Marine Nature Study Area Transect Protocol

Problem:

Does the change in elevation in a salt marsh affect the distribution of marsh plant species?

How does diversity change over an elevation gradient in the marsh?

Introduction:

This project deals with the zonation and distribution of marsh grasses over an elevation gradient. These basic zones include Subtidal, Intertidal, Supratidal, and Fringe. It consists of the collection of data on the frequencies of plant species, percent covers, elevations, and distances from marsh edge. A comprehensive procedure has been designed to collect the above data in the Marine Nature Study Area in Oceanside, NY.

This project was chosen because of an increased interest in tidal wetland preservation and its dynamic changes here along the east coast of the US. Marsh areas are rapidly declining because of increase in development world-wide and rising sea level. Knowing the living habitat of various species of marsh plants is essential to marsh ecology. This project will be the first step to determining the habitat qualifications of each plant species.

Background Information:

Salt marshes are one of the most important ecosystems in the world and a major habitat here in New York. Formed between 10,000 and 12,000 years ago, salt marshes have plays a vital role in the Bay ecology. Salt marshes serve as buffers, protecting the shorelines from erosion by absorbing and dissipating the force of waves. Such marshes also absorb and filter contaminants from the land, a nursery for many of the fish species of the bays and ocean, and feeding grounds of various living organisms year round. The grass blades become a vital part of the food chain when they break off and decay, providing food for detritivores (animals that eat decaying organic material) and nutrients to the marine environment. Tidal wetlands in New York State are found on the Hudson River from the Troy Dam south to the southern tip of Staten Island, and along the entire shoreline of Long Island, including the shorelines of Gardiners Island, Shelter Island and Fishers Island.

New York State recognized the importance of this unique habitat and sought to insure its protection from filling and dredging--human activities that had drastically reduced the amount of tidal wetlands in New York by passing the Tidal Wetland Act in 1973. In 1974 DEC collected a set of aerial infrared photographs of all the tidal wetlands on Long Island and along the lower Hudson River. Using these photographs, DEC established the New York State Official Tidal Wetlands Inventory, a set of maps delineating and classifying all the tidal wetlands in New York. These maps are used by DEC and other municipal agencies to control and manage the development, filling and dredging of areas in and around New York's valuable tidal wetlands. This Inventory is also available to the general public to examine. Many individuals wish to consult these maps before undertaking any building or landscaping along the shoreline. The statutory definition of a tidal wetland can be found in New York's Environmental Conservation Law, Article 25, entitled "Tidal Wetlands Act."

In comparison to the fresh water marsh, the salt water marsh supports a less diverse community of vegetation. Salinity is a limiting factor in a salt marsh, because very few plants can survive the harsh conditions of a saline environment. Therefore, approximately 36 acres of the 44 acres of the MNSA is intertidal, making 82 percent of the salt marsh is inhabited by *Spartina alterniflora*, a plant accustomed to high salinity and heavy wave action.

Table 1 Plants you may encounter

Fringe	Supratidal	Intertidal	Subtidal
Giant Reed *Phragmites australis* common reed Groundsel *Baccharis halimifolia* Marsh Elder *Iva frutescens* Jesuit's bark Black Grass *Juncus gerardii* saltmeadow rush Seaside Goldenrod *Solidago sempervirens* seaside goldenrod Annual Sea-blite *Suaeda maritima* herbaceous seepweed Saltmarsh Bulrush *Schoenoplectus maritimus* cosmopolitan bulrush Seaside Spurge *Chamaesyce polygonifolia* seaside sandmat Orach *Atriplex patula*	Saltmeadow Cordgrass *Spartina patens* Spike Grass *Distichlis spicata* saltgrass Slender Glasswort *Salicornia maritima* slender grasswort Sea Lavender *Limonium carolinianum* lavender thrift Saltmarsh Aster *Symphyotrichum tenuifolium* perennial saltmarsh aster	Saltmarsh Cordgrass *Spartina alterniflora* smooth cordgrass	Marine Algae: Sea Lettuce *Ulva spp.* Rock Weed *Fucus spp.*

S. alterniflora (or Saltmarsh Cordgrass) inhabits a medium saline environment and is found along the edges of marshes and other areas subjected to daily flooding. There are two forms of *S. alterniflora*. The tall form is approximately four to seven feet tall and has a dark green color. The short form is approximately one to two feet tall and has a yellow green color. The short form is usually found at a slightly higher elevation than the tall form, at the upper limits of the daily tidal influence. The tall form produces a flower in August, but the short form does not. Both forms of *S. alterniflora* produce seeds, but as far as reproduction goes, it relies mostly on underground rhizomes that send up young plants in nearby areas. The seeds that are not eaten by waterfowl remain lodged in the soil, where it is possible that they will germinate in the spring.

S. alterniflora has many adaptations that enable it to thrive in a saline environment. This unique marsh grass has the ability to regulate the salt concentration inside of its cells. It then has the ability to release the salt back into the environment through the pores in the blades of grass called stomata. It also has hollow stems allowing oxygen to get down into its roots that are bedded in a saturated soil so respiration can occur.

The *Salicornia* genus (saltworts or glassworts) contains *Salicornia virginica*, *Salicornia europaea*, and *Salicornia bigelovii*. These species are approximately six inches to two feet tall and are found in the drier and sandier areas of the marsh. *S. virginica* is sometimes found mixed with the short form of *S. alterniflora*. They have fleshy, thick green stems that are the color of jade. The stems of the species in this genus have the ability to retain water, which helps to maintain water balance, which is necessary for survival in a highly saline environment. In the autumn, *S. europaea* turns a deep pink or ruby red, while the other two species change to a brown or yellow.

Limonium carolinianum (or Sea Lavender) is a plant containing basal rosettes of fleshy, leathery, smooth leaves that surround a stem leading up to spreading inflorescences of tiny lavender or blue flowers. The basal rosette stands two to four inches high and four to eight inches wide, and the flower stem stands approximately 1 and 1/2 to 2 and 1/2 feet tall. Sea Lavender is another plant that is tolerant of a highly saline environment. It is thought that its protection against this environment is a woody substance, called lignin, which is found in the plants epidermal cell walls.

Atriplex patula (sometimes referred to as Orach or Spearscale) is found just above the mean high tide. The plant has gray-green triangular shaped leaves. *A. patula* is lax and prostrate, often growing like a vine. The branches may extend more than three feet from the main stem. Orach produces small green flowers on the terminal ends of the branches, and also produces small green, triangular shaped fruit

Suaeda maritima, or Sea Blite, consists of tiny, button-like, white flowers. The plant stands 3 to 12 inches in height and has leaves that are pointed and fleshy to the touch.

Spartina patens is a smaller member of the *Spartina* genus. It lives approximately five centimeters above the mean high tide and grows to a height between 1 and ½ to 5 feet tall. This grass has long, tapering leaves, which are rolled inwards towards the central stem and appear round. The flower itself is brown. This grass is commonly referred to as Saltmeadow Hay.

Found mixed with patens, one will find *Distichilis spicata*. Commonly called Salt Grass, it grows in the upper marsh to a height between 1 to 2 feet tall. The leaves of this plant are 1 to 5 inches long, trough shaped, and found arranged all in one plane. This plant invades new areas by way of rhizomes.

Iva frutescens, or Marsh Elder, lives in the upper levels of the marsh. Rarely growing over ten feet tall, this plant has a woody stem and thick, leathery leaves. Small flowers are arranged in a head and are often found on the terminal stems, appearing as green globular fruit.

The Groundsel Tree (*Baccharis halimifolia*) is found in the most upper limits of the marsh. This woody stemmed plant may grow to heights above 15 feet. The upper leaves on this plant are smaller, about ½ to 1 inch long, and lack teeth. The lower leaves are longer, approximately 1 and ½ to 2 and ½ inches long, and lack teeth.

Myrica pensylvanica, known to many as Bayberry, is a woody stemmed plant that is fragrantly spicy. The leaves are dark green in color and are approximately 2 and ½ to 4 inches long and 1 to 2 and ½ inches wide. This plant has waxy, bluish gray fruits and inconspicuous flowers are produced below the leaves on the stems.

Phragmites australius, stands higher than a man to three times as high. The plant contains alternating grayish-green leaves that are approximately two feet long and two inches wide. At the top of the plant there is a large seed or flower cluster, approximately 1 and ½ feet long. Each individual spikelet on the seed head contains 3 to 7 flowers with long hairs between the flowers. When young the seed head is often purple in color, but when old the seed is whitish-brown in color.

Aster tenuifolius, or the Perennial Salt Marsh Aster, stands 1 to 2 feet high. The flower is purple or white in color, with dimensions of ½ to 1 inch across. The leaves are very slender and fleshy to the touch.

METHODS AND TECHNIQUES

Quadrat Sampling:

Quadrat sampling is used for sampling parts of a whole by dividing a large sample area into many smaller, manageable plots. The total sampling area may be divided into grids or sampling may be performed using a quadrat frame of any shape but with a known area. For smaller organisms such as grasses, random sampling is best because a grid covers too large an area and includes literally millions of individuals. By using a quadrat frame sampler, individual plants can be accurately recorded and studied on a more reasonable scale of hundreds rather than thousands.

Frequency:

Frequency is the number or counts of each individual species found in the quadrat sample area. These numerical representations are used in species analysis of diversity and distribution.

Hypothesis:

The elevation in a marsh is a dominant factor in the distribution of grass species. Factors induced by elevation are the extent of the tidal influence, water saturation in the soil, and soil salinity. For measuring elevation, one needs an elevation meter . The elevation meter allows water to run through the clear tube whenever one side is lifted higher than another. By finding the difference between the two readings, one will know the change in elevation over a certain area.

Based upon the background information, certain plant species will be found in specific areas based upon their ability to tolerate a saline environment. For most species, such as *Iva frutescens* and *Spartina patens*, the frequencies should be higher at higher elevations, because these species do not tolerate salt well enough to be flooded twice a day. However, for species, like *Spartina alterniflora* (both forms), the frequencies should be higher at lower elevations, because these plants are better equiped to handle the flooding of salt water twice a day. Therefore, if a plant is more tolerant to a higher salinity, they will be found closer to the marsh edge, if not submerged under water during high tide. Those plants with low salt tolerances will be found in the higher marsh, away from tidal influences. Therefore, plant frequencies will be affected by elevation.

Also, based upon the background information, we think diversity will increase as the elevation increases. Very few species can tolerate high salinities. Therefore, we expect to find few species near the marsh edge where the elevation is the lowest, and more in the higher marsh, where the elevation should be higher.

CHOOSING YOUR TRANSECT

Line Transect

A transect line can be made using a nylon rope marked and numbered at 30cm intervals, all the way along its length. This is laid across the area you wish to study. The position of the transect line is very important and it depends on the direction of the environmental gradient you wish to study. It should be thought about carefully before it is placed. You may otherwise end up without clear results because the line has been wrongly placed. Time is usually money, so it is worth while thinking about it before starting.

A line transect is carried out by unrolling the transect line along the gradient identified. The species touching the line may be recorded along the whole length of the line (continuous sampling). Alternatively, the presence, or absence of species at each marked point is recorded (systematic sampling). The slope or elevation along the transect line is measured as well, the results can then be inserted onto this profile.

Belt Transect

This is similar to the line transect method but gives information on abundance as well as presence, or absence of species. It may be considered as a widening of the line transects to form a continuous belt, or series of quadrats.

In this method, the transect line is laid out across the area to be surveyed and a quadrat is placed on the first marked point on the line. The plants inside the quadrat are then identified and their abundance estimated. Estimate the percentage cover individual plant species. Cover is the area of the quadrat occupied by the aboveground parts of a species when viewed from above.   The slope or elevation along the transect line is measured as well, the results can then be inserted onto this profile.

Quadrats are sampled all the way down the transect line, at each marked point on the line, or at some other predetermined interval. It is important that the same person should do the estimations of cover in each quadrat, because the estimation is likely to vary from person to person. If different people estimate percentage cover in different quadrats, then an element of personal variation is introduced which will lead to less accurate results. The height of plants in the quadrat can be recorded and harvesting all the plants inside the quadrat and then weighing either fresh, or dry weight in the laboratory can also measure the biomass of plants. This is obviously a very destructive method of sampling and will not be used in this project. Sampling should always be as least destructive as possible and you should try not to trample an area too much when carrying out your survey.

Species Frequency by Elevation

The frequency data will be examined by means of statistical analysis. Species frequencies will be correlated to the data station elevations by a line of best fit. The regression line, or line of best fit, supplements a correlation coefficient referred to as "r." The "r" values will be then applied to a two-tailed null hypothesis test, supplying "t" values. The degrees of freedom, or the number of samples minus one, and the "t" values were applied to a two-tailed null hypothesis table to determine the significance level to a 95 percent degree of certainty. Those species that met or exceeded the specified "t" value were found significant. Those other species that did not meet the "t" value at a 95 percent degree of certainty were not found significant. Those species that will be found significant demonstrate a definite change in frequency over elevation.

Biological Diversity - the great variety of life

Biological diversity can be quantified in many different ways. The two main factors taken into account when measuring diversity are richness and evenness. Richness is a measure of the number of different kinds of organisms present in a particular area. For example, species richness is the number of different species present. However, diversity depends not only on richness, but also on evenness. Evenness compares the similarity of the population size of each of the species present.

1. Richness

The number of species per sample is a measure of richness. The more species present in a sample, the 'richer' the sample.

Species richness as a measure on its own takes no account of the number of individuals of each species present. It gives as much weight to those species which have very few individuals as to those which have many individuals. Thus, one daisy has as much influence on the richness of an area as 1000 buttercups.

2. Evenness

Evenness is a measure of the relative abundance of the different species making up the richness of an area.

To give an example, we might have sampled two different fields for wildflowers. The sample from the first field consists of 300 daisies, 335 dandelions and 365 buttercups. The sample from the second field comprises 20 daisies, 49 dandelions and 931 buttercups (see the table below). Both samples have the same richness (3 species) and the same total number of individuals (1000). However, the first sample has more evenness than the second. This is because the total number of individuals in the sample is quite evenly distributed between the three species. In the second sample, most of the individuals are buttercups, with only a few daisies and dandelions present. Sample 2 is therefore considered to be less diverse than sample 1.

	Numbers of individuals	
Flower Species	**Sample 1**	**Sample 2**
Daisy	**300**	**20**
Dandelion	**335**	**49**
Buttercup	**365**	**931**
Total	**1000**	**1000**

A community dominated by one or two species is considered to be less diverse than one in which several different species have a similar abundance.

As species richness and evenness increase, so diversity increases. Simpson's Diversity Index is a measure of diversity which takes into account both richness and evenness.

Simpson's Diversity Indices

The Simpson's Index is chosen because it takes into account certain species that tend to throw off diversity values. Such species could include refugee species, or species were there is only one individual, or species that are aggressive, such as *P.australius*. The Simpson's Index is also flexible and can be used when an entire population is sampled in part. To check the answers obtained by the Simpson's Index, we used a simple diversity formula. The answers obtained by the below formula should be close to, or equal to that given by the Simpson's Index.

The term 'Simpson's Diversity Index' can actually refer to any one of 3 closely related indices.

Simpson's Index (**D**) measures the probability that two individuals randomly selected from a sample will belong to the same species (or some category other than species). There are two versions of the formula for calculating **D**. Either is acceptable, but be consistent.

$D = \sum (n / N)^2$	$$D = \frac{\sum n(n-1)}{N(N-1)}$$
n = the total number of organisms of a particular species N = the total number of organisms of all species	

The value of **D** ranges between 0 and 1

With this index, 0 represents infinite diversity and 1, no diversity. That is, the bigger the value of D, the lower the diversity. This is neither intuitive nor logical, so to get over this problem, D is often subtracted from 1 to give:

Simpson's Index of Diversity 1 - **D**

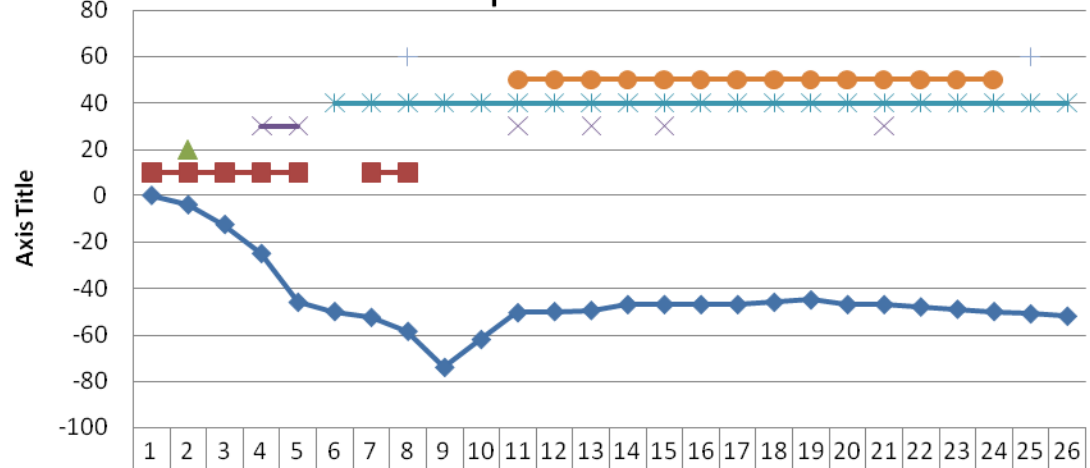
The value of this index also ranges between 0 and 1, but now, the greater the value, the greater the sample diversity. This makes more sense. In this case, the index represents the probability that two individuals randomly selected from a sample will belong to different species.

Another way of overcoming the problem of the counter-intuitive nature of Simpson's Index is to take the reciprocal of the Index:

Simpson's Reciprocal Index 1 / **D**

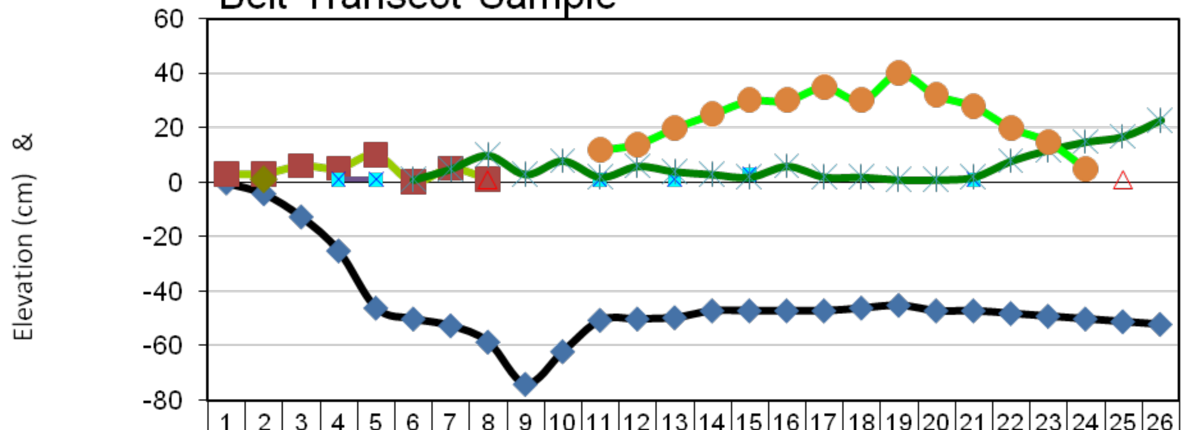
The value of this index starts with 1 as the lowest possible figure. This figure would represent a community containing only one species. The higher the value, the greater the diversity. The maximum value is the number of species (or other category being used) in the sample. For example if there are five species in the sample, then the maximum value is 5.

Line Transect Sample



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Elevation	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Spike Grass	1	1	1	1	1		1	1																		
Marsh Elder		2																								
Sea Lavander				3	3						3		3		3						3					
Saltmarsh Cordgrass						4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Saltmeadow Cordgrass											5	5	5	5	5	5	5	5	5	5	5	5	5	5		
Glasswort								6																	6	

Belt Transect Sample



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Elevation	0	-4	-1	-2	-4	-5	-5	-5	-7	-6	-5	-5	-5	-4	-4	-4	-4	-4	-4	-4	-4	-4	-4	-5	-5	-5
Spike Grass	3	3	6	5	10	0	5	1																		
Marsh Elder		1																								
Sea Lavander				1	1						1		1		3						1					
Saltmarsh Cordgrass						1	5	10	3	8	2	6	4	3	2	6	2	2	1	1	2	8	12	15	17	23
Saltmeadow Cordgrass											12	14	20	25	30	30	35	30	40	32	28	20	15	5		
Glasswort								1																	1	