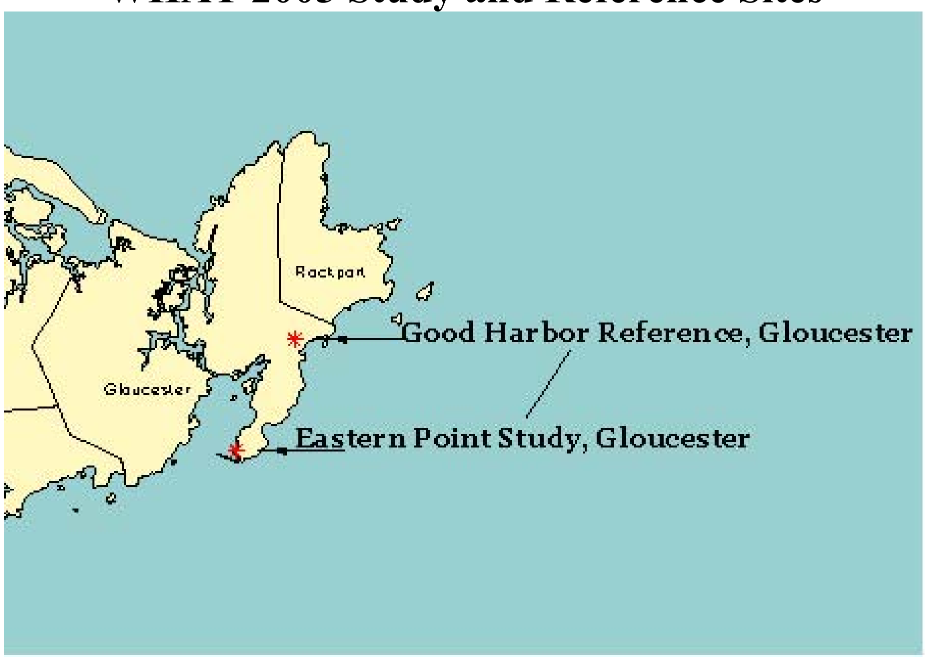
Wetland Health Assessment Toolbox (WHAT) Program
2005 Final Report

Eastern Point and Good Harbor Beach
SALT MARSHES
Gloucester MA

WHAT 2005 Study and Reference Sites



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Through its wetland monitoring at Eastern Point and Good Harbor Beach, SSCW has been able to contribute to the Gulf of Maine knowledge base on the effectiveness of restoration practices.

Author Credits

Barbara Warren, Executive Director of Salem Sound Coastwatch, prepared this report.

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EXCECUTIVE SUMMARY

During the summers of 2001, 2002, and 2003, Salem Sound Coastwatch “citizen-scientist” volunteers collected pre-restoration baseline data at the Gloucester Eastern Point salt marsh, which was adversely affected by a tidal restriction. The salt marsh west of Good Harbor Beach was monitored as the reference site to provide a comparative baseline with the Eastern Point study site. Using the Wetlands Health Assessment Toolbox (WHAT), seven parameters were measured - birds, fish, benthic macroinvertebrates, plants, water chemistry, tidal influence, and land use. This multi-metric approach identified a severely degraded salt marsh system at Eastern Point. After years of restricted tidal flow, the study site had become a brackish/freshwater marsh.

In response to this severe degradation, Massachusetts Audubon Society, NOAA Community-based Restoration Program, Massachusetts Wetlands Restoration Program, and several supporting agencies, local government and businesses combined efforts to restore tidal flow. A new box culvert and driveway culvert were installed in November 2003, and a small channel between the two culverts was opened to connect the salt marsh to tidal flow from the harbor. Salem Sound Coastwatch “citizen-scientist” volunteers have returned to monitor the post-restoration changes in the marsh for the past two summers.

Post-restoration monitoring results from 2004 and 2005 show that the Eastern Point salt marsh degradation has stopped. Tidal inundation has been restored; although at normal high tides, tidal flow still measures within the “significantly restricted” category. Despite this, ground and surface water salinity levels have returned to the normal range for salt marsh systems. Vegetation, fishes, and macroinvertebrates that need salt marsh conditions of high salinity and regular tidal flushing have increased. Post-restoration monitoring in 2005 documented the continued establishment of salt marsh communities.

The Good Harbor Beach salt marsh placed in the “ecological integrity not impaired” category during the three pre-restoration monitoring years. However, in 2004, the macroinvertebrate results indicated a potential worsening of ecological integrity. In 2005, the macroinvertebrate community reported a less impaired salt marsh invertebrate community condition than was detected in 2004. However, the reference marsh continues to fall within the category of “moderately impaired ecological integrity” due to stressors other than poor habitat. This is worth continued study. The environmental stressor of water quality degradation from stormwater runoff should be examined.

INTRODUCTION

Developed to evaluate the overall quality of wetland habitat, the Wetlands Health Assessment Toolbox (WHAT) Program trains volunteers to employ an established multi-metric protocol that measures biological, chemical, and hydrological characteristics of a salt marsh. Scientists from Massachusetts Bays Program, Massachusetts Office of Coastal Zone Management and UMass Extension developed the WHAT program. The program effectively measures the relative ecological health of a salt marsh by monitoring seven parameters: birds, fish, benthic macroinvertebrates, plants, water chemistry, tidal influence, and land use. The monitoring conducted by volunteers under the guidance of a trained professional help to identify those wetlands that are exhibiting marked signs of ecological impairment or improvement after restoration efforts. The data collected from this program are used to track changes in ecological health and aid in local wetland preservation, restoration, and conservation efforts.

In 1999, Salem Sound Coastwatch (SSCW) became the first citizen-based organization to implement WHAT. Over the past seven years, SSCW volunteers have used the WHAT program to study and evaluate six different salt marshes on the North Shore of Massachusetts. SSCW has been successful in monitoring sites both before and after restoration efforts.

During the summer of 2005 twenty-one volunteers assisted in the study of two salt marshes in Gloucester for over 387 hours of training and monitoring. The salt marsh at Eastern Point was the study site, while Good Harbor Beach salt marsh was the corresponding reference site that represented "best obtainable" conditions in the same type of wetland. Data collected at the reference site were used as a baseline for comparison with the study site. The Eastern Point salt marsh had been adversely affected by a tidal restriction. During the three summers of 2001-2003, volunteers collected important pre-restoration baseline data at Good Harbor Beach/Eastern Point. In response to this severe degradation, Massachusetts Audubon Society, NOAA Community-based Restoration Program, Massachusetts Wetlands Restoration Program, and several supporting agencies, local government and businesses combined efforts to restore tidal flow. A new box culvert and driveway culvert were installed in November 2003, and a small channel between the two culverts was opened to connect the salt marsh to tidal flow from the harbor. The 2004 summer of monitoring documented the first summer season of post-restoration and the Eastern Point marsh's succession back to a saltwater marsh. Monitoring in 2005 revealed that after two years of tidal flow, the Eastern Point marsh had returned to diverse salt marsh environment.

Volunteers attended an evening presentation covering the science and methodology employed by the WHAT program. At this time, sampling dates were scheduled. Training for volunteers was conducted in situ before each parameter (birds, fish, benthic macroinvertebrates, plants, water chemistry, and tidal influence,) was measured. A day-long workshop was conducted by a member of the science team to instruct volunteers in salt marsh vegetation identification and monitoring protocols. The training took place at the previously studied Little Neck Road salt marsh in Ipswich. Tidal flow was restored to this impacted salt marsh when the culvert was replaced in 2001. The data collected from this training session provides vegetation data for the fourth post-restoration year. A member of the science team and SSCW director accompanied volunteers on all bird monitoring sessions. Another member of the science team provided instruction and his expertise at the first fish monitoring session. During training and subsequent data collection days, volunteers were instructed to make every effort to avoid unnecessary disturbance to the sampling sites. The SSCW director and two summer interns always accompanied each team into the field providing equipment, assistance and supervision.

As the WHAT program continues, the data collected by the volunteers becomes more valuable, as a larger and therefore, more rigorous data set is established. The data collected by the volunteers are essential in tracking changes pre- and post-restoration at salt marsh restoration sites and in understanding how tidal restrictions affect salt marsh ecology. Although the data collected is important, the WHAT program also promotes and encourages stewardship.

The WHAT program is an excellent tool for engaging citizens in the protection of their local environment. The program allows individuals to learn more about the area they live in, and it gives people an opportunity to participate directly in a project that encourages the restoration and monitoring of salt marshes. The program promotes stewardship among the volunteers by teaching them about salt marshes at all levels – from the easily seen birds and vegetation, to the macroinvertebrates seen only under a microscope. Volunteers come away with increased knowledge and appreciation of their local environment and with the knowledge that they can make a difference. The visibility of the program within local communities, the education of volunteers and the ensuing desire among citizens to protect and restore the environment amplifies the WHAT program's success.

SITE DESCRIPTION

Eastern Point/Good Harbor Beach, Gloucester, MA

Figure 1. Good Harbor Beach, Gloucester
Reference Site

Figure 2. Eastern Point, Gloucester
Study Site

Eastern Point – Gloucester Study Site

The Gloucester Study site is located on the tip of Eastern Point, Gloucester, MA. The site can be located on Gloucester U.S.G.S. topographic map, 1:25,000. The site is part of a Massachusetts Audubon Society sanctuary, which encompasses approximately 53 acres. The salt marsh is approximately 5 acres in size and is separated from Gloucester Harbor by Eastern Point Blvd. The salt marsh is enclosed by this paved road to the west, a freshwater marsh (approx. 2.5 acres) to the north, a residential lot (one house) to the south, and rocks separating the marsh from open ocean to the east. A Coast Guard Station and the Eastern Point Lighthouse are located at the end of Eastern Point Blvd. The road provides access to a parking lot and to the Dog Bar Breakwater, which extends into Gloucester Harbor. Tourists and people wanting to fish frequent the breakwater. People have worn a footpath across the southeastern section of the marsh as they access the ocean to fish from the rocks.

This is the second year of post-restoration monitoring after three years of pre-restoration monitoring by Salem Sound Coastwatch. Post-restoration monitoring provides information on the salt marsh's recovery.

Good Harbor Beach – Gloucester Reference Site

The Gloucester reference site is located behind Good Harbor Beach, Gloucester, MA off Route 127A. This site can be located on Gloucester U.S.G.S. topographic map, 1:25,000. A tidal stream flushes this marsh and exits to the Atlantic Ocean at the southeastern end of Good Harbor Beach. Route 127A loops around the marsh west to north. Good Harbor Beach is located to the east of Route 127A, and a residential area is south of the marsh. Downstream of the sampled area, a small pedestrian bridge crosses the tidal creek but does not inhibit tidal flow. A berm on the eastern edge of the salt marsh offers some protection from the beachgoers' parking lot. The wetland evaluation area comprises a small part of the larger salt marsh system.

METHODOLOGY

More details on the WHAT methodology can be found in *A Volunteer's Handbook for Monitoring New England Salt Marshes* (Carlisle et al. 2002). An online version of this handbook can be obtained from www.mass.gov/czm/volunteermarshmonitoring.htm.

TIDAL INFLUENCE

According to the *Tidal Crossing Handbook: A Volunteer Guide to Assessing Tidal Restrictions* (Purinton and Mountain, 1998), tidal restrictions consist of some tidal crossings, usually a culvert or bridge, which "…limit water from freely passing from the upstream to the downstream salt marsh and vice versa." Two different techniques have been employed at the Eastern Point study site to measure tidal levels: reference mark and staff gauge. Since the 2004 results from both techniques were similar, only the staff gauge was used in 2005. Measurements were taken from low tide through high tide. All data, including names of investigators, date of sampling, and time of high tide, was recorded on the Tidal Influence Field Sheet (Appendix p.24). Separate data sheets were used for the reference side and study side of the tidal restriction.

Reference Mark Technique

A permanent or semi-permanent mark was fixed on both the reference and study sides of the tidal crossing from which to measure vertical distance to the water's surface. Using a tape measure, the distance from the reference mark to the water's surface was determined. This distance was measured every 15 minutes and was recorded, along with the time of day, on the field data sheet.

Staff Gauge Technique

A suitable location near the tidal restriction was found for the staff gauges and staff gauges were installed - one at the reference on the Gloucester Harbor side and one in the affected salt marsh study area. The staff gauges were graduated in feet and tenths. Water levels (tidal height) on the staff gauges were measured every 15 minutes and were recorded, along with the time of day, on the field data sheet.

Data Analysis

The difference in tidal range is computed by subtracting the study site tidal range from the reference site tidal range. This difference is the actual measurement of the amount of tidal restriction present on the day measured. The Tidal Range Ratio is computed by dividing the tidal range of the study site by the tidal range of the reference site, and multiplied by 100 to express it as a percentage. With free, unrestricted flow of the tides, the study site would have the same tidal range as the reference site (the tidal range ratio would be 1.0 and the percentage tidal range would be 100%). As the severity of the tidal restriction increases, so will the difference in tidal range between the two sites. The following numbers were used to classify the severity of a restriction: Ratio = less than 50% - severely restricted; 51-70% - significantly restricted; 71-85% - moderately restricted; 86-95% - slightly restricted; 95-100% - within normal ranges. The data was plotted as departure from mean tidal range (Y-axis) versus time (X-axis). This procedure is outlined in *Tidal Crossing Handbook: A Volunteer Guide to Assessing Tidal Restrictions* (Purinton and Mountain, 1998).

WATER CHEMISTRY - SALINITY

Sampling Procedures

The water chemistry effort measured both channel creek surface water and ground water salinity at stations at the study and reference sites. Three stations were established along two transects which bisected each wetland. Transect location was determined by measuring 150 and 300 feet from the tidal restriction along the salt marsh creek. At these locations, transects were laid perpendicular from the creek channel to the upland edge of the salt marsh. Two shallow ground water wells were installed along each transect, one closer to the bank and the second near the upland edge. Surface water samples were collected from the creek channel at the third sampling station located where the transect met the creek channel.

The shallow ground water wells were constructed of plastic PVC pipes and perforated geotextile fabric. Small (approximately ¼ inch) holes were drilled into the base of the PVC pipe at a frequency of roughly 1 hole per square inch. This area of the pipe was then wrapped in the geotextile fabric, covering completely the opening at the end of the pipe and the drill holes, and secured with duct tape. The top portion of the pipe was left intact, except for one vent hole drilled into the side of the pipe, and a screw-top cover was fitted over the pipe opening.
To install the wells, a small core of marsh sediment was extracted using a sand auger. The well was installed in the hole by pushing the cloth end of the pipe into the ground. The perforated section of the pipe was completely submerged into the ground. The marsh sediment extracted by

the auger was then packed around the edge of the well to fill any remaining gaps between the marsh sediment and the well.

Samples were collected during various tidal stages. Standing water was pumped out of the shallow ground water wells before salinity samples were taken using a hand-held pump. This ensured that the water sample consisted of recharge water and not rain or surface waters. Once a sufficient amount of groundwater had recharged the well, the water was extracted from the well using a PVC bailer. Water samples were collected from the creek channel using the same bailer. The bailer was rinsed with deionized water before collecting the sample and between all samples. The water sample was poured from the bailer into a clean, dry paper cup. A salinity measurement was taken from the sample using a VISTA Series Instruments Portable Refractometer (model number A366ATC (0-10% Sal.). The sensor on the refractometer was rinsed with deionized water and dried between readings. All salinity measurements were recorded onto the Salinity Field Data Sheet (Appendix p. 23). Data sheets included names of volunteers, site name, date, times of low and high tides, approximate tide at sampling, and additional observations (including weather).

Data Analysis

Salinity measurements were collected three times, July through September. The measurements taken at each sampling location were averaged over multiple sampling dates. For instance, salinity values from samples collected from the two well A's (transect 1 and 2) at a site, were averaged to arrive at one salinity value for those stations. This was also done for the salinity measurements taken at the B wells and from the salt marsh creek stations. A overall salinity average was computed for the site by averaging all of the salinity readings taken during the summer. Rather than using metric analysis, the average salinity values were reviewed and compared in order to identify any obvious differences in salinity between the study and reference sites. The error of the refractometer used to measure salinity, could be as much as 1.0ppt, therefore only salinity differences that exceeded the error of the refractometer were considered different.

VEGETATION

Sampling Procedures

Vegetation sampling took place in August. Plants were surveyed at the reference and study sites on the same day. The same wetland evaluation area (WEA) was used that was established for the pre-restoration monitoring. The WEA was stratified into three sections as follows: Section 1 was the area between the starting point of the evaluation area (0’) and a point 100’ along the salt marsh creek; Section 2 was the area between 100’ and 200’ along the salt marsh creek; Section 3 was the area between 200’ and 300’ along the salt marsh creek.

The same starting points and compass bearings were used for the 2004 and 2005 post-restoration monitoring as were used in the previous three years of pre-restoration monitoring. Originally, numbers were randomly generated for the location of two transects within each section (six per evaluation area). The random number was the distance in feet from the beginning of each section and marked the starting location of each transect. If the location of a transect placed it on a ditch, within 3 feet of another transect, or some other unworkable location, then another number/location was used. Transects ran from the bank to the upland edge, according to a consistent compass bearing. If the location or compass bearing for the second set of transects (on other side of culvert) yielded awkward or unworkable transect locations, such as transects falling directly on channels or excessively long transects, then a new compass bearing was used for the second set. A stake was secured at each end of the transect and labeled.

A 1m^2 plot frame constructed from ½ inch PVC material was placed every 60 feet along each transect, starting at the bank and progressing toward the upland edge. Plots were located every 30 feet if the transect length was less than 120 feet. The first plot was always placed at the beginning of the transect and the last plot was placed in the salt marsh border regardless of whether or not it fell in the 30 or 60 foot interval.

Individuals always walked on the left side of the tape measure and placed the plots on the right side to avoid trampling plants to be identified and to know that plot position was consistent. Plots were positioned so that the bottom left-hand corner of the frame was always located at the designated distance on the measuring tape (e.g., at 120 feet).

Starting at the first plot on the first transect, every plant that fell within the 1m^2 plot frame was identified. The plant community type was recorded within each plot (low marsh, high marsh, or border). The scientific name (genus and species) of each species was recorded on the field data sheet, Plant Survey Field Data Sheet (Appendix p.18-21). Using the Salt Marsh Vegetation Survey: Standard Cover Classes and Midpoints for Estimating Abundance worksheet (Appendix p. 22), the cover class that most accurately portrayed the abundance of each species in the plot was selected. All leaves, branches, and stems that fell within the vertical column made by the plot frame extended upwards were included. Total abundance for all the species in the plot could total more than 100%, as plants may have overlapped each other. Plot coverage estimates, which included areas within the plot frame that were not occupied by living vascular plants, were called "Other." This category included duff, old dead leaves, bare ground, and open water.

In the plots where *Phragmites australis* occurred, the height of the tallest 10 living individuals was measured (in plots containing less than 10 plants all living plants were measured). Plants were measured from the ground to the tip of the inflorescence (flowering part of the plant), or if no inflorescence was present, were measured to the tip of the highest leaf.

All data was recorded on the field data sheet. Names of investigators, site name, date, reference or study, transect number, distance from origin point, compass bearing of transect; plot ID, location on transect (feet) and community type, genus, species, % cover. If there was trouble identifying a specimen using *A Field Guide to Coastal Wetland Plants of the Northeastern United States* (Tiner 1987), *Field Guide to Coastal Wetland Plants of the Southeastern United States* (Tiner 1993) or a different field guide, the specimen was called "Unknown Species A" in the field data sheet and the plant and part of its roots were placed into a resealable plastic bag (along with a label) for later identification.

Data Analysis

Community Similarity

Community similarity refers to the similarity or difference in species between the two different communities. The ratio was calculated by dividing the number of species that the study site and reference site shared by the number of species at the reference site.

Taxa Richness

Species richness was computed by looking at the number of different species (or genera) that were documented at a particular site. The number of species was counted at each site and a ratio of species richness at the study site and reference site was computed.

Weighted Values

A species list was generated for the WEA. Each species identified in the WEA was listed only once with the total wetland abundance value (adding values for that species from various plots, if applicable) for that species in the WEA. Using this list, each species was assigned various wetland attribute scores. The attributes that were used are listed below.

For each species, the attributes were weighted to reflect the total abundance of that species. For instance, to arrive at the weighted wetness value for *Spartina patens*, the wetness attribute for *Spartina patens* (0.91) was multiplied by the total abundance of that species at the site (11.88) to arrive at a weighted wetness value of 10.81. This pattern was repeated for all species and for the other weighted attributes as well.

> **Invasive:** This attribute identifies whether or not a species has been identified as invasive. A species with a positive invasive attribute is defined as an aggressive colonizer of natural and disturbed areas, often forming extensive monoculture stands. Invasive species are often non-native. Examples of invasive species are: *Phragmites australis* (common reed) and *Lythrum salicaria* (purple loosestrife).
>
> **Wetness:** This attribute was taken directly from the U.S. Fish and Wildlife Service National List. Wetness values rank a species relative affinity to hydric (wet) conditions. Attributes range from obligate (wetland dependent) to upland, and are based on the median probability of a particular species occurring in a wetland. Wetness scores were assigned according to this scale: Obligate = 1.00; FacWet+ = 0.91; FacWet = 0.82; FacWet- = 0.71; Fac+ = 0.60; Fac = 0.50; Fac- = 0.40; FacUp+ = 0.29; FacUp = 0.18; FacUp- = 0.09; Upland = 0.00.
>
> **Salinity Tolerance:** This attribute ranks a species' tolerance to saline conditions. The attributes range from intolerant to very high tolerance. Intolerant species will not survive saltwater exposure, including the occasional ocean spray. Species with very high tolerance will survive in tidal areas with twice-daily inundation of saltwater. Salinity tolerance scores were assigned according to this scale: Very High = 1.00; High = 0.80; Medium = 0.60; Low = 0.40; Intolerant = 0.20. The values for this attribute were adapted from the New England Institute for Environmental Studies Plant Community Indicator Database (Michner, 1990).
>
> **Nutrient Regime:** This attribute ranks a species affinity for certain habitats associated with a corresponding nutrient availability. Attributes range from species generally occurring in areas with low nutrient availability (as in bogs and isolated wetlands) to those species occurring in areas with disturbances or enrichment from fertilizer or wastewater. Nutrient scores were assigned according to this scale: Bogs, lowest nutrients = 0.12; Sands, low nutrients = 0.23; Acid woods, till, and sandy loam = 0.34; Alluvial acid soils, enriched by flood deposits = 0.45; Sweet soils in calcareous areas = 0.56; Alluvial sweet soils = 0.67; Somewhat disturbed or partly enriched soils = 0.78; Disturbed or enriched soils = 0.89; Very disturbed and heavily enriched = 1.00. The values for this attribute were adapted from the New England Institute for Environmental Studies Plant Community Indicator Database (Michner, 1990).

Index of Vegetative Integrity (IVI)

Biological Condition Scores were used to assign a final score to each metric using the scoring criteria below. Scores were totaled and then converted to a percent value [(*n*/36)*100] called the Index of Vegetative Integrity (IVI) Score.

Table 1. Vegetation Index Metrics

Metric	Rationale	Response to Stressors	Metric Computation	Biological Condition Score
Community Similarity	Resemblance of communities to reference site will shift as stressors increase	Decline	Total percent shared species	# species at study site common to reference site / # species at reference site
Taxa Richness	Total number of plant species will change as stressors increase	Variable	Absolute difference of total taxa	|# species ref. site - # species study site|
Invasive	Increased presence of invasive species reduces habitat and other wetland functions	Rise	Total abundance of species with positive invasive attribute	
Wetness	Species composition will shift towards upland or obligate due to hydrologic stressors	Decline	Percent similarity of wetness value weighted for abundance	n / Ref. x 100
Salinity Tolerance	Species with lower salinity tolerance will colonize or persist with change in tidal hydrology	Decline	Percent similarity of salinity tolerance value weighted for abundance	n / Ref. x 100
Nutrient Regime	Species composition will shift with nutrient enrichment and elevated eutrophication	Variable	Percent similarity of nutrient regime value weighted for abundance	Ref. / n x 100

Table 2. Vegetation Biological Condition Scoring Criteria

	Biological Condition Scoring Criteria			
METRIC	**0**	**2**	**4**	**6**
Community Similarity	<40	40-59	60-80	>80
Taxa Richness	>6	5-6	2-4	<2
Abundance Invasive	>33	17-33	1-17	<1
Weighted Wetness	<88	88-91	92-96	>96
Weighted Salinity Tolerance	<70	70-79	80-90	>90
Weighted Nutrient Regime	<58	58-71	72-86	>86

AQUATIC MACROINVERTEBRATES

Sampling Procedures

Habitat Description

The volunteers fully described habitat conditions and potential stressors to the marsh. Observations were recorded on the field sheet, Form 1: Salt Marsh Invertebrate Field Sheet (Appendix p. 5-9).

Collecting Samples

Invertebrate sampling coincided with mid to low tide. Three sample stations were chosen (0, 150, 300ft) near the beginning, middle, and end of the transect. Care was taken to choose sample stations that were representative of local conditions. Sampling was begun at the downstream location against the flow of water and work "upstream" against the flow so that other unsampled stations above were not disturbed. Three types of samples were collected at each station: quadrat (or plot) samples at the top of the bank, D-Net samples in the stream, and auger samples in the stream. The instructions below were used to collect these samples.

Quadrat Sampling

The following procedure was used for quadrat sampling:

The quadrat was placed on the bank near the water's edge at a location that was typical of the bank condition. Every living invertebrate that was encountered was identified, counted, and recorded on the field sheet (Form 1). This procedure was repeated at the other sampling stations.

D-Net Sampling

The following procedure was used to collect D-Net samples:

The sampler faced against the flow of water. The flat side of the D-Net was placed on the surface of the substrate in the water, and the net was held perpendicular to the substrate as the sampler walked 10 strong and even paces toward the water flow, pulling the D-Net through and over different habitats (different substrate types, wood debris, etc.). The net containing the sample was brought to the surface for retrieval. The contents of the inverted net were placed over a bucket half filled with water and all debris and invertebrates were washed off the net and into the bucket. The contents of the bucket were poured through a standard US No. 30 brass sieve to remove the water. The contents of the sieve were placed into a resealable plastic bag. If a large number of snails and crabs were in the sample, they were identified in the field, the numbers of each family (and if possible, species) were recorded on the field sheets, and then they were returned back to the water alive. The resealable plastic bag was labeled (see instructions below) and the sample information was recorded on the field sheet (Form 1). The procedure was repeated at the two other sample stations, each sample was placed into a separate resealable plastic bag.

Auger Sampling

The following procedure was used to collect auger samples:

The auger was held perpendicular to the water surface above the point from which the D-Net sample was taken. The auger was pushed downward into the sediment until the bucket of the auger was half embedded in the substrate. The auger was carefully pulled out of the sediment and the sieve was quickly placed beneath the auger so that none of the sample was lost. The sieve was kept under the auger as the sampler returned to the bank, where the remaining auger contents were emptied into the sieve. Fine sediment was removed from the sieve by carefully placing it face up in the water (being careful that the water did not cover the top) and the sampler gently swirled the contents so that the fine sediment passed through the sieve. The sieve contents were placed into a resealable plastic bag, sealed, labeled (see instructions below), and the sample information recorded on the field sheet (Form 1). The procedure was repeated at the other two sampling stations, each sample was placed into a separate resealable plastic bag.

Sample Bagging and Labeling

The following procedures were used to label samples:

Using a permanent ink marker, all samples were labeled with the following information: sample number, field site identification, sampling station number, date, names of collectors, sampling method, and the preservative used. This was done before going into the field.

All bagged samples were flooded with 99% isopropyl alcohol. The sample numbers were recorded on the field sheet (Form 1). The bagged samples were placed in a cooler with ice to prevent heating in hot weather. The samples were stored in a refrigerator for no longer than two weeks before sorting.

Sample Sorting

The following guidelines were used for sorting samples:

The contents of a sample were emptied into the standard US #30 sieve. The sample was gently rinsed under tap water to remove fine organic detritus, silt, and clay. The sample was placed into a white sorting tray. The sorting tray was placed under a desk light or magnifying lamp. Using the magnifying lens and forceps, invertebrates were removed from the sediment and placed into a large (40mL) vial two-thirds filled with 99% isopropyl alcohol. After the sorting was finished, the program director scanned the debris in each sorting tray to double check the work. Each vial was tightly sealed and labeled (two for each sampling station: one for D-Net and one for auger), and the sample was registered on the registration sheet, Form 2: Invertebrate Samples Record Check (Appendix p. 10).

Identifying and Counting Samples

The following guidelines were used to identify and count invertebrates:

The contents of each vial were poured into a petri dish. The petri dish was placed under the dissecting scope and in a deliberate, systematic manner the identifier, scanned back and forth, identifying organisms. Using *Marine Animals of Southern New England and New York* (Weiss, 1995) and *A Practical Guide to the Marine Animals of Northeastern North America* (Pollock, 1998) and other references the invertebrates were identified to family level. Each taxon was recorded and counted on the bench sheet, Form 3: Invertebrate Laboratory Bench Sheet (Appendix p. 11-13). Immediately after a specimen was identified and recorded, it was returned to a labeled vial two-thirds filled with 99% isopropyl alcohol. The vials were labeled and safely packed for storage. The program director, trained by the previous aquatic invertebrate specialist, was present during identification sessions and reviewed all the identification work. The completion of this process was recorded for each sample on the registration sheet (Form 2). The data from the quadrat, D-Net, and auger samples taken from the same sampling station were combined on the bench sheet (Form 3). The total number of organisms for each family or taxonomic group, the number of different types of taxa identified, and the resulting total abundance for the completed composite sample were entered. This process was repeated for the remaining two sample stations, using a separate bench sheet (Form 3) for each station.

Data Analysis and Comparison

Metrics for 2004 and 2005 post-restoration data analysis were the same metrics used in 2003 to determine the Salt Marsh - Invertebrate Community Index (ICI) to facilitate data comparisons. It is to be noted that in 2004 and 2005, only the two Gloucester salt marshes were monitored. Therefore, with only one reference and one study site, it is impossible to establish a gradient of impact.

Metrics for 2003 were selected using the following procedure

All data was entered into Form 4: Invertebrate Data Form (Appendix p. 14-16). This data was also placed in an Excel spreadsheet version of Form 4. The three salt marsh sites were aligned along one row on an Excel spreadsheet according to a gradient of impact based on best professional judgment, ranged from least impacted through to most severely impacted. All possible metrics were listed in the first column, and matching data entered across the spreadsheet. If a particular candidate metric value increased across the sites gradient, or noticeably decreased across the gradient, particularly in respect to the Reference Average Value (the average derived from taking the mean across reference sites), it was selected as a metric for calculating the Salt

Marsh - Invertebrate Community Index (ICI). Average, Minimum, Maximum, Quartiles and Standard Deviations were calculated.

The Biological Condition Score (BCS) criteria table for the selected metrics was determined using the Reference Average Value to mark a maximum score of 6, and the Standard Deviation was used to set the breaks for the other scores 4, 2, and 0. Metric scores for each site were summed, and the sum converted to a percentage for the final ICI.

Table 3. Macroinvertebrate Biological Condition Scoring Criteria

Selected Metrics for 2003	Impact Trend	Ref. Avg.	0	2	4	6	Factor	Represents	Stnd. Dev.
Total Taxa Richness	Decline	16.33	<6	6-12	12-18	>18	6	.5 sd	6
% Predators	Rise	5.36	>9	6 - 9	3-6	<3	3	0.33 sd	9
% Deposit Feeders	Decline	20.81	<6	7-13	14-20	>20	6	.75 sd	8
% Contribution Dominant Taxa Group	Rise	54.52	>85	68-85	50-67	<50	17	sd	17
% Rare	Rise	38.59	>63	51-62	39-50	<39	11	.5 sd	22
% Phyllodocida	Decline	18.05	<7	7-13	14-18	>18	6	.33 sd	17
% Amphipoda	Decline	39.86	<15	15-29	30-44	>44	14	sd	14
% Tanaidacea	Decline	3.25	<1	1-3	4-6	>6	2	sd	2
% Other Groups	Rise	13.06	>81	48-81	14-47	<13	33	sd	33
% Insects, Spiders and Mites	Rise	18.26	>82	50-82	17-49	<17	32	sd	32

Habitat Assessment Score (HAS)

Form 1 and Form 5 (Appendix p.17) were used express habitat and water quality in a way comparable to the invertebrate community metrics and the ICI. Ten variables of habitat condition were used to compute an overall score, called the HAS. The HAS is expressed as a percentage of a theoretical optimal condition. The following procedures are used to compute the HAS:

1. The Form 1 information and best judgment were used to determine a score for each of the variables on Form 5. Scores ranged from zero to five, with zero = poor and five = excellent. Partial numbers were allowed to be used (i.e. 3.5). The score was then recorded in the appropriate column on Form 5.
2. The scores for each variable were summed and converted the total to a percentage. Conversion to % = total score for attributes/50 x 100

Summary of ICI and HAS

The Salt Marsh Invertebrate and Habitat Summary Graph were used as a graphical representation of the HAS and the ICI. The vertical axis of the graph represented the ICI and the horizontal axis represented the HAS. The graph provided a visual representation of salt marsh invertebrate community condition and provided some indication about the relative importance of habitat quality when marshes were plotted against the two axes.

NEKTONS

Nekton data were collected from the salt marshes creeks three times throughout the season with the reference site and study site being sampled at the same time.

Sampling Procedures

A total of six minnow traps (1/8" fine mesh) were used for each sampling date — three for the study site and three for the reference site. The traps were equally spaced along the study and reference gradient; that is, for a 300 foot stretch, traps were located at 0ft, 150ft, and 300ft. Traps were positioned at the edge of the tidal creek. Minnow traps were deployed for approximately 2 hours. Traps were retrieved and emptied into individual buckets of water. Samples were processed, and water quality readings were taken at deployment and retrieval (i.e., water salinity and temperature). All information was recorded on the Fish Data Sheet (Appendix p. 3-4). Information recorded also included names of samplers, date, time, station, temperature, and salinity.

New Additional Sampling Procedure - 2005

Ditches nets were employed following the Nekton Survey Protocol (p.33) from *A Volunteer's Handbook for Monitoring New Hampshire Salt Marshes*. The handbook was developed by New Hampshire Coastal Program and Ducks Unlimited through funding from the Gulf of Maine Council on the Marine Environment and the National Oceanic and Atmospheric Administration (NOAA). Two ditch nets were set in open ditch areas at both the reference and study site and left undisturbed for 30 minutes. Two people, kneeling on opposite sides of the ditch, pulled the ripcords to bring up the doors smoothly and quickly to enclose any nektons. These people stayed quiet next to the ripcords without moving or touching the ripcords for at least two minutes before closing the nets to avoid any vibrations that might disturb the nektons from the net. The nets were then lifted out onto the marsh. All captured nektons were identified to species, sexed and measured. The nektons were then returned to the water.

Sampling Processing

All fishes and crabs were identified to species and the numbers of each species were counted in each sample. The length of each organism was measured to the nearest millimeter. Standard length of fish was measured. Each species was weighed to the nearest gram. Any external abnormalities, such as skin lesions or parasites, were noted. Creatures were returned to the water as soon as possible to limit mortality. Shrimp were noted and counted.

The following procedure was used if greater than 40 individuals of any particular species were collected. The entire sample was separated by species. Species collected in large numbers were put in separate buckets. A small net was used to randomly capture 40 fish from the bucket containing the entire individual species catch. These 40 fish were measured. The entire sample of a particular species was weighed, and then the sub-sample was weighed. All of the fish were then counted. This information was recorded on the data sheet.

Data Analysis

The fish data was analyzed by creating a species list for each site and creating a table with the dates the species were found at each site. This table also included total number of organisms caught on per sample date. Several graphs were created to visually represent and compare the data. The average water salinity and water temperature for each site per sample date was computed. This was done by computing the average of all three stations and using this number as an overall average number for the site. The standard deviation was also computed and graphed.

The average standard length of the most common fish species caught, Mummichogs (*Fundulus heteroclitus*), was also graphed, by comparing the averages of the reference site vs. study site for each date sampled. The standard deviation was calculated and graphed. The average weight for each Mummichog caught was also computed, including standard deviation, unless the small sample size did not allow for a standard deviation to be calculated. The average number of Mummichogs caught per trap was also graphed, including standard deviation.

Length frequency was also computed. The number of fish caught in each length class was graphed. This information was graphed on a per sample date basis, comparing reference vs. study sites. The length classes included: 10-20, 21-30, 31-40, 41-50, 51-60, 61-70, 71-80, 81-90, and 91-100mm.

BIRDS

Observations and Data Collection

Bird data were collected during the summer months. Surveys were conducted early in the morning, at dawn when possible. Counts were conducted for the reference and study site on the same morning to minimize the effects of different environmental conditions (especially weather and tides) on bird richness and abundance. Surveys were done by conducting point counts at each of the sites. Five surveys were conducted at each of the salt marshes over the season.

Various site and weather conditions were recorded on the Avifauna Survey Field Form (Appendix p.1-2) immediately prior to sampling. Parameters recorded on this sheet included volunteer name(s), site name, date sampled, time sampling began, time sampling ended, approximate wind speed, wind direction, weather, tidal stage, and any other notes or observations deemed relevant.

A vantage point from which observers could see a representative portion of a salt marsh, including the marsh border was chosen and the same vantage point was used for all subsequent visits to the marsh. A twenty-minute observation session was conducted for both the study and reference site. All species seen and heard were recorded on the Field Form with notations of the number of individuals of each species. This included birds located in the wetland and a 50-100 foot wetland buffer. High-flying species passing over the wetland and judged not to be using the wetland in any way were not counted. However, birds flying over the wetland and conducting a wetland-related activity, such as hunting, were counted.

Observers recorded the activity and habitat of each bird observed on the Field Form. Activity was noted sitting or flying, or a combination of these choices. Habitat was noted as wetland or buffer, or a combination of these choices. "National Geographic's Field Guide to the Birds of North America" (Third Edition 1999), was used to aid in species identification. Volunteers listened to "Peterson Field Guides: Eastern/Central Birding by Ear" (1989) to enable identification by birdcall. A bird expert was with the volunteers at every count to ensure consistency and accuracy of data.

Data Analysis

Ten metrics were used to analyze the avifauna data. These metrics include species richness, neotropical migrants, wetland dependent species, resident species, tolerant species, starlings and blackbirds, insectivorous aerial foragers, regionally rare species, 3 most abundant species, community similarity. These metrics were chosen because it was anticipated that the species in these categories would reflect wetland quality to some degree. It is important to note that species noted may have been placed into more than one category or not included in any of the categories. Consequently, the summed percentages of the various groups at any particular sites may not total one hundred. All metrics were calculated as described below and then scored using the Avifauna Index metric scoring criteria for salt marsh sites.

Table 4. Avifauna Index Metrics

Metric	Rationale	Response to Stressors
Species Richness	Species richness is expected to be highest in sites where habitat quality and food supply are most optimal.	Decline
% Neotropical Migrants	Neotropical migrants are habitat specialists and sensitive to habitat quality.	Decline
# Wetland Dependant Species	Wetland-dependant species require habitat that ties them exclusively to healthy, aquatic sites.	Decline
% Resident Species	Resident species are less sensitive to habitat quality and tend to be habitat generalists.	Increase
% Tolerant Species	Tolerant species are generalists that adapt to human-altered habitats and landscapes.	Increase
% Starlings and Blackbirds	Starlings and blackbirds are tolerant species whose numbers are expected to increase in habitats that are degraded.	Increase
% Insectivorous Aerial Foragers	Flying, insect-feeding species depend on a healthy invertebrate population for food.	Decline
Number of Regionally Rare Species	Regionally rare species are expected to be found only in the best available habitat.	Decline
% Abundance of 3 Most Abundant Species	Overall species diversity will decrease under impacted conditions, allowing a few species to dominate.	Increase
Community Similarity Ratio	The percent similarity between reference sites and other similarly structured sites should be the same if they are healthy.	Decline

Species Richness

Species richness is the number of species observed. Species richness is an important variable because in general pristine salt marshes will support more species than disturbed salt marshes. Usually, severe pollution or habitat degradation will eliminate sensitive species, thereby reducing species richness. This metric does not always reflect pollution or degradation, especially when there are natural habitat differences between two sites. For this report species richness was calculated as an average number of species observed on a sampling date.

Percent Neotropical Migrants

Neotropical migrants are species that migrate toward the southern hemisphere for the northern winter, and include species such as warblers and flycatchers. This metric is the proportional abundance of these species. Most neotropical migrants are very sensitive species with specific habitat requirements. Higher quality wetlands are expected to support greater numbers of neotropical migrants. Time of year is an important consideration when using this metric, however, since migratory species are usually only encountered during the warmer months. The metric was calculated as the average percentage of the total species on a sample day and is expected to be higher at sites with greater habitat quality.

Number of Wetland-Dependent Species

Wetland-dependent species are those species that rely on wetlands for some portion of their life cycle such as nesting or feeding, and include species such as Red-Winged Blackbirds, various shorebirds, ducks, and herons. This metric is the proportional abundance of these species. Wetland-dependent species are more sensitive to habitat conditions and feeding opportunities in wetlands because they are strictly reliant on the wetland during critical phases of their life cycle. Polluted and degraded marshes can continue to support non-wetland species because they can forage in upland areas. Thus, the average number of wetland-dependent species is expected to be higher in pristine marshes, and lower in polluted or degraded marshes.

Percent Resident Species

Resident species — such as American Crows, House Sparrows, and Northern Cardinals — do not migrate, are generalists, and can shift their diets in response to seasonal or resource changes. This metric is the proportional abundance of these species and individuals. Since resident species have the ability to use different resources and adapt to scarce resources, they are better able to cope with alterations to food quality/quantity or habitat conditions that result from pollution or degradation. Therefore, resident species are expected to comprise a higher proportional abundance of the bird community in polluted or degraded marshes.

Percent Tolerant Species

Tolerant species are generalists that are adapted to living close to man and his activities, but unlike resident species may be migratory or partially migratory. Examples include American Robins, Cedar Waxwings, Blue Jays, and American Crows. This metric is the proportional abundance of these species and individuals. Similar to resident species, tolerant species have the ability to use different resources and adapt to scarce resources, and are better able to cope with alterations to food quality/quantity or habitat conditions that result from pollution or degradation. Sites that are suffering from environmental impacts should have more species that can tolerate such conditions.

Percent Starlings and Blackbirds

Blackbirds and starlings are opportunistic feeders that often occur in large flocks, and are generally tolerant of human disturbance. In our area, these include European Starlings, Red-Winged Blackbirds, Brown-Headed Cowbirds, and Common Grackles. This metric is the proportional abundance of these species and individuals. Similar to resident and tolerant species, a high proportional abundance of blackbirds and starlings can be a signal of poor habitat quality, since these species, when in large post-breeding feeding flocks, are generalists, tolerant of man, and thrive in poorer quality habitats.

Percent Insectivorous Aerial Foragers

The metric is calculated as the percentage of the total species and is expected to be higher at sites with greater habitat quality. Warblers, swallows, and flycatchers are among the many species that feed by flying around and catching insects, and are dependent on healthy invertebrate communities. This metric is the proportional abundance of these species and individuals. Marsh pollution or habitat degradation that affects invertebrate communities is also expected to decrease the proportional abundance of birds that prey on invertebrates. A high proportional abundance of aerial foragers is a good indication that environmental conditions are suitable for a healthy invertebrate community. In addition, many of the insectivorous aerial foragers are also neotropical migrants with specific habitat needs.

Number of Regionally Rare Species

Rare species are those with a restricted geographical distribution, or unusually specific habitat needs that only enable them to exist at extremely low population densities and a small number of locations. Examples include the Salt Marsh Sharp-Tailed Sparrow, Cliff Swallow, Least Tern, and Clapper Rail. This metric is simply the average number of rare species and individuals. The presence of rare species can sometimes be a good indicator of relatively pristine and healthy conditions. Caution should be used when interpreting this value because rare species are often found at unexpected times and in unexpected locations, and an observation may be largely due to chance.

Percent Abundance of Three Most Common Species

This metric is a measure of dominance and reflects the degree to which a community is dominated by a small number of species. In other words, it is a measure of how evenly distributed the species are in a community. Marshes that are polluted or degraded often provide few feeding opportunities, and the bird community is usually dominated by a small number of tolerant species that can adapt to existing resources. Pristine and healthy marshes provide many opportunities for nesting and foraging, which allow many different species to coexist, and leads to a more equitable distribution of species. Therefore, this metric is expected to be higher in polluted or degraded marshes and lower in pristine marshes.

Community Similarity Ratio

Community similarity refers to the types of species that occur in a community and in particular the similarity or difference between two communities. Metrics for species richness and relative abundance were already calculated, yet two sites can have identical species richness and relative abundance and have entirely different species. Since different species have different environmental requirements, the types of species in a community provide clues about salt marsh condition. When interpreting community composition data, it is important to understand the ecology and environmental tolerance of the birds. The community similarity ratio is a quick way to judge the similarity of two sites, but the interpretation of this ratio is somewhat subjective. More importantly, one must look at unique species from each site and consider what traits unite these species and why they are present at one site and not the other. Perhaps one site has a large number of sensitive neotropical migrants that are not found at another site, or a large number of resident or tolerant species that may indicate poor wetland conditions. After completing each metric computation, the results were scored using the criteria in the table below. The scores were summed and then converted to a percent score for that site [(*n*/60)*100], called the Avifauna Index.

Table 5. Avifauna Index Metric Scoring Criteria: Salt Marsh Sites

SCORE:	**0**	**2**	**4**	**6**
Species Richness	<8	8-12	>12-16	>16
% Neotropical Migrants	<15	15-25	>25-35	>35
# Wetland Dependent Species	<3	3-4.5	>4.5-6	>6
% Resident Species	>50	>40-50	30-40	<30
% Tolerant Species	>50	>40-50	30-40	<30
% Insectivorous Aerial Foragers	<5	5-15	>15-25	>25
# Regionally Rare Species	<.4	.4-.6	>.6-.8	>.8
% Starlings & Blackbirds	>35	>25-35	15-25	<15
% 3 Most Common	>70	>55-70	40-55	<40
Community Similarity Ratio	<40	40-60	>60-80	>80

LAND USE

Base maps were prepared for each of the impacted wetland sites and their respective reference sites in advance of the volunteer workshop. Infrared aerial photographs (1:12,000) were used to delineate the wetland areas. Within each wetland, two distinct zones of influence were delineated. The area 100 feet from the wetland edge was designated as Zone I. The area 100 meters from the wetland edge was designated as Zone II. The different land use types within the wetland and Zones I & II were outlined on the map and defined according to McConnell LU37 codes.

An onsite field visit to each wetland site was conducted to complete the Land Use Index Rapid Assessment Form (Appendix p. 25). Observers used a combination of local knowledge, maps, and best judgment to complete the form. The numerical scores for each question were summed and then converted to a percent score of rapid assessment of land use for each wetland area.

The area of the Wetland Evaluation Area, both Zones of Influence, and the various Land Uses were calculated using the grid method. The acreage grid consisted of a clear plastic sheet with a black-lined grid (1 grid square = 0.25inch^2) that was laid over the base map. The number of complete grid squares within in area was counted and recorded on the Worksheet 1: Computing Areas with the Grid Method (Appendix p. 26). The number of partial grid squares within the area was counted, divided by two, and recorded on the worksheet. These two values were summed and recorded as Total Grid Squares on the worksheet. Total Grid Squares was converted to an acreage value using the appropriate conversion factor.

Acreage of each land use type in Zone I & II was calculated using the Worksheet 2: Calculating LUI Index for Buffer Zone Areas (Appendix p. 27). The land use name or code, the total area of the land use type (calculated using the grid method), and the land use coefficient for that land use type (taken from "McConnell Land Use Types and LUI Loading Coefficients", see Appendix p. 28) were recorded on the worksheet. A land use coefficient of 1.00 is the highest score possible. This score indicates land uses such as forest, wetland, salt marsh and water that have no negative impact on the wetland evaluation area. The total area of each land use type was multiplied by the land use coefficient and recorded. That value was divided by the total area of the Index Zone (total area of Zone I or Zone II) and recorded.

RESULTS

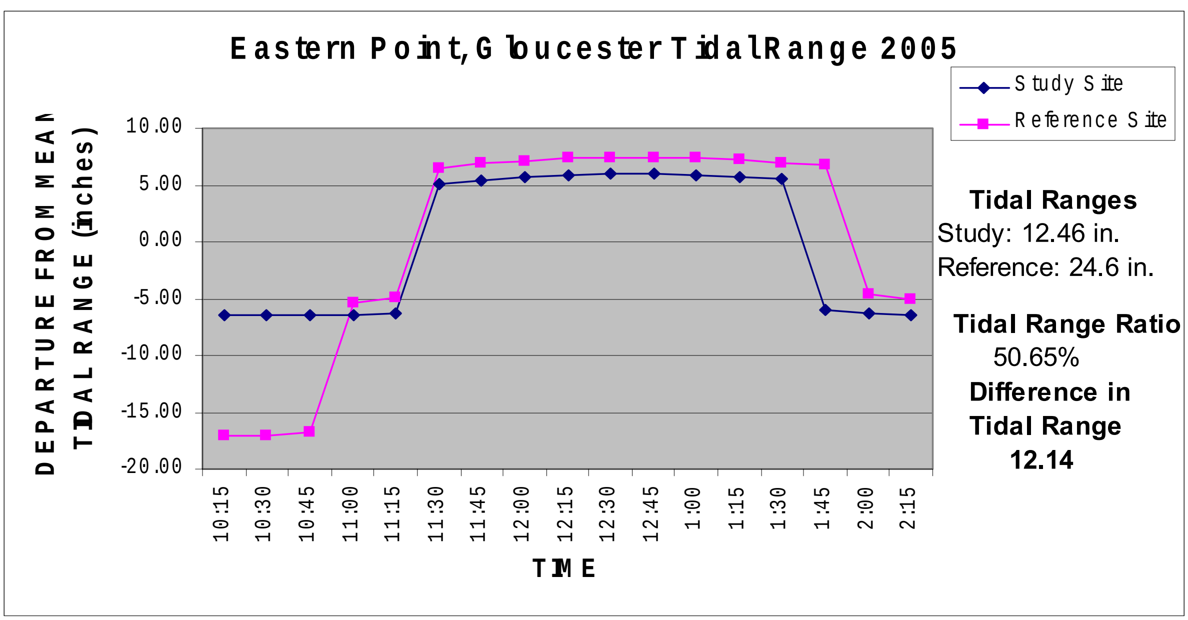
TIDAL INFLUENCE

To reach the Eastern Point salt marsh, tidal waters must pass through two culverts. The reference staff gauge was placed downstream at the Gloucester Harbor side of the new culvert. Measurements were compared to a staff gauge placed upstream where the water flows into the salt marsh on the upstream side of the driveway culvert. The percentage tidal range comparing Gloucester Harbor to the salt marsh was 50.65%, with a tidal range difference of 12.14. On the sampling date, a -1.3ft. low tide was at 6:22AM and a 9.3 ft. high tide was at noon.

Measurements were taken upstream and downstream of the driveway culvert in 2004. The percentage tidal range ratio was 99.92%, with only a tidal range difference of 0.01. Since the driveway culvert does not restrict the flow of water, it was not measured in 2005.

Photographs of the salt marsh were taken at the time of high tide. These photos show that during a spring tide most of the marsh is inundated including the north side where the vegetation during pre-restoration monitoring consisted freshwater invasive plants. Several pannes are forming on the marsh. The photographs are available on CD from Salem Sound Coastwatch.

Figure 3. Tidal Graph for 2005 using a Staff Gauge, Eastern Point, Gloucester



SALINITY

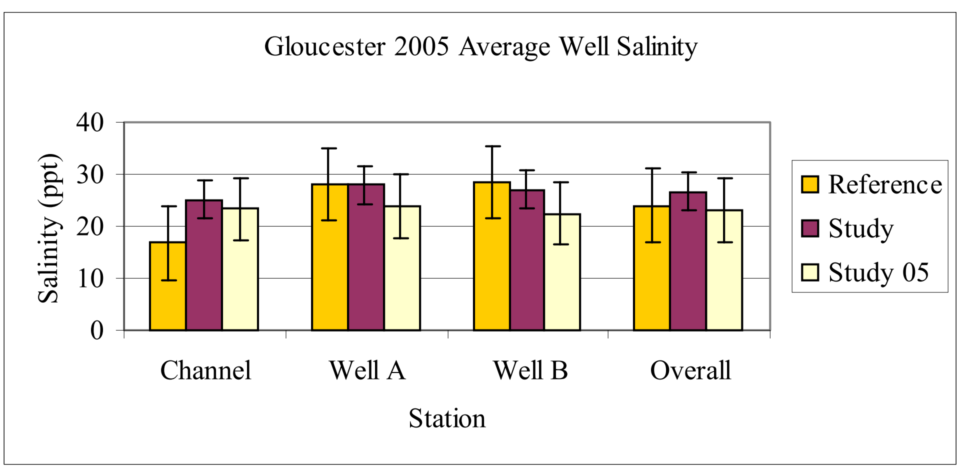
Salinity was measured on July 13 and 27, and again on September 7. The overall average for the reference site was 23.98 ppt (SD=7), while the study site's overall average was 26.61 (SD=3.7). The reference site overall was lower than 2004's recording of 31 ppt (SD=3.4). The fresh water influence from the channel at the time of sampling resulted in this lower salinity. The study site salinity recordings correspond with the 2004 site's overall average of 27 ppt (SD=4.6).

This year, four additional wells were installed at the study site since more water is flowing into the site than during the pre-restoration monitoring years of 2001-2003. Wells were added on the left or north side of the creek, which previously supported loosestrife, poison ivy and rosa rugosa. A third transect was added on the south side of the creek 150 feet beyond the second transect. Well B of this transect was placed at the edge of the bordering *Phragmites australis.* In Table 6., the Study New Wells column presents the results of these new wells, while the Study Site column shows the results from the previously sampled wells and channel. Comparisons to past years results should use the Study Site column.

Table 6. Average Well Salinity Values, 2005, Gloucester

SALINITY			
STATION	REFERENCE SITE	STUDY SITE	STUDY NEW WELLS
Channel	16.78	25.13	23.31
Well A	28.12	28.02	21.12
Well B	28.55	27	20.93
Overall	23.98	26.61	21.18

Figure 4. Graph of Average Well Salinity Graph, Gloucester



VEGETATION

Table 7. Eastern Point/Good Harbor Beach Vegetation Metric Scores 2005

METRIC	GLO-Ref	GLO-Stu	Stn. Dev
Community Similarity	100	92	8
Score	**6**	**6**	
Taxa Richness	12	12	
Absolute Difference	0	0	0
Score	**6**	**6**	
Abundance Invasive	0	3.19	3
Score	**6**	**4**	
Weighted Wetness	90.24	63.28	
n/Ref. x 100	100	70.12	27
Score	**6**	**0**	
Weighted Salinity Tolerance	95.78	64.86	
n/Ref. x 100	100	67.72	32
Score	**6**	**0**	
Weighted Nutrient Regime	34.09	25.65	
Ref./n x 100	100	75.26	25
Score	**6**	**4**	
IVI Scores	36	20	
IVI TOTALS	**100.00**	**55.56**	

When compared to the reference site, the study site had a community similarity of 92%. For the community similarity metric, both sites received Biological Condition Scores (BCS) of 6. This shows an improvement at the study site, which received a community similarity of 56% in 2004 and 35% in 2003.

Both sites had a taxa richness value of 12, and both received BCS of 6. Only *Iva frutescens* was found at the reference site, but not the study site. The only unique species found at the study site was *Phragmites australis,* the invasive common reed. *Agropyron pumgens, Atriplex patula, Distichlis spicata, Juncus gerardii, Limonium nashii, Puccinella maritma, Salicornia europaea, Solidago sempervirens, Spartina alterniflora*, *Spartina patens, and Suaeda linearis* were recorded at both sites.

The abundance invasive value was 0 at the reference site and 3.19 at the study site. No invasive species were found in the reference site transects. The only invasive species recorded at the study site was *Phragmites australis*. *Lythrum salicaria*, a freshwater invasive plant that was abundant at the study site in the past, was not observed in any of the vegetation transects. The reference site received a BCS of 6, and the study site received a BCS of 4 for the abundance invasive metric.

The adjusted weighted wetness value was 100 at the reference site and 70.12 at the study site. The reference site received a BCS of 6, while the study site received a BCS of 0 for the weighted wetness metric.

The adjusted weighted salinity tolerance value was 100 at the reference site and 67.72 at the study site. The reference site received a BCS of 6 whereas the study site received a BCS of 0 in the weighted salinity tolerance metric.

The adjusted weighted nutrient regime value was 100 at the reference site and 75.26 at the study site. The reference site received a BCS of 6 whereas the study site received a BCS of 4 for the weighted nutrient regime metric.

The Index of Vegetative Integrity (IVI) Scores were 100 for the reference site and 55.56 for the study site (on a scale of 100.00).

The average heights of the ten tallest *Phragmites australis* per transect were calculated and is compared to monitoring data from 2004. There were no *Phragmites australis* in transect 1 at the study site or in any of the transects at the reference site. In 2003, the percent abundance of *Praghmites australis* was 2.67%; increased to 6.58% in 2004, but was lower in 2005 at 3.19%. Average height of the ten tallest *Phragmites australis* decreased slightly, but it will take more years of monitoring to understand the *Phragmites australis* dynamic.

Table 8: Average Height of Ten Tallest Phragmites australis at Study Site, 2003, 2004 & 2005.

Phragmites australis				
Average Height (cm)				
	Transect	2005	2004	2003
	2A	209.6	232.6	160
	2B	0	133.3	-
	3A	153.7	166.8	120.8
	3B	158.2	183.3	80.2
Average of All Plants		173.8	179	114

In 2005, the vegetation sampling was extended to the north side of the tidal creek at the study site. At the time of pre-restoration monitoring, this side of the creek was covered in *Lythrum salicaria* (purple loosestrife) and *Toxicoderndron radicans* (poison ivy). Since the return of tide waters and the die-off of fresh water plants, salt marsh vegetation has begun colonizing the north side between the creek and Eastern Point Boulevard. Therefore, six vegetation transects along with two wells were established in this new evaluation area. Because of the close proximity of the road, each transect had two quadrat samplings, one at the creek bank and another 30' zero degrees compass bearing from the salt marsh creek bank.

The Index of Vegetative Integrity (IVI) Scores were 100 for the reference site and 33.33 for the new north study site (GLO-StuN). When the two sides of the creek are compared using the previously monitored study evaluation area as the reference, GLO-StuN had an IVI of 44.44.

Table 9. Vegetation Metrics for New North Study Transects 2005

METRIC	GLO-Ref	GLO-StuN	Stn. Dev	GLO-Stu	GLO-StuN	Stn. Dev
Community Similarity	100	58	42	100	58	42
Score	**6**	**2**		**6**	**2**	
Taxa Richness	12	7		12	7	
Absolute Difference	0	5	5	0	5	5
Score	**6**	**2**		**6**	**2**	
Abundance Invasive	0	0	0	3.19	0	3
Score	**6**	**6**		**4**	**6**	
Weighted Wetness	90.24	57.38		63.28	57.38	
n/Ref. x 100	100	63.59	36	100.00	90.68	9
Score	**6**	**0**		**6**	**2**	
Weighted Salinity Tolerance	95.78	50.34		64.86	50.34	
n/Ref. x 100	100	52.56	47	100.00	77.61	22
Score	**6**	**0**		**6**	**2**	
Weighted Nutrient Regime	34.09	20.22		25.65	20.22	
Ref./n x 100	100	59.32	41	100.00	78.82	22
Score	**6**	**2**		**6**	**2**	
IVI Scores	36	12		34	16	
IVI TOTALS	**100.00**	**33.33**		**94.44**	**44.44**	

AQUATIC MACROINVERTEBRATES

Macroinvertebrate sampling was conducted on August 4, 2005. The results are a composite from D-net, auger, and creek bank quadrat samplings. Metrics used in the 2003 pre-restoration analysis were used for the 2004 and 2005 post-restoration calculation of the Salt Marsh – Invertebrate Community Index (ICI).

Table 10. 2005 Macroinvertebrate Metric Table, Gloucester

METRIC/INDEX	Reference	Study
Total Taxa Richness	13	9
Score	4	2
% Predators	7.4	27.4
Score	2	0
% Deposit Feeders	45.8	29.9
Score	6	6
% Contribution Dominant Taxa Group	41.8	53
Score	4	4
% Rare	38.7	33.3
Score	6	6
% Contribution Phyllodocida	7.4	12
Score	2	2
% Contribution Amphipoda	41.8	29.9
Score	6	6
% Contribution Tanaidacea	31.7	0
Score	6	0
% Contribution Other Groups	17.5	53
Score	4	2
% Insects, Spiders and Mites	14	53
Score	6	0
Raw Score for Selected 10 Metrics	46	28
Adjusted as Scale of 100	76.7	46.7
INVERTEBRATE COMMUNITY INDEX	**77**	**47**
BIOLOGICAL CONDITION	SWI	MI
HABITAT ASSESSMENT SCORE	77	62

The average number of organisms was 129.7 at the reference site and 39 at the study site. The Total Taxa Richness was 13 at the reference site and 9 at the study site. The reference site received a Biological Condition Score (BCS) of 4; the study site received a BCS of 2 in the Total Taxa Richness metric.

The % Predators were 7.4 at the reference site and 27.4 at the study site. The reference site received a BCS of 2; the study site received a BCS of 0 in the % Predators metric.

The % Deposit Feeders were 45.8 at the reference site and 29.9 at the study site. Both sites received BC scores of 6 in the % Deposit Feeders metric.

The % Contribution Dominant Taxa Group was 41.8% at the reference site consisting of Amphipoda, while the Dominant Taxa Group of Insects, Spiders and Mites made up 53% of the study site sample. Both sites received BC scores of 4 in the % Contribution Dominant Taxa Group metric.

The % Rare was 38.7% at the reference site and 33.3% at the study site. Both sites received BC scores of 6 in the % Rare metric.

The % Contribution Phyllodocida was 7.4% at the reference site and 12% at the study site. Both sites received a BC score of 2 in the % Contribution Phyllodocida metric.

The % Contribution Amphipoda was 41.8% at the reference site and 29.9% at the study site. Both sites received BC scores of 6 in the % Contribution Amphipoda metric.

The % Contribution Tanaidacea was 31.7% at the references site and 0% at the study site. The reference site received a BCS of 6; the study site received a BCS of 0 in the % Contribution Tanaidacea metric.

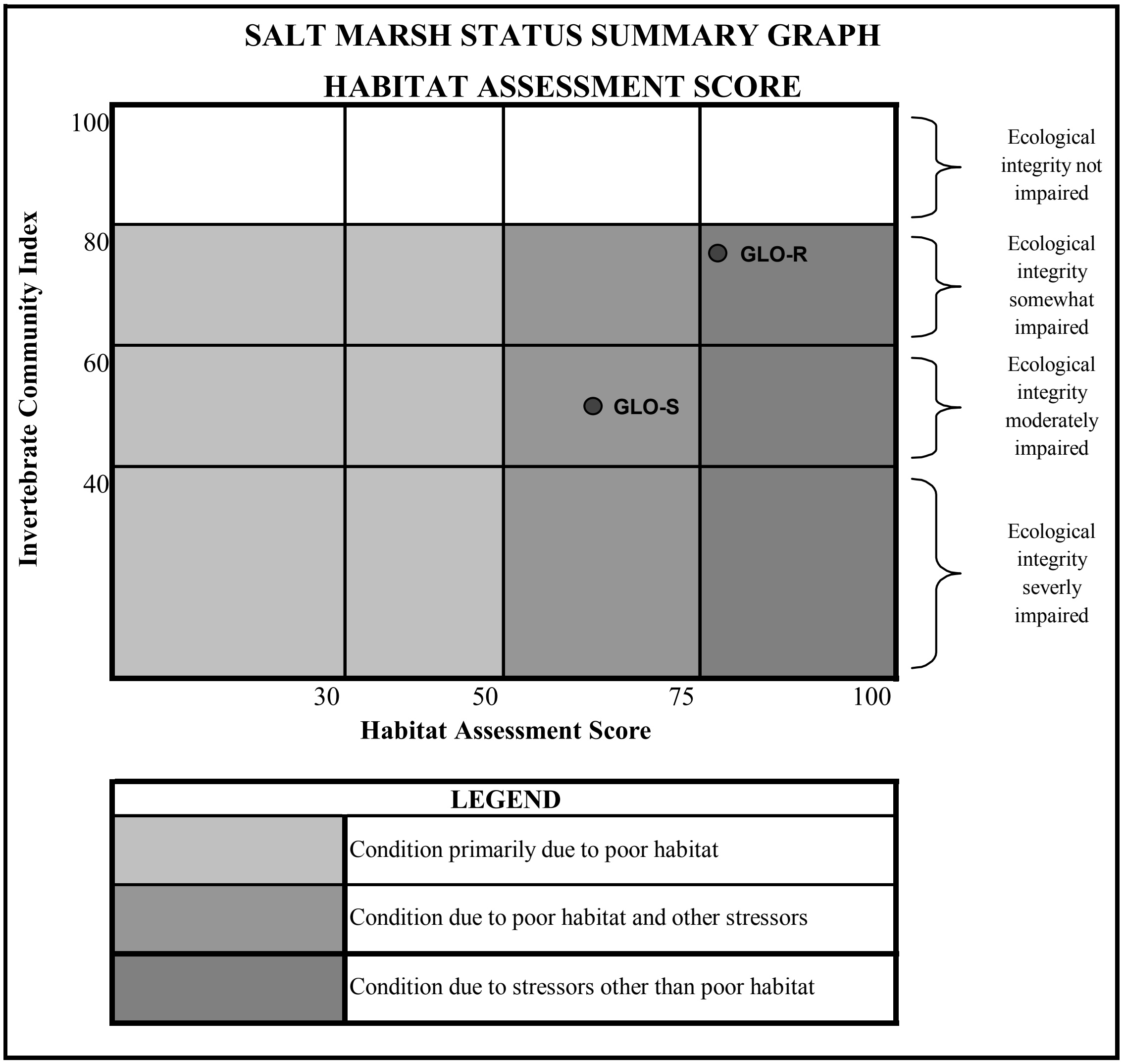
The % Contribution Other Groups was 17.5% at the reference site and 53% at the study site. The reference site received a BCS of 4; the study site received a BCS of 2 in the % Contribution Other Groups metric.

The % Insects, Spiders and Mites was 14% at the reference site and 53% at the study site. The reference site received a BCS of 6; the study site received a BCS of 0 in the % Insects, Spiders and Mites metric.

One *Hemigrapsus sanguineus*, the invasive Asian shore crab, was found at the reference site.

The Habitat Assessment Scores were 77 – "somewhat impaired" for the reference site and 62 – "moderately impaired" for the study site. The Salt Marsh Status Summary Graph provides a visual representation of the invertebrate community condition (ICI) and the assessed habitat quality (HAS). The biological condition of the invertebrate community is somewhat impaired at the reference site (77), while the study site's invertebrate community is moderately impaired category (47). The comparison of ICI to HAS placed the Good Harbor Beach salt marsh as having "somewhat impaired ecological integrity" due to stressors other than poor habitat, while Eastern Point salt marsh is "moderately impaired ecological integrity" due to poor habitat and other stressors.

Figure 5. Salt Marsh Status Summary Graph, Gloucester



NEKTONS

Nekton sampling was conducted in June, July and August. The total fishes trapped at the reference site were 413, while 674 were trapped at the study site. *Fundulus heteroclitus* (Mummichogs) was trapped as well as *Fundulus majalis* (striped killifish), *Pungitius pungitius* (ninespine stickleback), and one *Tautogolabrus adspersus* (cunner). *Carcinus maenas* (green crab) were caught at the study site. The average water temperatures were similar between reference and study sites. Salinity levels were more varied due to freshwater influences. The salinity ranged between 14 to 30 ppt depending on the ebb and flow of the tide. The lowest salinity reading was at the reference site on 7/20/06, which was an ebbing tide.

Minnow traps continued to be used for nekton sampling, to maintain data compatibility with past data collected, but the 2004 GPAC recommended protocol of employing lift nets was added as a sampling method. Ditch net sampling was employed for the first time on 8/19/05 during the last day of nekton sampling with the minnow traps. Two nets were set in open ditch areas at the reference and study site. Because the reference creek is much larger than the study, ditches equivalent in size to the study site creek were selected at Good Harbor Beach salt marsh. The directions of the New Hampshire Salt Marsh Monitoring Program were followed. No nektons were collected at the reference, while the following was collected at the study site: one female *Fundulus heteroclitus* (mummichog), four *Pungitius pungitius* (ninespine stickleback) and five *Carcinus maenas* (green crabs).

Table 11. Nekton Species Observed in 2005, Gloucester MA

Nekton Species - Eastern Point/Good Harbor Beach, Gloucester, MA					
	Scientific Name	**Common Name**	**6/22/2005**	**7/20/2005**	**8/19/2005**
Reference Site	*Fundulus heteroclitus*	Mummichog	28	0	247
	Fundulus majalis	Striped killifish	0	99	7
	Pungitius pungitius	Ninespine stickleback	20	7	0
	Apeltes quadracus	Fourspine stickleback	3	1	0
	Tautogolabrus adspersus	Cunner	0	1	0
	Carcinus maenas	Green Crab	0	0	0
Study Site	*Fundulus heteroclitus*	Mummichog	186	215	227
	Pungitius pungitius	Ninespine stickleback	1	31	11
	Fundulus majalis	Striped killifish	0	3	0
	Carcinus maenas	Green Crab	2	2	1

Figure 6. Average Water Temperature from Sampling on 6/22, 7/20, 8/19/2005, Gloucester

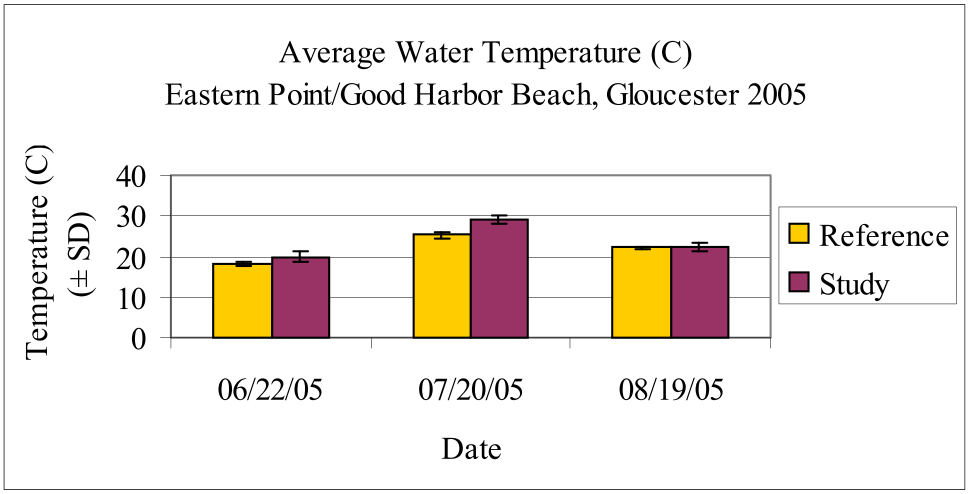


Figure 7. Average Salinity from sampling on 6/22, 7/20, 8/19/2005, Gloucester

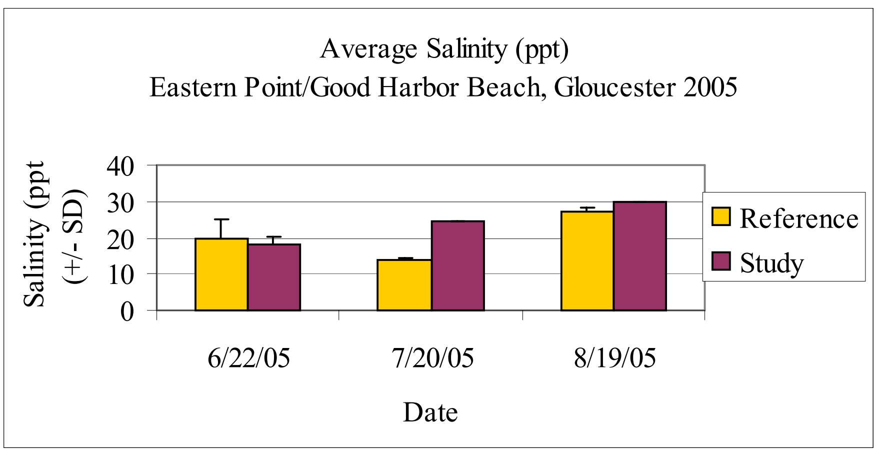


Figure 8. Average Number of all fishes per Sampling Date in 2005, Gloucester

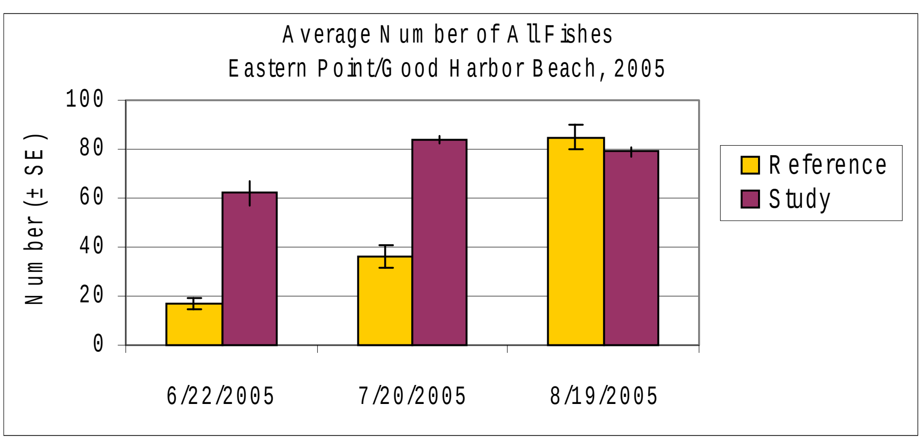


Figure 9. Average Number of Mummichogs per Sampling Date in 2005, Gloucester

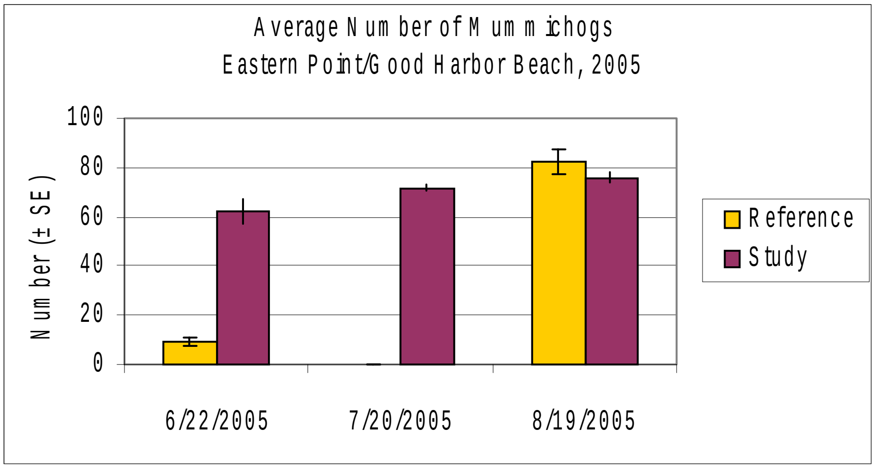


Figure 10. Average Standard Length of Mummichogs in 2005, Gloucester

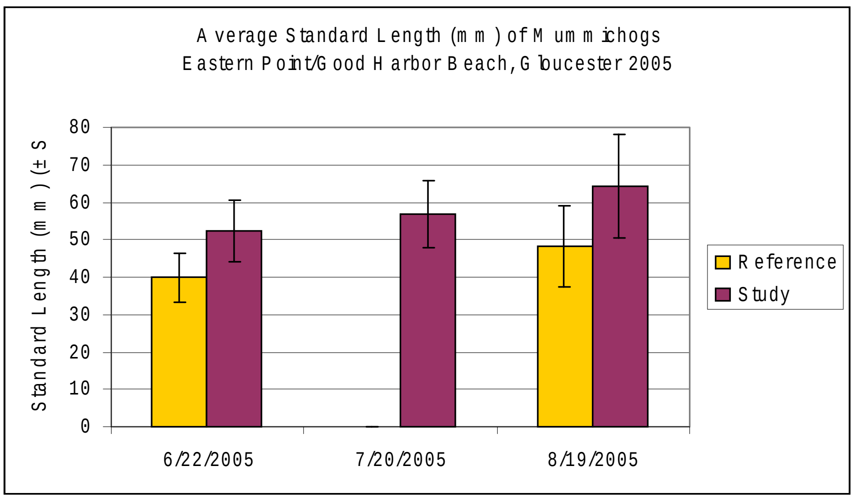


Figure 11. Average Weight of Mummichogs in 2005, Gloucester

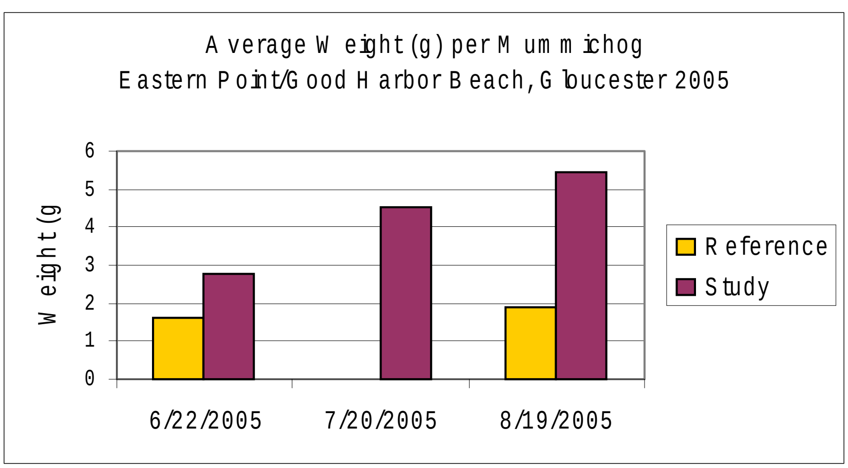
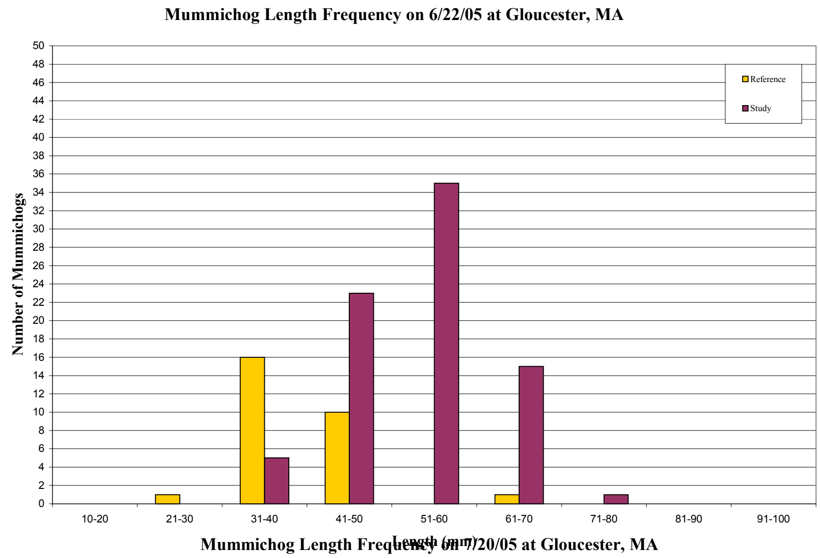
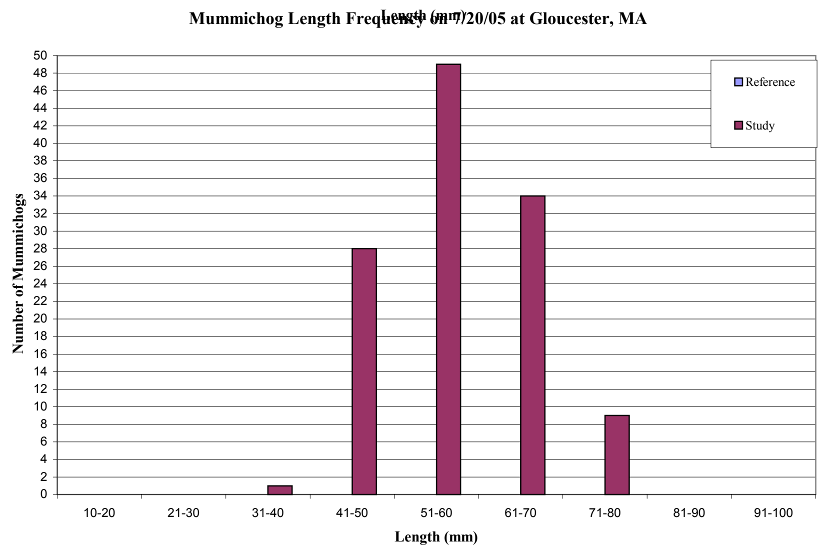
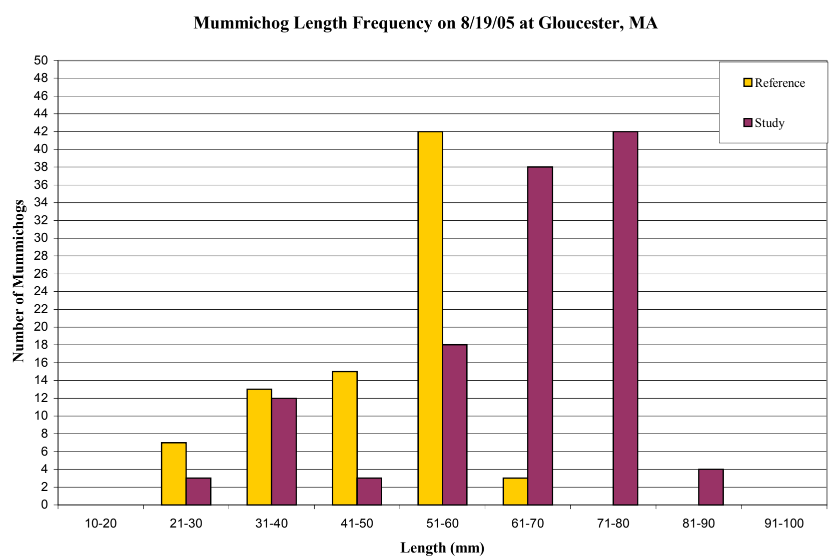


Figure 12, 13, 14. Length Frequency Graphs for Mummichogs 2005, Gloucester







BIRDS

Table 12. 2005 Avifauna Index, Gloucester

	Gloucester Reference		Gloucester Study	
Metric	Avg. per date	AVI Score	Avg. per date	AVI Score
Species Richness	10.4	2	14	4
% Neotropical Migrants	22.6	2	20	2
# Wetland Dependent Species	4.8	4	4.4	2
% Resident Species	57.5	0	60	0
% Tolerant Species	51.5	0	66.7	0
% Insectivorous Aerial Foragers	3.5	0	13.3	2
# Regionally Rare Species	0.4	2	0	0
% Abundance of 3 Most Common Species	68.6	2	61.7	2
Community Similarity Ratio	100	6	61.2	4
% Starlings & Blackbirds	27.4	2	22.4	4
	TOTAL AVI	**33.3**	**TOTAL AVI**	**33.3**

The reference site yielded 207 bird sightings and 29 species, while 372 birds and 26 species were sighted at the study site. While the Species Richness was slightly higher at the study site, the average was lower at the reference site because three of the five sampling dates fewer birds were seen or heard at the reference area. However, it should be noted that often many more birds are using the marsh than could be counted. At extreme low tide, many birds feed in the creek bottom out of view. Based on the daily average the reference site received a biological condition score (BCS) of 2, while the study site received a 4.

The % Neotropical Migrants average was slightly higher at reference site, 22.6% compared to 20% for the study site. Both sites received a biological condition score (BCS) of 2, a drop from 4 in 2004. The neotropical migrant species seen at both sites included: Barn Swallow, Tree Swallow, Least Sandpiper and Yellow Warbler. The neotropical migrants species seen only at reference site were Black-Bellied Plover, Semipalmated Plover, Greater Yellowlegs, Killdeer, and Great Egret. Northern Waterthrush, Eastern Kingbird, Willow Flycatcher, Snowy Egret and Spotted Sandpiper were seen only at the study site.

The Number of Wetland Dependent Species average was 4.8 at the reference for a score of 4 at the reference site and 4.4 at the study site for a score of 2. Wetland Dependent Species at the reference site were Black-Bellied Plover, Common Yellowthroat, Double-crested Cormorant, Great Blue Heron, Great Egret, Greater Yellowlegs, Herring Gull, Killdeer, Least Sandpiper, Mallard, Red-winged Blackbird, Salt Marsh Sharp-tailed Sparrow, Semipalmated Plover, and Yellow Warbler. At the study site, Eastern Kingbird, Great Black-backed Gull, Herring Gull, Least Sandpiper, Northern Waterthrush, Red-winged Blackbird, Snowy Egret, Spotted Sandpiper, Willow Flycatcher, and Yellow Warbler were the wetland dependent species present.

The % Resident Species averages were 57.5% at the reference site and 60% at the study site. Both received a BCS of 0.

The % Tolerant Species averages were 51.5% at the reference site and 66.7% at the study site Both sites received a BCS of 0.

The % Insectivorous Aerial Foragers average was higher at the study site at 13.3% at the study site and 3.5% at the reference site. The reference site received a BCS of 0, while the study site a BCS of 2. This was consistent with the 2004 results (15.4% study; 5.9% reference).

The Number of Regionally Rare Species average was 0% at the study site, but two sightings of a Salt Marsh Sharp-tailed Sparrow at the reference site resulted in a daily average of 0.4%, which was also similar to 2004 results. The study site received a BCS of 0 and the reference a BSC of 2.

The % Abundance of 3 Most Common Species average was similar at both sites, 68.6% at the reference site and 61.7% at the study site. Both sites received a BCS of 2. European Starling was common at both sites. Barn Swallow was the most common (16%) at the reference site followed by Rock Dove (15%) and then European Starling (11%). At the study site, European Starling was the most common (50%), followed by House Finch (9%) and then Red-winged Blackbird (5%).

The Community Similarity Ratio is calculated with the reference being assigned a 100 (score = 6), and the study site similarity being compared to this 100 result. The study site had 61.2% similarity ratio. The study site received a BCS of 4.

The % Starlings and Blackbirds average was only slightly higher at the reference site with 27.4% compared to 22.4% at the study site. The study site received a BCS of 4, while the reference received a BSC of 2.

In 2005, the total AVI score were identical for the reference and study sites at 33.3, compared to 2004 scores of 46.7 for the reference and 36.67 for the study site.

LAND USE

The 2001 land use data analysis has been used for the pre- and post-restoration monitoring, since there has been little to no land use change in the last five years. This computation is slightly different than that described in the methods section; however, the results are comparable. (The method is fully outlined in the WHAT 1999 report.)

Table 13. Gloucester Reference (Good Harbor Beach) Site Land Use Index

LUI for Zone of Influence	1) 93.0
LUI Score from Rapid Assessment Form	2) 83.3
Final Land Use Index Score for Wetland Evaluation Area	3**) 88.1%**

Table 13. Gloucester Study (Eastern Point) Site Land Use Index

LUI for Zone of Influence:	1) 94.8
LUI Score from Rapid Assessment Form	2) 80.6
Final Land Use Index Score for Wetland Evaluation Area	3**) 87.7%**

DISCUSSION

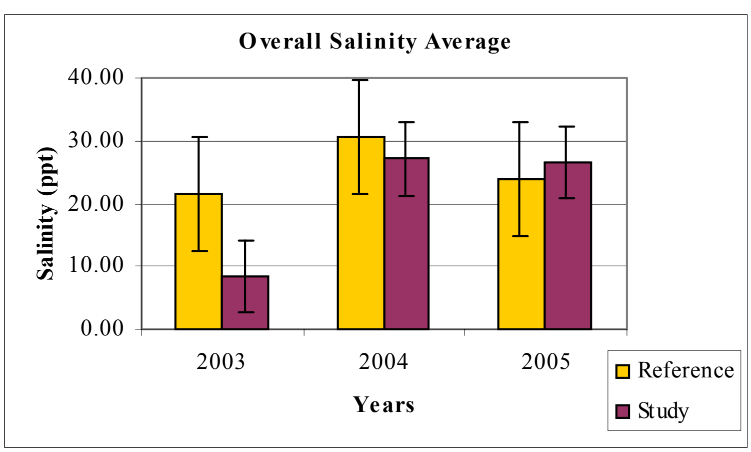
TIDAL INFLUENCE

Since the installation of two culverts and the opening of a small channel to connect the salt marsh to Gloucester Harbor tidal flow in November 2003, the Eastern Point salt marsh has been receiving regular tidal inundations from the harbor. No tidal restriction was found at the driveway culvert, percentage tidal range ratio = 99.92%, during the 2004 tidal hydrology measurement. However, the measured tidal range (2005=50.65%; 2004=51.63%) remains within the significantly restricted category (51-70%). It takes approximately five hours of incoming tide before water begins flowing through the harbor side culvert into the salt marsh. High tide waters flow into the marsh for an hour to an hour and half. Thirty to twenty minutes after high tide, the water begins flowing back out of the salt marsh. This means the salt marsh is receiving salt water for an hour or two every twelve-hour tidal cycle. The marsh may not become inundated on neep tides, but there is extensive inundation on spring tides, as can be seen in the photographs taken on 7/22/2005.

SALINITY

Salinity readings between 25-35 ppt are considered normal for a salt marsh. The study site's overall averages are within the normal range. For two years in a row, the study site's overall average was 27 ppt, demonstrating considerable improvement compared to the 8 ppt overall average salinity before the 2003 restoration. The influence of freshwater in the creek at Good Harbor Beach marsh resulted in a lower overall average for the reference site. The pore wells at the reference site recorded higher salinity readings with an average 28 ppt.

Figure 15. Comparison of Overall Salinity Averages for 2003, 2004 and 2005



Because the study site now receives regular tidal inundation, two wells were added on the north side of the marsh between the creek and the road, and two more wells were placed farther upstream on the south side. The addition of these wells will show how much of the marsh is being inundated and influence of fresh and salt water. One of the new south wells (5B) was placed at the edge of the *Phragmites australis* stand. Its overall average was 21ppt. Long-term monitoring of the *Phragmites australis* should be conducted to observe if there is die back. There was room for only two well A, each 50 feet from the creek channel, because the road prohibits the placement of well B. The measurements for these two wells ranged from 12 to 27 over the three sampling dates for an overall average of 19 ppt, showing that the ground salinity is high enough to kill off freshwater invasives and promote the growth of more salt tolerant plants.

VEGETATION

Compared to the reference site (scale of 100), the study site's the Index of Vegetative Integrity (IVI) increased slightly from 50 at the study site in 2004 to 56 in 2005. Community similarity of study to reference increased from 56% to 92%. Before restoration the community similarity of the study site with the reference site was 35% in 2003. Thus, two years after restoration, the Eastern Point salt marsh vegetation has returned, despite still having a significantly restricted tidal restriction.

The taxa richness remained at 12 species (2004 and 2005) at the study site to match that of the reference site. The study site had a higher taxa richness (20) in 2003, which was the result of a mix of salt, brackish and fresh water tolerant species. Brackish and freshwater species such as *Lythrum salicaria* (Purple Loosestrife), *Polygonum* sp. (Smartweed, Tearthumb), and *Ranunculus cymbalaria* (Seaside Crowfoot) are no longer present. In contrast, salt marsh vegetation has become well established, including *Atriplex patula*, *Spartina alterniflora, Spartina patens, Distichlis spicata, Juncus gerardii, Suaeda linearis, Salicornia europaea, Solidago sempervirens and Limonium nashii*. The only species not found at the study site but present at the reference is the high marsh shrub *Iva frutescens.* It would be interesting to note if and when this plant becomes established at Eastern Point.

When the vegetation from the newly monitored section of the study site, i.e. north side of the tidal creek, is compared to the study and reference sites, it becomes apparent that the north side of the marsh is still in transition. The north side's community similarity is 58%, consisting of seven species: *Atriplex patula*, *Spartina alterniflora, Spartina patens, Juncus gerardii, Suaeda linearis,* *Salicornia europaea, Solidago sempervirens*. However, 41% of the quadrats were "other" (bare ground and dead shrubs); 38% was *Suaeda linearis* and 8% *Salicornia europaea,* both early colonizing species. There were no *Phragmites australis* on the north side of the marsh in 2005.

The reference site continues to support a healthy salt marsh vegetative community with no *Phragmites australis*. There was a slight reduction in height of the tallest *Phragmites australis* from 2004 to 2005 at the study site. However, since suppression of this invasive can take up to ten to fifteen years, further monitoring will be necessary to observe any trends.

AQUATIC MACROINVERTEBRATES

Comparisons with the past four years of monitoring show continued increase in the Invertebrate Community Index for the study site.

Table 14. Comparisons of Invertebrate Community Index Scores, Gloucester, MA 2002-2005

Invertebrate Community Index				
	Reference	**Study**	Not Impaired	80-100
2002	86	2	Somewhat Impaired	60-80
2003	80	20	Moderately Impaired	40-60
2004	47	40	Severely Impaired	0-40
2005	77	47		

The reference site Invertebrate Community Index (ICI) score increased over the 2004 ICI but has not returned to the "ecological integrity not impaired" rating it received in 2002 and 2003 monitoring when the Habitat Assessment is compared with the ICI score (see Salt Marsh Status Summary Graph, Figure 5 pg. 30).

Although there has been some improvement at the reference site, the Salt Marsh Status Summary Graph still falls in the category of moderately impaired ecological integrity due to stressors other than poor habitat for the Good Harbor Beach salt marsh. The visible habitat remains unaltered and the reference site continues to have good tidal flushing and a well-established bank edge to provide habitat and food to support a healthy macroinvertebrate community. Two other stressors that affect invertebrate community health are water quality and prey-predator relationship. Water quality was not tested but should be in future monitoring to rule out water quality degradation. The possibility of an increase in predator populations must also be considered. The average number of macroinvertebrate organisms collected did increase in 2005 from the previous year. Upon examination of the fish count at the reference site, the total fish trapped increased from 301

(2003) to 742 in 2004, but was lower in 2005 at 413. Although the avifauna index does not show a substantial difference between the study and the reference sites, it must be noted that the Good Harbor salt marsh creek is a feeding ground for many ducks and shore birds.

In contrast, the ICI for the study marsh continued to improve from a score of 40 (2004) to 47 (2005). When compared to the pre-restoration ICI, this is a great improvement. In 2003, Ephydridae, shorefly larvae found in brackish marshes and stagnant pools, made up 93% of the organisms sampled. Like the 2004 results, no Ephydridae was recorded in 2005. Amphipods and polychaetes (in particular, Neiridae - clam worms) continue to increase in numbers since the return of tidal flow. The macroinvertebrate community has moved out of the severely impacted catergory to the moderately impacted range. Continued post-restoration monitoring will provide data on the level of recovery from the restoration efforts.

NEKTONS

It is difficult to draw conclusions from nekton data because nektons are mobile and experience natural variability in abundance. However, it can be said that the study site is a much healthy habitat for fish than in the pre-restoration period when the water was stagnant and reeked of ammonia and sulfur. In 2005, three species were trapped *Fundulus heteroclitus* (mummichogs), *Fundulus majalis* (striped killifish) and *Pungitius pungitius* (ninespine sticklebacks). Since study site restoration, the mummichog average standard length and weight has been greater at the study site than the reference site. Hundreds of mummichogs continue to be observed flowing in and out with the high tide at the harbor-side culvert. This is in contrast to 2003, when fishes sampled at the study site were smaller in length and weight, indicating either a lack of an adequate food supply or that only smaller fish could access the restricted marsh.

The ditch net sampling, added to the nekton protocols because it is a preferred method in the GPAC Protocol for nekton monitoring, resulted in a much smaller catch than the minnow traps.

Table 15. Nekton Species Recorded at Eastern Point, Gloucester, 2001-2005

Mummichogs at Eastern Point, Gloucester, MA, 2001 - 2005					
			Number	Avg. Weight	Avg. Length
2001	No Fish trapped		0		
2002	*Fundulus heteroclitus*	Mummichog	450	4.4 g	31 mm
2003	*Fundulus heteroclitus*	Mummichog	70	1.9 g	45 mm
2004	*Fundulus heteroclitus*	Mummichog	139	3.2 g	40 mm
2005	*Fundulus heteroclitus*	Mummichog	628	4.33 g	56 mm

BIRDS

The Avifauna Index (AVI) for both the reference site and study site was 33. The study site had a higher Species Richness than the reference, 14 to 10.4, when averaged per days (5) sampled. However, 29 species were sighted or heard at the reference site, while 26 species were present at the study site. The scoring was identical in the categories of % Neotropical Migrants, % Resident Species, % Tolerant Specie and % Abundance of the 3 Most Common Species. The study site continued to have a slightly higher average percentage for Insectivorous Aerial Foragers. The reference site received higher scores for three metrics: average number of Wetland Dependent Species, number of Regionally Rare Species, and Community Similarity Ratio. The regionally rare, Salt Marsh Sharp-Tailed Sparrow was seen at Good Harbor twice this season, as in 2004 during July. Although the study site received a higher score for % Starlings and Blackbirds, the two sites were quite similar with the reference site having 27% and the study 22%.

The average number of Wetland Dependent Species average increased at the study site from 2.2 in 2004 to 4.4 (reference 2004 - 4.4, 2005 – 4.8). Ten species of wetland birds were present at the reference site including Black Duck, Double-crested Cormorant, Eastern Kingbird, Greater Yellowlegs, Herring Gull, Killdeer, Least Sandpiper, Mallard, Red-winged Blackbird and Snowy Egret. The six species observed using the study salt marsh and buffer were Great Black-backed Gull, Willow Flycatcher, Yellow Warbler, Herring Gull, Red-winged Blackbird and Semipalmated Plover. None of these wetland birds are restricted to salt marsh wetlands.

The study site is 5 acres out of the 53 acres conserved by Massachusetts Audubon as a bird sanctuary. The habitat diversity of upland forest, freshwater marsh and salt marsh attracts many bird species. While the reference site is a larger salt marsh, it has less habitat diversity since it is surrounded by residential development on three sides and the ocean on the other. The difference in habitat types may explain the relative similarities of the two sites.

LAND USE

No major land use changes have occurred at either of these sites in the past four years. Both the reference site, LUI = 88.1, and the study site, LUI = 87.7 (out of 100), show some signs of human impact.

CONCLUSION

INTERPRETATION OF THE CONDITION OF THE EASTERN POINT/GOOD HARBOR BEACH SALT MARSHES

The completion of a second year of post-restoration monitoring after three years of pre-restoration monitoring by Salem Sound Coastwatch has produced important post-restoration monitoring information on the salt marsh's recovery. Pre-restoration monitoring from 2001 through 2003 reported a severely degraded salt marsh system at the Gloucester Eastern Point study site, while the Good Harbor Beach reference site maintained unimpaired ecological integrity. During the ten years of restricted tidal flow, the study site had difficulty supporting any viable salt marsh community. However, the reconnection of tidal flow in November 2003 by the installation of two culverts and the construction of a connecting channel halted this degradation. Salinity levels in the ground and surface waters are in the normal range for salt marsh systems, increasing from an overall average of 8 ppt to 27 ppt, more than a 200% increase. In 2005, vegetation, fishes, and macroinvertebrates that need salt marsh conditions of high salinity and regular tidal flushing continue to increase in species richness and abundance. With the complete die-off of the freshwater invasive *Lythrum salicaria* (purple loosestrife), twelve different salt marsh species have become established. The second year of restoration found *Limonium nashii* (sea lavander) growing among the vegetative salt marsh community. A variety of estuarine fishes have access in and out of the marsh during the high tide cycles. Freshwater shorefly larvae were replaced by Polychaeta (clam worms) and Gammaridea (amphipods), and Least sandpipers, Northern Waterthrush, Snowy Egret and Spotted Sandpiper were seen foraging in the Eastern Point tidal creek, while Eastern Kingbird and Willow Flycatcher collected insects above the marsh.

Tidal flow restoration has brought the back the salt marsh. However, at normal high tides, the percentage tidal range (51.63%) still remains within the "significantly restricted" category (51-70%). Compared to the pre-restoration baseline where the Gloucester study site (Eastern Point) received almost no tidal flushing, this is an improvement. Given the distance and time the harbor waters need to rise to inundate the marsh, the extent of recovery remains in question. This situation should be reexamined to determine if there are other ways of increasing tidal flow, or if this is the best case scenario for a salt marsh that is separated from the harbor by elevation and a road. Also, *Phragmites australis* remain at the edge of the salt marsh on the ocean side. Long-term monitoring should be conducted to observe if there is any die back from the increased tidal inundation.

Gloucester's Good Harbor Beach salt marsh, during the 2002 and 2003 pre-restoration baseline monitoring, placed in the "ecological integrity not impaired" category when its Habitat Assessment score (HAS) was compared to its Invertebrate Community Index score (ICI). The 2005 macroinvertebrate sampling showed an improvement in community structure compared to the previous year. However, despite the reference site's good tidal flushing, well-established bank edge, and productive vegetative salt marsh community, the Salt Marsh Status Summary Graph, a visual representation of the invertebrate community condition (ICI) and the assessed habitat quality, shows an invertebrate community biological condition of "somewhat impaired" and a Habitat Assessment score (HAS) also "somewhat impaired". The comparison of ICI to HAS placed the Good Harbor Beach salt marsh as having an ecological integrity somewhat impaired due to stressors other than poor habitat. This is worth continued study. Degradation in water quality may be one of these potential stressors and needs to be examined, which is currently under investigation by the City of Gloucester.

Although funding does not exist to continue the level of biomonitoring that Salem Sound Coastwatch and its trained volunteers have been able to conduct over the past five years, reexamination of the salt marsh communities five years after restoration (2008) should be undertaken to assess salt marsh recovery of its biological communities. Few salt marsh studies have been able to document the degradation and then recovery over a five-year period. Data sets with 2 or more years of post-restoration monitoring made up less than 25% of the 36 GOM salt marsh monitoring restoration projects analyzed by Konisky et al.[1] Data collection in 2008 will may the scientific study of salt marsh recover at the Eastern Point Restoration Project even more valuable to the scientific community and resource managers. Study site data collected from four new wells and vegetation monitoring on the north side of the tidal creek in 2005 provide new baseline data that could not be collected during the pre-restoration years because of the abundance of *Toxicoderndron radicans* (poison ivy). This new information will be useful in future studies at the Eastern Point salt marsh.

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[1] Konisky, R.A., D. Burdick, M. Dionne, H. Neckles. 2004. A regional assessment of salt marsh monitoring and restoration in the Gulf of Maine. Third Draft September 22, 2004.

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APPENDIX