordinates on **Data Sheet A**. Marsh zones can be delineated using the following definitions:

High marsh. The high marsh is infrequently flooded during spring tides and/or storm surge. The lower limit of the high marsh will be delineated by the presence of *Spartina patens* and a wrack line usually visible in a GE image.

Mid marsh. The mid marsh experiences variable tidal flooding. The lower limit of the mid marsh will be determined by the presence of *Spartina alterniflora*. The lower limit can usually be detected by a change in the shading in your GE image.

Low marsh. The low marsh experiences daily tidal flooding. The lower limit of the low marsh will be determined by the sea shore or major body of water at the end of the sample transect.

Remember that this is a planning exercise and that you will be visiting the marsh prior to sampling. It is meant to make locating the line transect and quadrats easier and reduce time spent and impact on the marsh. If your GE image lacks visible definition making it difficult to define the marsh zones as described, and therefore plan the locations of sample quadrats, you will have the chance to accomplish this during your pre-sampling visit.

Here is a list of components and data you should have when the GE exercise is completed.

- 1.) Date of the GE image.
- 2.) *Sample Transect*. The length of the sample transect (minimum 75m) and the GPS coordinates in decimal degrees at the transect start and end points to be used as a guide in the field.
- 3.) *Sample Quadrats*. The GPS coordinates in decimal degrees of three 1m² sample quadrats positioned along the line transect near the middle of each marsh zone.
- 4.) *Major Physical Features*. The GPS coordinates in decimal degrees of major features intersected by the sample transect and near the quadrats (within a 10-m radius) will be noted. These include wrack line, pannes, ditches, creeks, and boulders.

Pre-sampling Day Marsh Reconnaissance

The marsh will be visited prior to sampling day to translate the GE site plan to the actual marsh. A GPS unit (set to record in decimal degrees) and the printout of the Google Earth image will be needed to find/confirm the locations found on the GE imagery, confirm access routes to the marsh and get an estimate for travel time and walking your planned transect. Bring a hammer and wooden stakes (or yellow plastic tent stakes) with brightly colored surveyors tape to mark positions of the line transect and quadrats, and a transect tape to measure transect length and quadrat positions. Walkie-talkies will be helpful if available to facilitate communication and cut down on walking on the marsh. **Data Sheet B** will be utilized to record your findings, including actual length of your line transect, actual positions of quadrats, major physical features, notes to help remind about marsh access, and highlight what aspects to look for when you bring the students on sampling day. Recording GPS coordinates of all sampling components is essential in case physical markings are lost either within a summer season or between years. The coordinates will also help to identify locations and changes in physical features over the same time frame.

The first exercise will involve positioning of the actual line transect and quadrats using what was planned using GE imagery. Marking the start and end points of the line transect will save time on sampling day. These points will be verified by matching your GPS meter and GE GPS coordinates before marking them with wooden stakes driven into the marsh using a hammer. If you need to relocate your line transect from the planned position, record the new GPS coordinates of the start and end points. Record the length of your line transect in meters. In addition, the positions of the high, mid, and low quadrats will be established along the line transect using the GPS coordinates recorded from GE imagery and marked with stakes. There are at least two instances when repositioning of the planned quadrats may be desired. On the occasion that there is a creek or ditch where the quadrat sample was planned, relocate the quadrat on the line transect one meter away from the bank of the waterway. Also since vegetation may be easier to identify on the ground as opposed to GE imagery, you may want to reposition quadrat locations on the line transect and record the new quadrat GPS coordinates. Since the mid-zone quadrat locations are approximate, the new positions can be located either above (towards the

high marsh) or below (towards the low marsh) those originally planned. Re-positioning is an instance when convenience can be used to make decisions.

Locate major physical features encountered by the line transect and within a 10-m radius of the quadrats, recording their GPS coordinates. Examples of such features are pannes, creeks, ditches, and the wrack line. When not crossed by the line transect, record their point closest to the transect. Make notes to indicate whether or not pannes were visible on the GE imagery since some may have formed after aerial surveillance. Likewise, note if pannes seen in the imagery are no longer visible on the ground to signify change.

Here is a list of components and data you should record on **Data Sheet B** after visiting the sample site.

- 1.) *Sample Transect*. The length of the actual line transect and the GPS coordinates at the transect start and end points which have been marked with stakes.
- 2.) *Sample Quadrats*. The GPS coordinates of positions of three 1m² sample quadrats located along the line transect near the middle of each marsh zone that have been marked with stakes.
- 3.) *Major Physical Features*. The GPS coordinates of major features intersected by the line transect and near the quadrats (within a 10-m radius). These include wrack line, pannes, ditches, creeks, and boulders.
- 4.) Notes to help guide sampling day activities referring to marsh access, spots which might be challenging to navigate along the line transect, how long it takes to walk the line transect, animal markings and birds to look for, and anything else that might assist sampling day activities.

Pre-Sampling Day Preparations

The chances of not having an essential piece of equipment once out on the marsh will be significantly reduced by making preparations the day before bringing the sampling team to the marsh. Nothing can be more disappointing once out on the marsh with the sampling team than to find the camera, GPS meter, transect tape or any other essential piece of equipment has been left behind. The tide waits for no one and time constraints eliminate the chance of sending someone back to the camp to retrieve what was accidentally left behind.

The day before sampling, equipment and supplies should be gathered and arranged using a check-off list to confirm everything needed is available. This is best accomplished by at least two people, so one can confirm what the other has done. Durable equipment can be loaded into buckets while more delicate pieces of equipment (binoculars, cameras, GPS meters, salinometers, etc.) should be packed separately. Sliding Ziploc[®] plastic bags are handy for storing equipment that needs to keep dry. Once the check-off list on **Data Sheet C** has been completed, the location of the assembled equipment should be made known to the leaders of the sampling team in case the participants who assembled the supplies are not present on sampling day for some unexpected reason.

The marsh should ideally be sampled on a falling tide to allow the most time for sampling activities. Minus tides (low tides lower than average) will result in the most time, but each camp needs to decide how much time should be necessary based on their group size and transect length. In some cases, choosing only days with minus tides will not be necessary. Tide tables are among many useful products provided by the NOAA Tides & Current web portal found at http://tidesandcurrents.noaa.gov/tide_predictions.html

SAMPLING EXERCISES

Arrival at the Marsh

The moment of arrival at the marsh is perhaps one of the most important points in time spent with the sampling team. In addition to that being an ideal time to take photographs of the marsh, two activities will be conducted: deployment of fish traps and wildlife observations. In addition to preparing the sampling team for the activities about to unfold, this time is when observations of wildlife may be possible before inadvertently disturbing the atmosphere by your presence. Teams should plan on spending 5 minutes watching and listening to the marsh and recording their observations on **Data Sheet D**. For example, you can instruct the students to scan the marsh with the unassisted eye and record any birds, mammals and humans visible, identifying them and counting their numbers when possible. Likewise, record any animals you might identify by the sounds they make. A pair of binoculars will be useful to help with field guides for identifications. As you spend the day on the marsh, look for animal signs (muskrat lodges, tracks, scat) and make note of them.

Upon arrival at the marsh, set out the fish traps so they will have the maximum time to fish. This step can be completed by a satellite team (one or two assistants) who leave the group behind at the head of the marsh while they make wildlife observations. The trap should be set in a main creek that is connected to tidal-influenced flowing water, not a mosquito ditch. Deploy the trap from a firm marsh bank that will not crumble when walked on. Record their number and the time when traps were deployed on **Data Sheet E**. Note time retrieved to the closest minute and calculate the approximate duration of they fished.

Sampling Protocol - Measurements and Data Collection

The sampling protocol has been written in three steps. The first step lays the ground work for the remaining ones and should be completed either as a group activity right after measuring sight/sound species richness or a pair of leaders could complete this step while the group watches and listens for animals upon arrival at the marsh. The remaining steps have multiple components and some camps may wish to assign teams to complete them concurrently. Other camps might decide to complete steps two and three in that order. For example, after establishing the line transect (Step 1), it may be possible to have a team measure elevation (Step 2A). In the meanwhile, a third team could focus on quadrat sampling (Step 3A, B & C). Once these tasks are completed, everyone can inspect the fish traps (Step 3C). How the tasks are divided depends on

each camp and the number of students and leaders they have on hand on a particular day. In the end, the logistics of carrying out the protocol will be best decided individually by each camp. However the protocol is implemented, there should be a record made in notes describing the logistics and number of participants each day marsh sampling is executed. *Most important is reminding the participants to walk in a straight line and keep to that path to minimize impact to the marsh. The significance of this can be underscored by relating it to marsh health.*

1. Establish the transect line and confirm quadrat locations.

Locate the stake for the start of transect and have one team member walk the line with the transect tape until the end is reached. The tape should lie on the marsh surface, easily accomplished across mud but difficult to achieve in heavily vegetated areas. Make certain that the transect tape is securely attached to the start and end stakes to eliminate the need to confirm it has not moved during sampling. The transect tape should intersect the stakes set to mark high, mid and low quadrat positions during pre-sampling day surveillance. Record the transect length to compare against pre-sampling measurement and any new changes made to the transect and/or quadrats position(s) and why.

2. Measurement of Physical Features and Abiotic Parameters

Measurements of elevation will be taken at 10 sample points along the line transect and temperature and salinity at each quadrat. The elevation points should be established independent of the quadrat locations. If a sample point coincides with a creek/ditch, move the sample point either towards or away from the previous sample point depending on which direction is the shortest distance travelled before reaching a new sample point 50 cm away from the bank of the waterway. Data collection for pannes does not depend on sample points. Therefore, that procedure will be described last in this section of the protocol.

Using the total length of your line transect, calculate the position of the 10 sample points so they are equidistantly spaced from each other. The first and last are at the start and end of the line transect and the remaining eight in between. Record the location of sample points on the line transect to the closest centimeter.

A. Elevation

Changes in elevation of the marsh will be measured by working in pairs (or teams as numbers permit). One person (the “sighter”) will stand at the start of the line transect with the mounted hand sight level scope. Another team member (the “staffer”) will walk to the second measurement point with the calibrated PVC pole and cuff. Both the pole mounted scope and calibrated pole must be held in perfectly vertical positions. Looking through the level, the “sighter” will focus on the cuff and instruct the “staffer” to slide the cuff up or down the staff until the bubble in the scope is level (Figure 1). It is very important that the site is level. There is a bubble level on top of the site. An additional person to keep track of the level may be helpful. Once that is achieved, the “sighter” calls out that the scope is level and the “staffer” will record the height on the pole where the cuff is positioned on **Data Sheet F**. Increases in elevation will be assigned a positive value and decreases a negative value. These steps will be repeated until reaching the low marsh at which point nine elevation measurements will have been taken. The

10th measurement is the reference point of “zero elevation” at the start of the line transect where the scope was first positioned.

From these recordings, the general changes in slope can be visualized by plotting them on graph paper (optional). The overall change in elevation will be calculated by adding up the differences in elevation (positive and negative readings) between readings. The sum (a negative value) of the series of elevation changes will represent the drop in elevation from the high marsh to the low marsh. The general slope of the marsh, $\sin(\theta)$, will be calculated by:

$$\left[\frac{(|elevation|)}{(transect\ length)} \right] \sin^{-1} = \text{angle of slope}$$

where: *elevation* = the change in elevation in cm just calculated (entered as a positive value);

transect length = the length of the line transect in cm;

\sin^{-1} = inverse *sine* found on your calculator key pad as “ \sin^{-1} ”.

An example of how to calculate change in elevation and general slope of the marsh appears in Figure 2.

B. Temperature

Three temperature measurements will be taken at each of the quadrats (**Data Sheets G, H and I**). In addition to recording the temperature, note with the recordings at each point if the marsh surface was bare or covered with vegetation (simply as absence/presence). The thermometer will likely become wet and dirty. Therefore, before measuring each of the temperatures, be certain that the thermometer is clean and not wet. Between sampling points, keep the thermometer dry and out of direct sunlight. The time needed to obtain a stable reading will vary among sampling points depending on conditions of each. Not rushing these measurements and waiting for a stable reading on the thermometer is important. We recommend waiting 1 minute for temperature to stabilize with the thermometers provided.

The three temperatures that will be recorded with vegetation presence/absence are:

- 1.) *Air Temperature*. Measured with sun to the back of the recorder at chest height.
- 2.) *Surface Temperature*. Measured directly on the marsh surface. When taking this measurement, do not dip the thermometer into the marsh surface.
- 3.) *Subsurface (Below ground)*. Measured at each sipper position (see below in 2C. Salinity). Insert the thermometer into the 15 cm hole to a depth equal to the length of the thermometer.

C. Salinity

Up to three salinity measurements will be made along the line transect with a refractometer that is standardized before it is used on each sampling day. Using the refractometer, measure the salinity of water sampled either directly with a dropper or with a clean dry container. Only a small volume of water is needed for each measurement. Dirt and foreign material can interfere with refracted light measurements so clean water samples are best. Bring some coffee filters with you in case they are needed to strain samples, particularly of pore water. Straining sample water through a coffee filter will sufficiently extract debris to obtain a clean volume to measure. If using a container is necessary, be certain to either rinse with freshwater sample water between each sampling or use a new container each time a sample is taken. Rinse the container with sample water before taking a sample for salinity measurement. Rinse with fresh water and dry the refractometer between each measurement. Between sampling points, keep the refractometer dry and out of direct sunlight.

The three salinities that will be measured are:

- 1.) *Creek/ditch*: surface water measured whenever these features are encountered by the line transect. If sampled with a container, be certain only surface water is collected (no deeper than 5 cm).
- 2.) *Pannes*: surface water measured in pannes intersected by the line transect and any found within a 10-m radius of a quadrat.
- 3.) *Pore water*: measured at 3 quadrats at a depth of 15 cm. Pore water will be extracted using a sipper made of plastic tubing and a syringe from a hole made in the peat with a steel rod described in the following section.

Sampling Creek/Ditch surface water

By hand, obtain a small volume of surface water (no deeper than 5 cm) from the creek/ditch edge being careful of footing and inspecting the edge by the water making sure it can support weight. If necessary, strain the sample through a coffee filter to extract any debris that could interfere with measuring salinity. In many cases, this will not be necessary.

Sampling Panne surface water

By hand, obtain a small volume of surface water from the panne edge being careful of footing and making sure it can support weight. Sediments can sometimes be soft and sinking into the marsh while sampling can happen. When sampling water from pannes not intersected by the line transect, choose the point closest to the line transect to sample from. If necessary, strain the sample through a coffee filter to extract any debris that could interfere with measuring salinity. Sometimes pannes are dry so salinity measurement is not possible.

Sampling pore water

Either by hand or using a small hammer, push the steel rod vertically into the marsh so that the 15cm depth marked on the rod is flush with the marsh surface. If a subsurface

obstruction is encountered (rock, wood, etc.), move the point of insertion from the original sampling point the shortest distance necessary (no more than 6 inches) to achieve an unobstructed penetration of 15cm. If a sample still cannot be taken, continue to move the point of insertion in small increments until the underground obstruction is cleared. Be sure to record if the sample position had to be moved along with its old and new locations on the line transect. Remove the rod and insert the tubing of the sipper into the hole to attempt to retrieve a water sample by pulling on the syringe plunger. Only a *small volume of water* is needed for the refractometer to measure salinity. Be certain not to insert the tube deeper than the 15 cm mark.

Sucking up mud and blocking the tubing with peat and debris (i.e., roots) can easily occur. To avoid clogs from happening, when inserting the sipper tubing do not jam the tubing into the hole or beyond the depth of the hole. Insert the sipper tube no deeper than the 15 cm mark on the tube. Should the sipper become stopped-up, place a new piece of tubing onto the syringe and try again. If you run out of clean tubing, remove the clog by sucking up clean fresh water from a container carried with you and flush the tubing until it is clean. The cleaned tubing must be dry before used to retrieve a pore water sample. There may be sample points that do not yield any sample of water because the ground is dry, porous, or due to some other conditions.

D. Pannes

Locate any pannes intersected by the line transect and any found within a 10-m (~33 ft) radius of a quadrat. Record the GPS coordinates of the point closest to the line transect of each panne. Using a measuring tape marked with metric units, two dimensions will be measured by across each panne encountered:

- (1) greatest N/S distance;
- (2) greatest E/W distance.

From these measurements the area of a panne will be approximated using GIS software.

3. Measurement of Biotic Parameters

A. Quadrat Sampling

Three 1m² sample quadrats, each located along the line transect near the middle of each marsh zone, will be photographed and sampled for different measures of the biotic community captured within. The positions of the quadrats will have been marked with stakes prior to sample day during pre-sampling reconnaissance. Each 1m² PVC quadrat sampler should be positioned to the right of the transect line with the left side parallel and arranged with the location stake just outside of the bottom left corner. Photograph the quadrat prior to sampling activities and make certain to record the GPS coordinates and their accuracy. Each quadrat should be photographed from above (“bird’s eye view”) being careful not to cast a shadow on the subject.

Three measurements characterizing the plants and animals encompassed by each quadrat will be estimated.

Two of the three measurements focus on the plant community:

- 1.) *% Cover*: Identify the dominant species of plants defined as occupying $\geq 25\%$ of the quadrat area within the PVC sampler. Visually estimate and record the total area taken up by each species within the quadrat. The total % cover should add up to $\leq 100\%$ unless there is an under story, in which case the total % cover might be $> 100\%$.
- 2.) *Canopy Height*: Measure and record the height of three of the tallest individual plants of each dominant species. The average of the three measurements will be used to calculate average canopy height for each dominant species.

One of the three metrics will focus on the community of animals within each quadrat:

- 3.) *Species Richness*: The presence of animals will be recorded using a check-off list and supplemented with notes for any additional species seen in the quadrat. The procedure for measuring species richness is described in the next paragraph.

For quadrat *Species Richness*, an animal must be located inside of the PVC quadrat sampler to be recorded as present. Otherwise, animals are recorded as present whether they be located on or embedded in the marsh surface or crawling on vegetation.

Some animals may be hard to find without moving vegetation to the side. Therefore, be sure to measure % Cover and Canopy Height beforehand. Some animals are more elusive than others, so observations for these species is recommended prior to sampling the plant community. Fiddler crabs are one such species. Do not use burrows as an indication of fiddler crab presence unless crabs are seen escaping into them.

The check-off list will include the following easily identified animals:

- Green Crabs (*Carcinus maenas*)
- Fiddler crabs (*Uca pugnax*, *Uca pugilator*, *Uca minax*)
- Coffee Bean Snails (*Melampus bidentatus*)
- Common periwinkles (*Littorina littorea*)
- Blue Mussels (*Mytilus edulis*)
- Ribbed Mussels (*Geukensia demissus*)

B. Insect Abundance (optional)

Using a sweep net, make four sweeps at waist height through the vegetation adjacent to each quadrat. Collect the captured insects into a container and separate them according to major insect types, i.e., ants, beetles, flies, grasshoppers, and leaf hoppers. Spiders and centipedes, not true insects, also should be counted. The number of individuals of each type will be counted and

the insects released. Optional: If counting in the field is difficult, insects can be brought to the lab for counting and returned to the marsh afterwards.

C. Fish Species Richness

Fish traps deployed at the time of arrival at the marsh will be retrieved at the end of abiotic and biotic sampling activities of all three quadrats, and their contents placed into buckets of sea water and examined. Record the time traps are retrieved so that the duration they fished can be calculated using the time traps were set. Fish will be identified to genus, and if possible, species using field guides. A check-off list will be supplied to facilitate identification. Highly unlikely will be the case when fish will need to be touched; fish can be identified without handling them in almost all cases. Depending on the time of year sampling is performed, vagrant tropical species brought to shore from the Gulf Stream might be trapped. These individuals will not be among fish listed on the check-off list. Be certain to photograph any fish that cannot be identified (isolating them in a Ziploc[®] bag will help) since the identities of many species can be made using their captured images. In addition, any other organisms, i.e., crabs, caught in the fish traps will be identified. All animals will be released into sea water unharmed before leaving the marsh.

A BRIEF TUTORIAL FOR USING GOOGLE EARTH

Google Earth is an excellent platform for anyone who is unfamiliar with using GIS programs like ArcMap which are complex. Some commonly used basic features found in GIS programs are available in Google Earth. Another version, Google Earth Pro is more advanced and supports the capability of importing/exporting excel spreadsheets, making movies, linking photographs to locations, examining elevations across paths among other tasks.

The purpose of this brief tutorial is to begin to describe in steps how to perform some basic functions using Google Earth. These features will be handy to know for many instances needing mapping capabilities.

Making Paths (or Transect Lines)

1. Grab the Earth with the “Hand” cursor by holding down a right-click on the mouse and spin the globe by moving the mouse to the approximate region of the place of interest. Zoom into the area where the path will be drawn using the sliding scale in the upper right hand corner of the Google Earth Screen. Zooming in and out is also accomplished by clicking your mouse either right or left, respectively.
2. At the top of the page, there is a ribbon with a series of buttons shown with icons. Becoming familiar with their functions will be useful since they can be used to mark locations () , draw polygons for calculating areas () , and draw paths () .
3. Select the path button () and a window will appear on the screen with the title “Google Earth-New Path” at the top. In this “Index Card,” there is a window to “Name” the path (which should have “**Untitled Path**” highlighted in blue already in it. There are also series of tabs: Description, Style, Color, View, Altitude, and Measurements.
4. When the path button is selected, simultaneously with the appearance of the “Index Card” on the screen is a “Square” with cross-hairs in place of what was a ‘Hand’ for a cursor. Using the mouse, move the “Square” to the start of your path and left click once. A colored square should appear marking the spot left-clicked.
6. Now move square to the location of the end of the path and left click once. A different colored square will appear where the mouse was left-clicked with a line simultaneously appearing that connects the start and end points of your path.
7. Name the path in the index card box where the highlighted “**Untitled Path**” appears. “Planned Transect” with the name of the marsh might be a good choice.
8. Add a “Description” using the first tab in the “Index Card,” something like “Summer on the Marsh 2014.”

9. Select the “Style, Color” tab. Here the preferred “Color” of the path can be chosen using a palette that appears when “Color” is selected. Its width and opacity (how transparent the path will be) can also be chosen.

10. Select the “Measurements” tab next, the last of the tabs. Here, the units for measurements can be chosen using a dropdown box. Choose “Meters” and the length of the path will automatically appear. At this point, steps 11 and 12 can be skipped. Proceed to step 14.

11. The “View” and “Altitude” tabs were skipped over in steps 9 & 10. These are useful but they are not essential at this time. You may read on steps 12 and 13 to learn more.

12. The “View” tab allows a “snapshot” to be taken of the image on the screen. When that button is selected (bottom right corner), the latitude, longitude, range, heading, and tilt automatically appear in their corresponding windows. The “Date/Time” can also be chosen as a “Time Stamp” or “Time Span” using the drop down box next to the label. What was chosen for “Date/Time” will appear in the box below it simultaneously with the other values. The time components (Month, day, year, time) can be adjusted using the buttons with up/down pointed triangles.

13. The “Altitude” tab allows adjustment of where the path is set in 3 dimensions. The default is “Clamped to the ground.” To choose another aspect, left-click on the drop down box where “Clamped to the ground” appears and select another preference. For example, if “Relative to the ground” is selected, the “Altitude” box and sliding scale “Ground to Space” become active. To try this function, select “Relative to the ground” and an altitude of 25 m using the sliding bar. Two new start and end squares will appear on the Google Earth image, representing positions 25 m above the original locations. If “Extend path to the ground” is selected, a colored “wall” will appear that connects your path on the ground to the one 25 m above it.

14. At this point, all the essential information has been added to the “Index Card” for the path. In the bottom right corner, select the “OK” button and the Index Card will vanish. The path will still be shown on the Google Earth image.

15. If ever viewing or revising information on the “Index Card” for a path is needed, place the “Hand” cursor with the mouse on the path and *right-click* on it. A box will appear with “Properties” at the bottom. When “Properties” is selected, the “Index Card” will appear and information about the path can now be viewed and revised.

16. **IMPORTANT!** To save the work just completed, go to the top ribbon and select “File,” “Save,” and “Save My Places.” The work will be lost if this step is skipped. “Save My Places” will save the work completed in the “Place” pane on the left of your screen. If a path was drawn, the path icon will appear with the name that was given to it. The path can be accessed at another time by left-clicking on the icon in the “Place” pane and the Earth will automatically zoom in on the path from where ever the Google Earth image happens to be at the time.

17. An image of the screen with the path can be saved by selecting “Save,” then “Save Image.” When this is done, a box will appear where the resolution of the image can be chosen. A screen

shot is the simplest and fastest to save and meets the requirements for most purposes. The image can be saved after selecting the “Save” button to anywhere on your hard drive.

Pinning Locations on a Google Earth Image

1. Grab the Earth with the “Hand” cursor by holding down a right-click on the mouse and spin the globe by moving the mouse to the approximate region of the place of interest. Zoom into the area where the path will be drawn using the sliding scale in the upper right hand corner of the Google Earth Screen. Zooming in and out is also accomplished by clicking your mouse either right or left, respectively.
2. At the top left pane, type your GPS coordinates into the window that has a “Search” button to the right. Type longitude and latitude separated by a comma (Lat, Long) and select “Search.”
3. Google Earth will zoom to the location you have given where it will be shown as a Pin with your coordinates.
4. To name the location, right-click on the pin and an “Edit Place mark” frame (or “Index Card”) will appear. “Name:” appears to the left of a window where your coordinates will be shown. Type in the window the name you want to give the location. When you type, the coordinates will disappear from this window but they will still be shown in the windows just below it.
5. If you want to change the appearance of the place mark from a pin to some other icon, chose the button to the right of the “Name:” window and a new frame will appear with a variety of icons to choose from. The color, scale, and opacity can be adjusted here also. You can also add custom icons using the button at the bottom of the frame.
6. A description can be added by selecting “Description,” the first tab in the “Index Card.”
7. At this point, all the essential information has been added to the “Index Card” for the location. In the bottom right corner, select the “OK” button and the Index Card will vanish. The location will still be shown as a pin on the Google Earth image.
8. **IMPORTANT!** To save the work just completed, go to the top ribbon and select “File,” “Save,” and “Save My Places.” The work will be lost if this step is skipped. “Save My Places” will save the work completed in the “Place” pane on the left of your screen. Another way to “Save my Places” is to right-click on the point and a drop down menu will appear that can offer that selection. If a GPS position was pinned, the pin icon will appear with the name that was given to it in the “Places” pane. The point saved can be accessed at another time by left-clicking on its icon in the “Places” pane. Google Earth will automatically zoom in on the point from where ever the Google Earth image happens to be at the time. The search bar at the bottom of the “Places” pane can also be used to locate a saved point if it was given a name.

Setting Google Earth Coordinates to Decimal Degrees

1. In the top ribbon select “Tools” and from the drop down list choose “Options.”
2. In the 3D View tab (shown first by default), find the “Show Lat/Log” box.
3. Select “Decimal Degrees” (or any other format wanted).
4. On the bottom right of the Google Earth Options frame select the “Apply” button followed by “OK.”

Saving Images as KML Files

In many cases a KML file is desired rather than a saved image. KML files can be opened in Google Earth where, unlike in the case of a saved image, all the features of the program can be used (pinning locations, drawing paths, etc.). There are a few ways to do this. One will be described here.

1. In the “Places” pane on the left of the screen, right click on the location to be saved and select “Save place as” from the drop down list.
2. A frame will appear at the top of the screen where the file name will be shown. For the “Save as type:” select “Kml (*.kml)” using the upside down triangle on the right of the bar.
3. Choose the “Browse folders” button to select where to save the file on the computer hard drive.
4. Select “Save”
5. To open a file in Google Earth, select “File” from the top ribbon and “Open” from the drop down menu.
6. Search for the file desired (shown with Earth Icon) and open. The file (with Earth Icon) will appear in the “Places” pane under “Temporary Places” and be shown on Google Earth. Whether or not the file appear can be turned on and off by checking or un-checking the box next to the file. The file can be saved using “Save my places.”

When saving more than just the minimum information about a place mark is desired, it should be saved as a KMZ file. This is a zipped file that includes the KML file along with images or files associated with the KML file. These data are placed in subfolders of the KMZ file.

Measuring Marsh Elevation

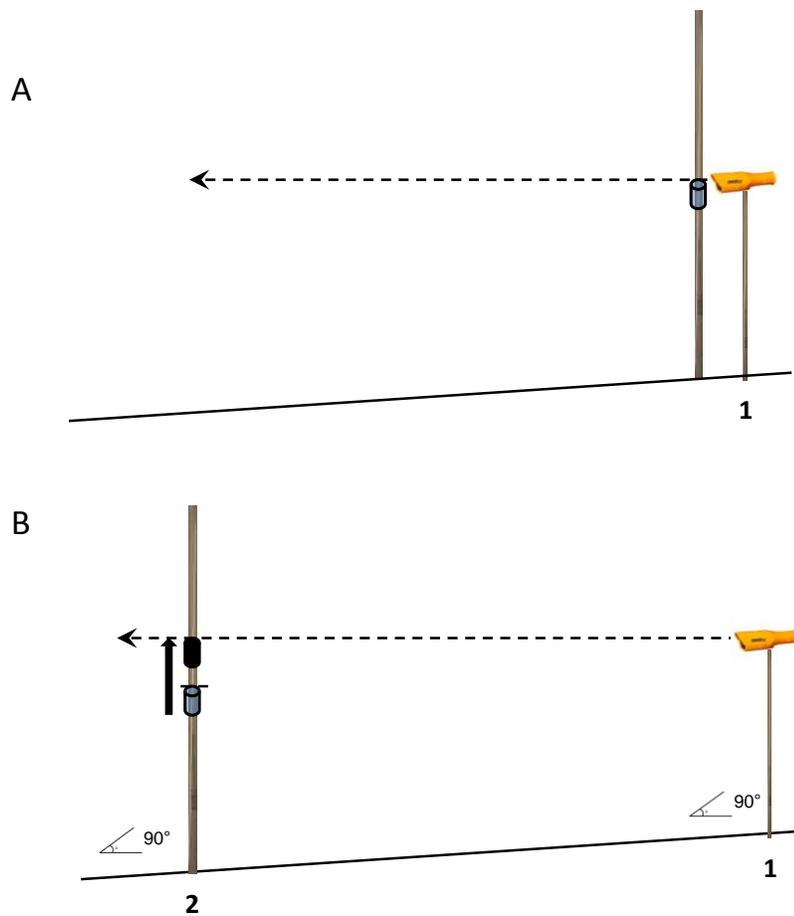
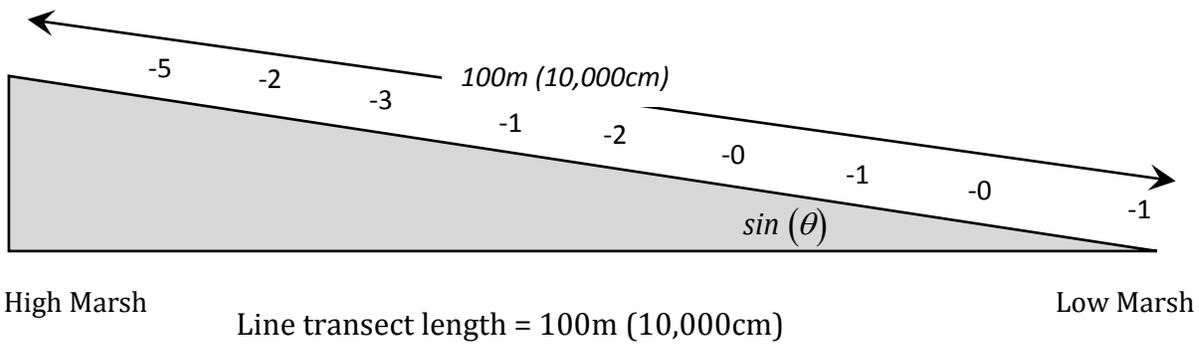


Figure 1. Measuring elevation. A. Calibrated PVC staff with collar set at height of hand level scope at sample location 1 (line transect start position). This is the reference elevation set at zero. B. Calibrated PVC staff at sample location number 2. Holding both instruments at 90 ° relative to the ground, the collar is slid up the staff to the position level with the hand held level scope. The number of cm needed to move the collar to its new position from the reference position is recorded.

Calculating the Slope of the Marsh



Sample Location	Staff Measurement	Change in Elevation
1	0 cm	—
2	-5 cm	-5 cm
3	-2 cm	+3 cm
4	-3 cm	-1 cm
5	-1 cm	+2 cm
6	-2 cm	-1 cm
7	0 cm	0 cm
8	-1 cm	-1 cm
9	0 cm	0 cm
10	-1 cm	-1 cm

$\sin(\theta)$ is the slope of the marsh in degrees

$$\left[\frac{(|elevation|)}{(transect\ length)} \right] \sin^{-1} = \text{angle of slope}$$

$$\left[\frac{(|1cm|)}{(10000cm)} \right] \sin^{-1} = \text{angle of slope}$$

$$[0.0001] \sin^{-1} = \text{angle of slope}$$

$$0.006^\circ = \text{angle of slope}$$

Overall change in elevation = SUM = -1 cm

Marsh Profile

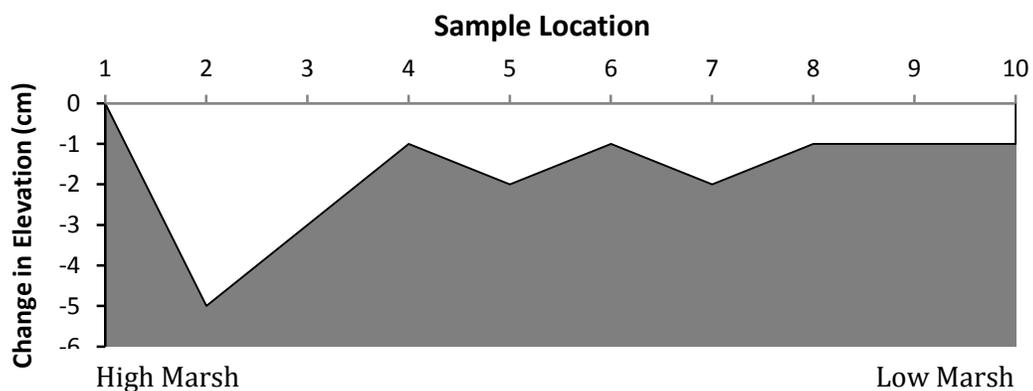


Figure 2. Calculating marsh elevation.

EQUIPMENT LIST

Each camp should have the following items (alphabetical listing):

- 1.) Binoculars (one pair minimum)
- 2.) Buckets
- 3.) Camera
- 4.) Clipboards (6 or more)
- 5.) Coffee filters
- 6.) Compass for pan measurements (3)
- 7.) Container and forceps for insects
- 8.) Container(s) for fresh water (flushing sippers, rinsing refractometer)
- 9.) Field guides (plants, fish, birds, animal tracks)
- 10.) Fish trap(s)
- 11.) Fresh water (enough for drinking and flushing equipment)
- 12.) GPS unit (set to decimal degrees)
- 13.) Hammer
- 14.) Hand lens
- 15.) Hand sight level mounted on a 1m length of PVC for elevation measurements
- 16.) Insect sweep net
- 17.) Measuring tape calibrated in metric units for pan measurements
- 18.) Meter stick
- 19.) Pencils/pens
- 20.) Plastic surveyors tape
- 21.) Pocket microscope (recommended)
- 22.) 1m² PVC quadrats (3)
- 23.) 2m PCV pipe hand-calibrated in metric units with bright colored markings that has a collar to slide up and down (plastic tube will work)
- 24.) Refractometers (2)
- 25.) Sippers (hand-made) with 20 cm metal (steel?) rod/tube for hole making (including extra set of tubing connectors to replace clogged ones)
- 26.) Sun protection/insect repellent
- 27.) Thermometer (all camps should use the same kind)
- 28.) Transect tape ($\geq 100\text{m}$)
- 29.) Trash bag
- 30.) Walkie-talkies (recommended/optional)
- 31.) Wooden or plastic stakes to mark start and end of transect and quadrats
- 32.) Ziploc (zipper kind) bags to hold and keep dry equipment and field guides