BAR BEACH SALT MARSH RESTORATION
HEMPSTEAD HARBOR, NEW YORK

FIFTH YEAR MONITORING REPORT

Submitted to:
National Oceanic and Atmospheric Administration
New York, New York

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EXECUTIVE SUMMARY

In 2003, The National Oceanic and Atmospheric Administration (NOAA), New York Department of Environmental Conservation, and U.S. Fish and Wildlife Service restored 0.8-acre salt marsh in Bar Beach Lagoon, North Hempstead, New York, as part of a Superfund settlement (AES Shoreline Realty) with the Performing Parties Group to address natural resource damages (NRD) that had occurred as a result of the release of contaminants into Hempstead Harbor. Restoration activities included the removal of substantial volumes of fill consisting of sand, gravel, concrete, and solid waste debris from the site, as well as the physical removal of approximately 0.2 acres of common reed (*Phragmites australis*). Each of the fill removal areas was excavated to sub-grade, backfilled with clean soils, and planted with native wetland and coastal upland plant species. The Town of North Hempstead participated in the restoration through receipt of a NOAA Community-based Restoration Program grant by providing site access, labor, trucks and waiving of disposal site fees for the excavated materials at the nearby landfill, as part of their in-kind match for the NOAA grant. The Town of North Hempstead is also responsible for managing this site, including the control of invasive, non-native plant species. The Town also obtained independent funding from the state of New York and restored salt marsh within Bar Beach Lagoon along West River Road adjacent to the NRD restoration project and repaired the culvert apron to dissipate flows into the Lagoon. The Town has future plans to restore the south shore of Bar Beach Lagoon.

The Louis Berger Group, Inc. conducted the final monitoring of the 5-year monitoring period on June 18th and 19th, and September 22nd and 23rd, 2008. This monitoring consisted of biological sampling of vegetation, nekton, and benthos at the Bar Beach Lagoon restoration site and at a nearby reference site. Avian monitoring was conducted by an experienced birder (volunteer) affiliated with the North Shore Audubon Society and arranged by NOAA staff. The monitoring program was developed in collaboration with NOAA staff, and in accordance with the Final Restoration Plan (NOAA *et al*. 2002).

The restoration site has met the 85 percent native species vegetative cover requirement developed as a goal for the restoration. *Phragmites australis* and other undesirable invasive species have been limited to 10 percent or less of the total vegetative cover of the restored area, as set forth in the restoration plan. Field quadrat sampling revealed that an average of 90.6 percent of the restoration site was covered with native wetland and coastal upland vegetation in 2008, as compared to 22.5 percent recorded during baseline pre-construction monitoring. The mean height of *Spartina alterniflora* at the restoration site increased from 93 cm in 2004 to 113 cm by 2008. The percent of *Spartina alterniflora* flowering was higher at the restoration site than at the reference site. Based on quadrat sampling, cover by *Phragmites australis* was limited to 1.0 percent of the restoration site in 2008.

Monitoring results indicate that nekton density and abundance at the restoration site were greater than that at the reference site. Monitoring results also suggest that the restoration site supports a more diverse benthic macroinvertebrate community than the reference site. Benthic macroinvertebrate species richness for each site was the same, but benthic abundance at the restoration site was considerably lower than that at the reference site. Higher densities of ribbed mussels and mud snails at the reference site may be due to the greater maturity of its substrate. The restoration site had greater avian abundance and diversity than the reference site, and twice the number of species as the reference site, but likely due to differences in the surrounding conditions affecting each site. Two waterfowl species, brant and red-breasted merganser, not seen during monitoring from 2004 to 2007, were sighted at least once at each site in 2008.

The fifth year monitoring results indicate that restoration performance has been successful in reestablishing a salt marsh community similar to nearby reference marsh community. The planted salt marsh grasses and coastal shoreline vegetation are well-established and flowering. Fish, benthic, and avian communities at Bar

Beach are comparable or trending towards that of the reference site although it is recognized that marsh restoration may require multiple decades to achieve the full functionality of natural, unaltered wetlands. Because the restoration site has not attained or exceeded the reference site conditions, the case Trustees seek to continue monitoring the site in future years.

Site management recommendations include follow-up evaluation of common reed, mugwort, Queen Anne's lace, Japanese knotweed, and porcelainberry at the site, and retreatment as necessary to control these non-native species. Continued monitoring and treatment of invasive plant species should be performed at least annually.

1.0 INTRODUCTION

In 2003, The National Oceanic and Atmospheric Administration (NOAA), New York Department of Environmental Conservation, U.S. Fish and Wildlife Service, and the Town of North Hempstead restored the salt marsh in Bar Beach Lagoon (also known as Hempstead Harbor Cove, see Figure 1), North Hempstead, New York, as part of a Superfund settlement addressing natural resource damages that had occurred as a result of the release of contaminants into Hempstead Harbor. Prior to the restoration activities, Bar Beach Lagoon consisted of mudflats and sparsely vegetated hummocks, and dense stands of common reed (*Phragmites australis*) covered a portion of the high marsh and coastal fill uplands. Concrete debris and other fill had been dumped along much of the shoreline, possibly for erosion control. Restoration activities included the removal of substantial volumes of fill consisting of sand, gravel, concrete, and solid waste debris from the site. Removal of *Phragmites australis* was also a component of the project, and involved physical removal of both above and below ground biomass for approximately 0.2 acres. Each of the fill removal areas was excavated to sub-grade, backfilled with clean soils, and planted with native wetland and coastal upland plant species. A fringe of smooth cordgrass (*Spartina alterniflora*) was generally present at elevations below the fill removal areas, but existing soils and vegetation in these low marsh areas were not disturbed during restoration activities.

Spartina alterniflora was planted in the intertidal zone at elevations from 2.5 to 4 feet National Geodetic Vertical Datum (NGVD). Salt meadow grass (*Spartina patens*) and spikegrass (*Distichlis spicata*) were planted in the high marsh at elevations from 4 to 5 feet NGVD. Between the high marsh and the upland, a coastal shoreline zone consisting of marsh elder (*Iva frutescens*), groundsel-bush (*Baccharis halimifolia*), bitter panic grass (*Panicum amarum*), and seaside goldenrod (*Solidago sempervirens*) was planted. Upland areas adjacent to the restoration site were seeded with a native warm season grass mixture and various native shrubs were planted in the upland periphery. Additional plantings in 2004 augmented the 2003 plantings where mortality, erosion, and fill compaction occurred. In 2004, switchgrass (*Panicum virgatum*) plugs were planted in the upland to address areas that did not respond well to seeding. Virginia creeper (*Parthenocissus virginiana*) was initially planted in the restoring upland area, but because its survival was poor and the primary purpose for the plantings was stabilization of soils, it was not replanted.

In the spring of 2005, the Performing Parties Group replanted the center portion of the peninsula area of the restoration site with *Spartina alterniflora*, and also erected herbivore-exclusion fence and overhead string. Dead shrubs in the coastal shoreline zone were also replaced and additional *S. patens* plants were installed at the eastern end of the site where ice damage had occurred. In the fall of 2008, the Nassau County Soil and Water Conservation District, in cooperation with the Town of North Hempstead, removed the invasive species including multiflora rose (*Rosa multiflora*), Japanese knotweed (*Polygonum cuspidatum*), Norway maple (*Acer platanoides*), mugwort (*Artemisia vulgaris*), and *Phragmites australis* from the restoration site. These species were replaced with 100 saplings and shrubs including red maple (*Acer rubrum*), American holly (*Ilex opaca*), and northern bayberry (*Myrica pensylvanica*), as well as 1,500 plugs of switchgrass, big bluestem (*Andropogon gerardii*), and bitter panicgrass (*Panicum amarum*).

As part of the Superfund settlement, a monitoring program was implemented to assess performance of the restoration project. The performance criteria for the restoration project requires 85 percent vegetative cover of the restoration area (marsh and stabilized coastal shoreline) within 5 years of initial planting and minimal re-establishment of *Phragmites australis* and other undesirable, non-native, invasive vegetation limited to 10 percent or less of the total restored area. Performance criteria also included 90 percent survival of *Spartina alterniflora* and shoreline vegetation after two full growing seasons, which was independently evaluated by NOAA and not discussed in this report. In addition, fish, benthic macroinvertebrate, and avian species richness, abundance, and composition were targeted to demonstrate a strong positive trend toward and not significantly differ from that of a reference marsh. The reference marsh, located 600 feet to the northeast of the restoration site, is also a fringing marsh and was selected to serve as the reference site for this monitoring

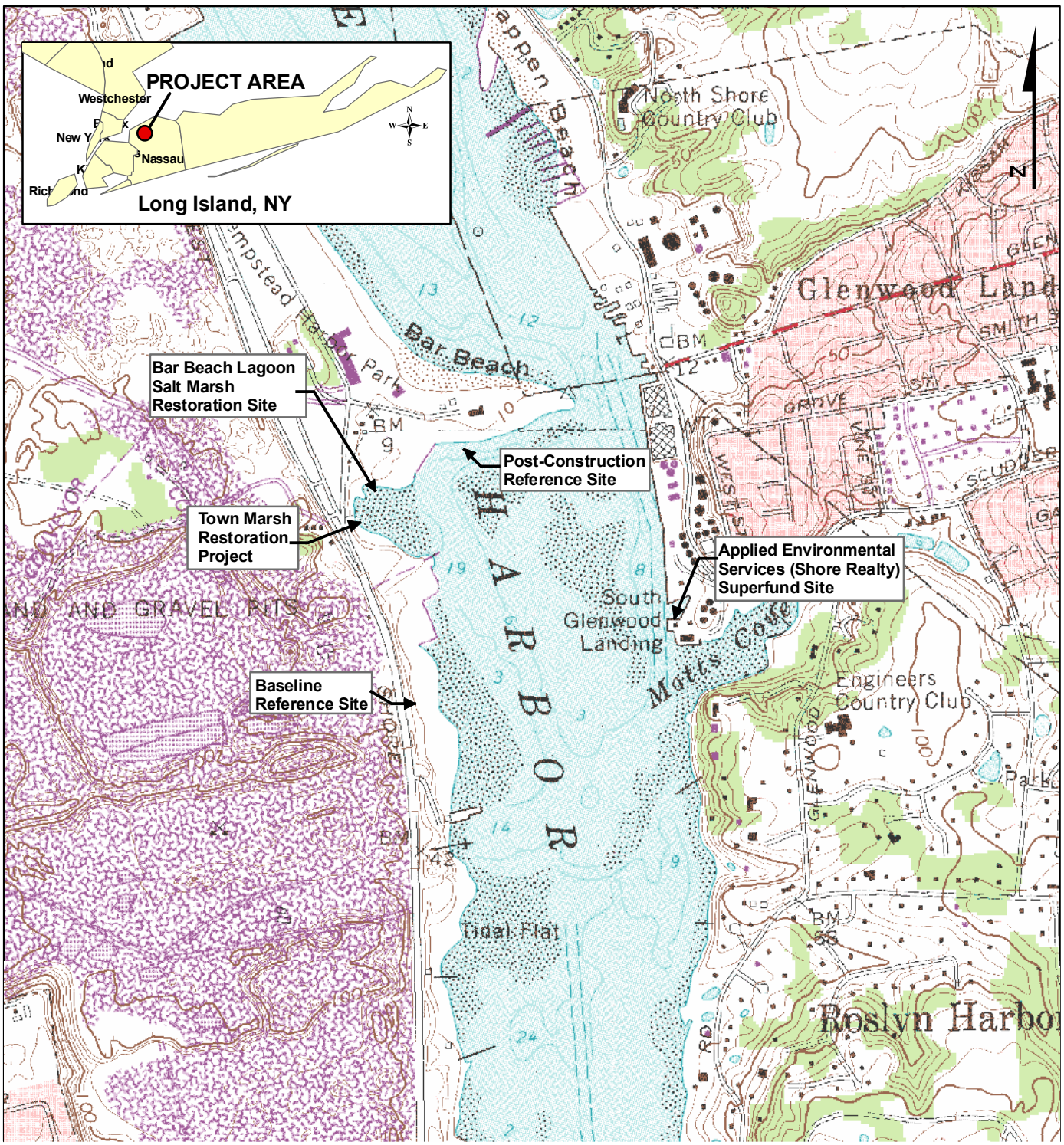
program. The restoration site and the post-construction reference site are similar in size, each consisting of approximately 0.8 acres. The baseline reference marsh used by NOAA during pre-restoration monitoring, also a fringing marsh, and located approximately one-half mile south of Bar Beach Lagoon, was not selected as the reference site for post-construction monitoring because it is larger than the newly selected reference site and is further removed from the restoration site.

On behalf of NOAA and its co-trustees, The Louis Berger Group, Inc. conducted the spring component of the fifth year of monitoring on June 18th and 19th, of 2008, and the fall monitoring on September 22nd and 23rd, of 2008. Vegetation was monitored in the early fall, at the end of the growing season (peak biomass), while nekton and benthic macroinvertebrates were monitored during the spring and fall, but only every other year. Table 1 presents the monitoring schedule which was followed during the 5-year monitoring period. Avian monitoring was conducted by an experienced birder (volunteer) arranged by NOAA staff. The monitoring program was developed in collaboration with NOAA staff, and in accordance with the Final Restoration Plan (NOAA *et al*. 2002).

Table 1. Monitoring Schedule.

Year	Season	Monitoring Parameter		
		Vegetation	Nekton and Benthos	Avian
2004	Spring			
	Fall	✓	✓	✓
2005	Spring			✓
	Fall	✓		✓
2006	Spring		✓	✓
	Fall	✓	✓	✓
2007	Spring			✓
	Fall	✓		✓
2008	Spring		✓	✓
	Fall	✓	✓	✓

Monitoring may continue beyond 2008 if an additional funding source is identified.



Feet

1,250 625 0 1,250

SOURCES:
Base Mapping: USGS 7.5 Minute Topographic Map,
Sea Cliff Quadrangle.

National Oceanic
and Atmospheric Administration

Bar Beach Salt Marsh
Ecological Restoration Monitoring
Site Location Map

Location: Hempstead Harbor, Long Island, NY

Date: FEB 2008 ID: JR 5110

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Figure 1

2.0 VEGETATION MONITORING

2.1 Methodology

Plant cover at the restoration site and reference site was measured within 1-meter square quadrats placed along permanently established transects (Figure 2). The restoration site was sampled along seven transects composed of forty quadrats. Six of these transects were oriented from the upland to the lower edge of the marsh, while the seventh transected the peninsula area from southwest to northeast. The reference site was sampled along three transects composed of ten quadrats, also oriented from upland to the lower edge of the marsh. Quadrats were arranged so that the first quadrat was positioned in the coastal shoreline zone (above 5 feet NGVD), the second quadrat was placed in the high marsh (4 to 5 feet NGVD), and remaining quadrats were placed in the low marsh (2.5 to 4 feet NGVD).

The ends of each transect were marked in the field with PVC pipes driven into the substrate and were surveyed with a Trimble Pro XRS Global Positioning System (GPS) with Asset Surveyor software. The distance of each quadrat along each transect was measured and recorded to ensure that the same stations were sampled each year. The locations of the vegetation transects appear in Figure 2, and the discrete positions of the transect ends and quadrats are presented in Appendix A. The elevations of the center point of each quadrat were measured in 2004 and 2005 using a Leica Geosystems Rugby 100 laser level.

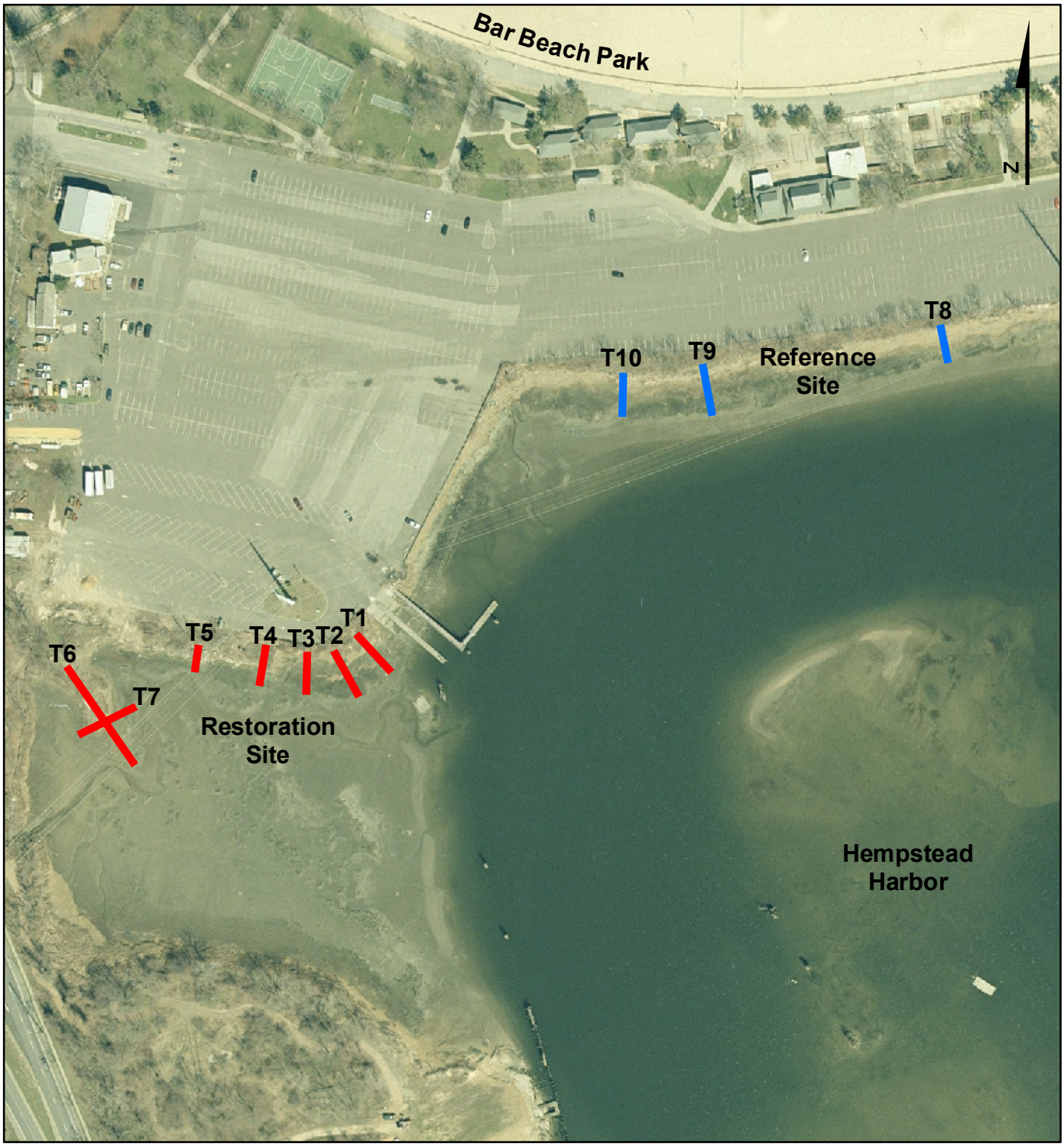
2.2 Results

Elevation measurements of each quadrat in 2004 and 2005 are reported in Appendix B, and did not document any discernable changes. A summary of vegetation observed within sampled quadrats at the restoration and reference sites in 2008 is presented in Table 2. A total of 10 species were present within the sampled quadrats at the restoration site, six of which were planted and four which volunteered, including *Phragmites australis*. The coastal shoreline zone at the restoration site was primarily vegetated with the planted species *Iva frutescens*, *Panicum amarum*, *Solidago sempervirens*, and *Spartina patens*, while the marsh vegetation consisted almost entirely of *Spartina alterniflora*, *Spartina patens*, and *Distichlis spicata*. Sea lavender (*Limonium nashii*) and switchgrass (*Panicum virgatum*) are also present at the restoration site, but were not present within sampled quadrats. Only five plant species were present within the sampled quadrats at the reference site. Vegetation in the coastal shoreline zone of the reference site was dominated by *Phragmites australis*, while marsh vegetation consisted of *Spartina alterniflora* and *Phragmites australis*.

Table 2. Plant Species Observed in Sampled Quadrats in 2008.

Common Name	Scientific Name	Restoration Site	Reference Site
Marsh orach	*Atriplex patula*	✓	✓
Spike grass*	*Distichlis spicata*	✓	
High tide bush*	*Iva frutescens*	✓	✓
Panic grass*	*Panicum amarum*	✓	
Common reed	*Phragmites australis*	✓	✓
Glasswort	*Salicornia europa*	✓	
Seaside goldenrod*	*Solidago sempervirens*	✓	✓
Smooth cordgrass*	*Spartina alterniflora*	✓	✓
Salt meadow grass*	*Spartina patens*	✓	
Sea blite	*Sueda linearis*	✓	

*Species planted or seeded at the restoration site



Legend

Vegetation Transects

- Restoration Site
- Reference Site

Feet

200 100 0 200

SOURCES:
Base Mapping: New York State DOQQs, Nassau County, 2000.

National Oceanic and Atmospheric Administration

Bar Beach Salt Marsh
Ecological Restoration Monitoring
Transect Location Map

Location: Hempstead Harbor, Long Island, NY

Date: Feb 2008 ID: JR 5110

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Figure 2

Figure 3. View of the Restoration Site, September 2008

Table 3 presents a summary of vegetative ground cover, including cover by *Phragmites australis*, for each transect in the restoration and reference sites in 2008, as well as the mean value for these parameters across all transects at each site. Quadrat sampling indicates that native vegetative cover of the restoration site was 90.6 percent, representing no change from the 2007 native cover. Between 2004 and 2008, native plant cover along Transects 1, 2, 3, 5, 6, and 7 increased by between 7 and 12 percent. Native plant cover along Transect 4 however, decreased from 80 to 73 percent during this time, due to the loss of most of the *Spartina alterniflora* cover in quadrat 5. This quadrat, located at the low edge of the marsh, had 60 percent cover of *Spartina alterniflora* in 2004, 25 percent in 2005, and then 10 percent from 2006 to 2008. Some loss of *Spartina alterniflora* cover also occurred at the low marsh edge quadrats on Transect 1, 2, and 3 during this time frame, however there was subsequent recovery. The cause of this loss is not known, but a review of the project data indicate that similar coverage losses occurred at the low marsh edge quadrats of all three reference site transects between 2004 and 2006. While low marsh in the vicinity of the edge quadrats along Transect 8 and Transect 10 ultimately recovered by 2008, Transect 9 experienced a net loss of 30 percent *Spartina alterniflora* cover over the 5-year monitoring. Substrate elevations of the vegetation monitoring quadrats measured in 2004 and 2005, and presented in Appendix B, do not indicate a relationship between elevation change and loss of cover in these low marsh quadrats. Of note is that Transects 5, 6, and 7, which are located well within the lagoon, did not experience loss of cover at their lowest quadrats during this time frame, suggesting that the cause of the loss of cover may be related to the degree of exposure to waves, wind, and possibly ice.

Phragmites australis accounted for 1.0 percent of overall restoration area cover, representing an increase from the 2007 observation of 0.6 percent cover. *Phragmites australis* has been present in quadrats along Transect 2 and Transect 5 since 2004, when it covered 1 and 3 percent, respectively. By 2008, Transect 2

and Transect 5 *Phragmites australis* cover was 3 and 4 percent, respectively, and Transect 6 had 1 percent cover in 2008. *Phragmites australis* along these transects is stunted and not flowering. Total native vegetative cover of quadrats at the reference site was 73 percent, with *Phragmites australis* covering 12.5 percent of quadrats.

Prior to restoration activities, the upper elevations of the restoration site were dominated by *Phragmites australis*, while lower elevations were unvegetated, covered with concrete rubble and debris, or colonized by *Spartina alterniflora*. The restoration activities did not disturb the existing *Spartina alterniflora* that was present at the lower elevations such that the reconstructed marsh consists of restored and original vegetation and soils. Sampling conducted by NOAA in 2002 before the restoration indicated that total plant cover of the restoration site was approximately 47 percent, with *Spartina alterniflora* covering 22.5 percent of sampled quadrats and *Phragmites* covering 14.5 percent of quadrats sampled. High tide bush, spikegrass, poison ivy (*Toxicodendron radicans*), mugwort (*Artemisia vulgaris*), sea lavender, and glasswort were also present, but accounted for minimal cover.

Mean *Spartina alterniflora* height within quadrats at the restoration site in 2008 was 113 cm, essentially unchanged from the 115 cm average height in 2007. In 2002, prior to the restoration, NOAA staff measured *Spartina alterniflora* height at the restoration site, finding the mean height of the remnant plants in the lower tidal elevations to be 116 cm. The mean height of plants in quadrats at the reference site was 108 cm. After six growing seasons, plants at the restoration site have reached the average height of plants prior to the restoration and have slightly exceeded the height of plants measured at the reference site. At the restoration site, 50.1 percent of *Spartina alterniflora* measured were flowering, while at the reference site, 43.8 percent of plants sampled were flowering in 2008. At both sites, *Spartina alterniflora* plants in quadrats at upper marsh elevations are visibly shorter than plants at lower marsh elevations. A short form of *Spartina alterniflora* generally occupies the upper marsh elevations, while the tall form dominates areas which are flooded daily, due to drainage and soil chemistry differences of the upper elevations (Bertness, 1985).

Table 3. Summary of 2008 Vegetative Ground Cover

Transect	Number of Quadrats	Mean Percent Vegetative Ground Cover for All Species Excluding *Phragmites australis*	Mean Percent Vegetative Ground Cover of *Phragmites australis*	Mean Total Percent Cover
Restoration Site				
1	5	95	0	95
2	5	93	3	96
3	5	97	0	97
4	5	73	0	73
5	5	90	4	94
6	10	89	1	90
7	5	99	0	99
Mean (all quadrats)		90.6	1.0	91.6
Reference Site				
8	3	85	5	90
9	4	54	28	81
10	3	87	0	87
Mean (all quadrats)		73	12.5	85.5

Plant field data documenting the ground cover estimates for the restoration and reference sites, as well as *Spartina alterniflora* height measurements and flowering status, are presented in Appendix B. Photographs taken along each transect at the restoration site appear in Appendix C. Appendix G contains NOAA pre-restoration monitoring of percent plant cover by species at the restoration site.

3.0 NEKTON MONITORING

3.1 Methodology

Nekton use of the restoration and reference sites was investigated by means of throw trap sampling conducted around the time of high tide. Nekton sampling was conducted in May and September of 2008. Fifteen stations were sampled, following the protocol established in conjunction with NOAA in 2004. Ten stations were sampled at the restoration site, and five were sampled at the reference site. The throw locations ranged from high marsh to low marsh. The throw trap consisted of an open-ended 1-meter square polycarbonate box measuring 75 cm in height. Sampling was conducted by throwing the trap onto the flooded marsh surface so that the open end fully contacted the substrate, preventing any escape. Sampling locations were limited to areas of relatively flat substrate where *Spartina alterniflora* growth was not so dense as to prohibit the trap from fully contacting the substrate. Fish and invertebrates were removed from the trap by passing a 1-meter-wide net of 0.25-inch mesh through the trap. Repeated passes of the net through the trap were made until three successive passes failed to produce any fish or invertebrates. All fish were identified to species and measured (as total length) before being released. Invertebrates were identified to species, counted and then released.

Figure 4. Throw Trap Sampling for Nekton with Sampled Striped Killifish (*Fundulus majalis*, male).

3.2 Results

Table 4 presents the pooled spring and fall 2008 sampling results, including species richness, abundance, diversity and density for nekton collected in the throw traps at the restoration and reference sites. Nekton field data for the spring and fall sampling events are provided in Appendix D. Mummichogs (*Fundulus heteroclitus*) and striped killifish (*Fundulus majalis*) were caught at the restoration site, as well as large numbers of grass shrimp (*Palaeomonetes pugio*). These three species, plus several Atlantic silversides (*Menidia menidia*) were caught at the reference site. All of these species were caught by NOAA during pre-restoration monitoring, and all had been caught annually during the previous four years of post-construction monitoring.

Overall fish abundance in 2008, as measured by the mean number of fish per trap throw, was 7.9 fish at the restoration site, which was slightly lower than the abundance of 10.6 fish at the reference site. Less than 10 fish were caught at each site during the spring sampling event, probably because striped killifish and mummichog are less active early in the season when water temperatures are low, however, grass shrimp were equally abundant in the spring and fall. Fish density for the restoration site, with a mean of 19.4 fish per cubic meter of water, was slightly lower than the density of 23.0 fish per cubic meter of water at the reference site. Fish diversity, as measured by the Shannon-Weaver Diversity Index, was 0.247 at the restoration site, which was lower than the reference site diversity index of 0.378. Grass shrimp abundance and density were markedly higher at the restoration site than at the reference site. At the restoration site, grass shrimp mean abundance was 33.9 shrimp per throw, and the density was 83.6 shrimp per cubic meter of water. At the reference site, mean shrimp abundance was 5.8 shrimp per throw, and the density was 12.6 shrimp per cubic meter of water. Shrimp may have a habitat preference for the calmer, more protected waters of the restoration site. The reference site is more exposed to open water and experiences considerably greater wave energy from wind and boat wakes than the restoration site.

Table 4. Summary of 2008 Nekton Sampling Results

Species		Restoration Site		Reference Site	
Common Name	Scientific Name	Number Caught	Mean Abundance	Number Caught	Mean Abundance
Mummichog	*Fundulus heteroclitus*	117	5.9	50	5.0
Striped killifish	*Fundulus majalis*	40	2.0	50	5.0
Atlantic silverside	*Menidia menidia*	0	--	6	0.6
Grass shrimp	*Palaemonetes pugio*	677	33.9	58	5.8
All Fish Species		157	7.9	106	10.6
Fish Diversity Index		0.247		0.378	
Fish Density (fish per m^3)		19.4		23.0	
Grass Shrimp Density (shrimp per m^3)		83.6		12.6	

The length-frequency distributions of *Fundulus heteroclitus* and *F. majalis* from the fall sampling event appear in Figure 5. Fish lengths from all trap throws within the restoration site and the two seasonal samplings were pooled, as were all throws within the reference marsh site. Few fish were caught during the spring sampling event (less than 10 per site), so these fish were not plotted. Also, very few *Menidia menidia* were caught during sampling, so this species was not plotted. Members of the 2008 year class of both *Fundulus* species were well represented at the restoration site and reference site during the fall, with greater size distributions recorded for both species at the restoring marsh. Lengths for *F. heteroclitus* ranged from ~28-68 mm at the reference site compared to ~23-88 mm at the restoring site. Similarily, *F majalis* lengths ranged from ~28-67 mm at reference site compared to 23-79 mm at the restored site. Several individuals of both *Fundulus* species assumed to be of the 2007 year class (based on their size) were also caught. The

average size of both *Fundulus* species was smaller at the restoration site than the reference site in the September 2008 sampling (*F. heteroclitus* mean length of 36.8 mm at the restoration site and 41.7 mm at the reference site; *F. majalis* mean length of 36.5 mm at the restoration site and 44.7 mm at the reference site), possibly indicating some type of difference in habitat preference between the sites for this particular sampling period. Other factors may also contribute to differences in fish size between the reference and restoration sites. The reference marsh is more mature and there are significantly more bivalves at the reference site. The presence of bivalves creates more structure, stabilizes and sequesters sediments, and recycles nutrients; and is associated with increased invertebrate and fish populations (Coen et al. 2007). Yet, differences in average fish size between the restoration and reference sites were not apparent in either 2004 or 2006.

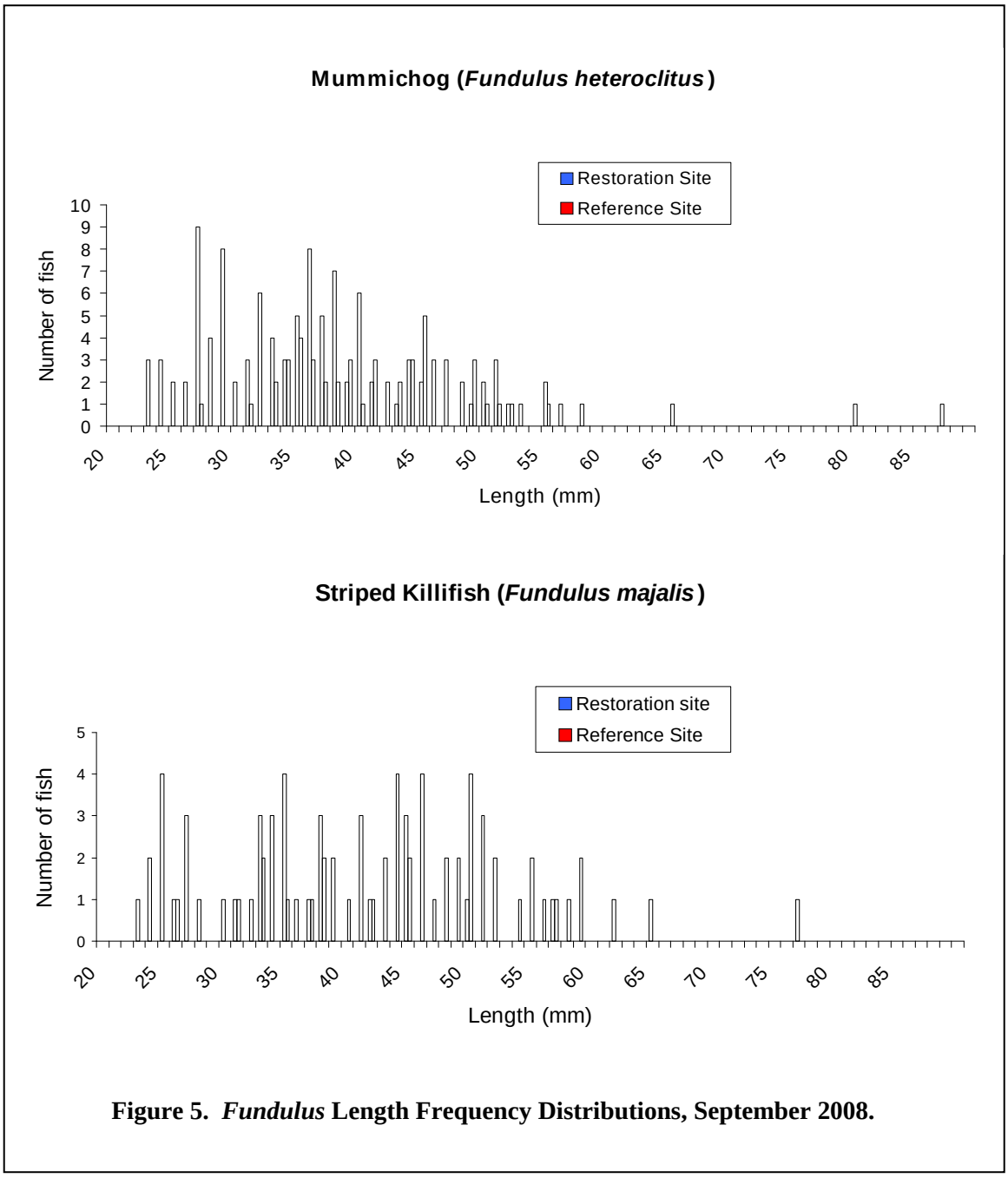

Figure 5. *Fundulus* Length Frequency Distributions, September 2008.

4.0 BENTHIC MACROINVERTEBRATE MONITORING

4.1 Methodology

Benthic macroinvertebrate monitoring was conducted in June and September 2008 using 0.25-meter square quadrats randomly laid on the marsh surface during low tide. All macroinvertebrates observed at the marsh surface within the quadrats were identified and recorded. In the case of fiddler crabs, because they are highly mobile, only their burrows were counted. Quadrat sampling was stratified to sample both high marsh and low marsh habitats, with the majority of quadrats located in the low marsh, which accounts for most of the area of both sites. Twenty-five quadrats were sampled at the restoration site (5 in the high marsh and 20 in the low marsh), and 15 quadrats were sampled at the reference site (3 in the high marsh and 12 in the low marsh).

Figure 6. Benthic Macroinvertebrate Quadrat Sampling, June 2008.

4.2 Results

Table 5 presents macroinvertebrate species composition, abundance, and diversity for the restoration and reference sites, pooled from spring and fall 2008 quadrat sampling. Macroinvertebrate field data for each sampling event are provided in Appendix E. A total of 12 macroinvertebrate species were found in quadrats at the restoration site and the reference site, but only 11 species were quantified. Ribbed mussels (*Geukensia demissa*) and mud snails (*Nassarius obsoletus*, also known as *Ilyanassa obsoleta*) dominated the macroinvertebrate communities at both sites but were more abundant at the reference site. Burrows of the

mud fiddler crab (*Uca pugnax*) were present at both sites, and several species of crabs, isopods, and snails were also present.

Table 5. Summary of 2008 Benthic Macroinvertebrate Sampling Results

Species		Restoration Site	Reference Site
Common Name	Scientific Name	Mean Abundance (per ¼ m^2)	Mean Abundance (per ¼ m^2)
Mud fiddler crab	*Uca pugnax*	3.9	0.2
Green crab*	*Carcinus maenas*	0	0.3
Mud crab	*Neopanopeus sayi*	0	0.1
Asian shore crab*	*Hemigrapsus sanguineus*	0	0.2
Wharf roach*	*Ligia exotica*	0.2	0
Roly poly isopod	*Sphaeroma quadridentata*	0.04	0
Salt marsh snail	*Melampus bidentatus*	0.9	0
Mud snail	*Nassarius obsoletus*	28.9	72.9
Rough periwinkle	*Littorina saxatilis*	6.2	0.1
Ribbed mussel	*Geukensia demissa*	49.9	69.5
Striped anemone*	*Diadumene lineata*	0.1	0.07
All Species		90.2	143.3
Number of Native and Non-Native Species		8	8
Number of Native Species		6	5
Number of Invasive Non-Native Species		2	3
Diversity Index (Native and Non-native species)		0.470	0.320

Asterisk (*) denotes non-native invasive species.
Amphipods were present under wrack in some quadrats, but could not be enumerated due to their rapid departure once the wrack was disturbed.

At both the restoration site and reference site, benthic macroinvertebrate abundance in the high marsh was low, relative to the low marsh. High marsh benthic macroinvertebrates consisted of small numbers of fiddler crab burrows, marsh snails, ribbed mussels, and isopods. Overall, mean macroinvertebrate abundance at the restoration site was 90.2 individuals per quadrat, which is substantially lower than the mean of 143.3 individuals per quadrat at the reference site. Although abundance includes the non-native invasive crabs, roach, and anemone, those species do not contribute significantly to overall abundance comprising ≤0.4% of the total. However, macroinvertebrate diversity (of all species), as measured by the Shannon-Weaver Diversity Index was higher at the restoration site (0.470) than the reference site (0.320), a pattern which was also observed in 2004 and 2006.

Eight benthic macroinvertebrate species were found in quadrats at the restoration site and reference site in 2008, though each site's quadrats contained three species not found at the other site. The lower-intertidal native species mud crab, and the non-native species green and Asian shore crabs were only found in reference site quadrats, where they occur in the structured habitat comprised of dense mussel beds. High-intertidal species including the native salt marsh snail and non-native wharf roach were not found in reference site quadrats. Also, the isopod *Sphaeroma quadridentata* was only found in quadrats in the flat portion of the peninsula area of the restoration site, among *Fucus* sp. interspersed around *Spartina alterniflora* stalks. This finding suggests that the isopod has an affinity for specific micro-habitat conditions. *Fucus* sp. was not present in quadrats at the reference site. Burrows of the mud fiddler crab were much more abundant at the restoration site than at the reference site. This may be due to the well-developed high marsh

plant community at the restoration site, and the low marsh characterized by a flat, sandy substrate on the peninsula area of the restoration site, where many fiddler crab and burrows were observed. Also, burrows occurring in areas of high ribbed mussel density at the reference site may be obscured in this high micro-relief environment and so the non-invasive sampling method employed may undercount burrows in this habitat.

These benthic community differences appear to highlight differences in the character of the plant communities and the sediment substrates at the restoration and reference sites. The restoration site constructed with sandy loam has well-developed native high marsh and coastal shoreline zone plant communities, and densely vegetated mid- and low marsh habitats. The reference site has a rather bare high marsh zone consisting of wrack and consolidated, finer-grained sediments than present at the restoring site, High marsh vegetation is limited to where *Phragmites australis* is present, while lower elevations are densely vegetated with *Spartina alterniflora* and its mature benthic community associated with the plant structure and compact substrate.

The higher abundances of sampled benthic macroinvertebrates at the reference site, also observed in 2004 and 2006, are due to the greater numbers of ribbed mussels and mud snails, as most other macroinvertebrates are present in relatively low numbers. Ribbed mussels and mud snails will likely continue to colonize the restoration site, but their abundance is likely dependent upon characteristics of the site's substratum. The establishment of these two dominants at the restoration site is dependent upon the metamorphosis of their larvae in response to stimuli received upon encountering a favorable substratum that meets their specific habitat requirements. Kraus and Crow (1985) found that ribbed mussels in a New Jersey salt marsh were most frequently found on substrates with low organic decomposition, high organic content, and low sand content. Scheltema (1961) found that metamorphosis of the mud snail, a deposit-feeding species, can be delayed for up to two weeks until a suitable substratum is encountered, in this case unrelated to sediment grain size, but rather the biological and chemical character of the sediment. Based on this requirement, the transition from "clean fill" placement during the restoration in 2003 to a substrate possessing natural chemical signatures (such as from micro-fauna, bacteria, and diatoms) and the trapping of finer-grained sediments by marsh vegetation is expected to take longer than the five years covered by the post-construction monitoring for this marsh restoration. To add, Warren *et al.* (2002) observed a protracted multi-decadal recovery of a restoring saltmarsh benthic community. Since benthic organisms are so intricately linked to the character of the substrate, it is expected that ribbed mussels and mud snails would continue to increasingly colonize the Bar Beach Lagoon restoration site as a more favorable substrate develops.

5.0 AVIAN MONITORING

5.1 Methodology

Avian monitoring was conducted by an experienced ornithologist from the North Shore Audubon Society arranged by NOAA. During 2008, monitoring was conducted each month and typically at least twice a month, for a total of 42 sampling events. For each event, the ornithologist spent back-to-back 20 minutes at the restoration site and 20 minutes at the reference site, and noted the bird species present (observations and calls) within each site, their numbers and activity, as well as the weather and tide conditions. Birds within 100 yards of the restoration and reference sites were also noted, but not included in the analysis, as they were generally flying through the area, or were between the sites in the parking lot or on the powerlines or utility towers.

5.2 Results

Table 6 presents avian species abundance, composition, and diversity for the restoration and reference sites in 2008. Avian monitoring data are provided in Appendix F. Twenty-six avian species were observed at the restoration site, while thirteen were observed at the reference site. Mean avian abundance per event at the restoration site was 14.3, which was higher than the mean of 9.9 birds per event at the reference site. Avian diversity, as measured by the Shannon-Weaver Diversity Index, was 0.743 at the restoration site, which was slightly higher than the reference site diversity index of 0.659. Both songbirds and waterbirds were well represented at the restoration site, while the bird community at the reference site consisted primarily of the flocking species Canada goose, Ring-billed gull, and the non-native European starling.

Diversity at the restoration site was particularly high during the fall migration, when a variety of sparrows and other songbirds were observed foraging at the site. Several species of sparrows were frequently heard or observed while foraging in the marsh grass and planted shrubs at the restoration site, however, sparrows were uncommon at the reference site. The observed differences in species composition and abundance between the restoration site and reference site were similar to conditions presented in previous monitoring reports.

Brant (*Branta bernicla*) and red-breasted merganser (*Mergus serrator*) were observed at the restoration site and the reference site in 2008, but had not been noted at either site in previous years. Seventeen species documented at the restoration site in 2007 were not noted in 2008. Most of these species were songbirds that were observed in small numbers or as single individuals in 2007.

The greater avian species richness and diversity of the restoration site as compared to the reference site and the difference in species composition are likely due to differences in bordering conditions. The waters adjacent to the restoration site are less exposed to wind and waves than the reference site, and the restoration site is partially adjacent to a parking lot but is surrounded on two sides by a narrow fringe of densely wooded habitat that is a source of food and shelter in close proximity for songbirds. The reference site by comparison also borders a parking lot but the wooded edge is narrower providing less sheltering and foraging habitat, and has been noted to be active with recreationists and other users parking near the reference marsh. The differences in species composition between the restoration site and reference site were apparent during all five years of monitoring.

Table 6. Summary of 2008 Avian Monitoring Results

Species		Restoration Site		Reference Site	
Common Name	Scientific Name	Number of Individuals	Mean Abundance	Number of Individuals	Mean Abundance
Osprey	*Pandion haliaetus*	1	0.02	0	--
Brant	***Branta bernicla***	16	0.4	17	0.4
Canada goose	*Branta canadensis*	327	7.8	241	5.7
Mute swan	*Cygnus olor*	7	0.2	14	0.3
Mallard	*Anas platyrhynchos*	3	0.1	24	0.6
Red-breasted merganser	***Mergus serrator***	1	0.02	8	0.2
Great blue heron	*Ardea herodias*	2	0.05	2	0.05
Great egret	*Ardea alba*	15	0.4	15	0.4
Snowy egret	*Egretta thula*	6	0.1	0	--
Belted kingfisher	*Ceryle alcyon*	5	0.1	1	0.02
Double-crested cormorant	*Phalacrocorax auritus*	2	0.05	0	--
Herring gull	*Larus argentatus*	0	--	2	0.05
Great black-backed gull	*Larus marinus*	0	--	3	0.1
Ring-billed gull	*Larus delawarensis*	18	0.4	45	1.1
Killdeer	*Charadrius vociferus*	1	0.02	0	--
American robin	*Turdus migratorius*	2	0.05	0	--
Mourning dove	*Zenaida macroura*	7	0.2	0	--
Common grackle	*Quiscalus quiscula*	3	0.1	0	--
Red-winged blackbird	*Agelaius phoeniceus*	2	0.05	0	--
European starling	*Sturnus vulgaris*	111	2.6	40	1.0
Northern mockingbird	*Mimus polyglottos*	9	0.2	0	--
Barn swallow	*Hirundo rustica*	3	0.1	0	--
Field sparrow	*Spizella pusilla*	2	0.05	0	--
Song sparrow	*Melospiza melodia*	19	0.5	2	0.05
House sparrow	*Passer domesticus*	35	0.8	0	--
mixed sparrows	NA	1	0.02	0	--
Purple finch	*Carpodacus purpureus*	2	0.05	0	--
Common yellowthroat	*Geothlypis trichas*	1	0.02	0	--
	Abundance	601	14.3	414	9.9
	Number of Species	26		13	
	Diversity Index	0.743		0.659	

Species appearing in bold font have not been previously observed at the restoration site.

6.0 2004-2008 COMPARISONS

6.1 Plant Cover

Monitoring over the 5-year period indicates that the total ground cover of the restoration site increased every year between 2004 and 2008 (Table 7). Native plant cover also increased every year except 2008, when native cover was the same as the prior year. Mean height of *Spartina alterniflora* at the restoration site increased every year from 2004 to 2007, and was essentially the same in 2007 and 2008. *Phragmites australis* cover at the restoration site was very low (≤1%), but doubled between 2004 and 2008. Ground cover of native species and *Phragmites australis* at the reference site varied between years, but was relatively unchanged over the 5-year monitoring period. Mean height of *Spartina alterniflora* at the reference site varied over the monitoring period. Percent of flowering *Spartina alterniflora* varied between 37 and 66 percent at both sites, and a greater percentage of plants flowering at the restoration site than the reference site in all sampled years.

Table 7. Plant Cover Monitoring Comparisons, 2004-2008.

Parameter	Restoration Site					Reference Site				
	2004	2005	2006	2007	2008	2004	2005	2006	2007	2008
Percent Ground Cover (excluding *Phragmites*)	83	84	87.8	90.6	90.6	71.4	64	66	67	73
Percent Cover by *Phragmites*	0.5	0.4	0.3	0.6	1.0	11.5	19	14	12.5	12.5
Total Ground Cover	83.5	84.4	88.1	91.2	91.6	82.9	83	80	79.5	85.5
Mean *Spartina alterniflora* height	93	103	114	115	113	117	110	108	95	108
Percent *Spartina alterniflora* Flowering	NS	NS	66.1	57.7	50.1	NS	NS	51.9	36.9	43.8

NS=Not Sampled

The number of species in monitoring quadrats at the restoration site declined from 12 in 2004 to 10 in 2008 (Table 8). The annual species marsh orach, sea blite, and pearlwort were not present in quadrats every year, and pearlwort did not occur within quadrats after 2006. Also, the only groundsel tree which was located within a quadrat (transect 5, quadrat 1) died prior to the 2007 monitoring, and plant cover was replaced by panic grass. Pearlwort tends to cover barren areas in the coastal shoreline zone, however, these areas were largely colonized by perennial plants by 2006. Naturally-colonizing sea lavender (*Limonium nashii*) was observed on the marsh at the restoration site, but did not occur within quadrats. The number of plant species in restoration site quadrats was always at least twice the number present in reference site quadrats, reflecting the high diversity of plant species in the restored high marsh and coastal shoreline zones. The number of plant species in reference site quadrats varied slightly by year over the 5-year monitoring period.

Table 8. Vegetative Species Observed in Quadrats, 2004-2008.

Common Name	Scientific Name	Restoration Site					Reference Site				
		2004	2005	2006	2007	2008	2004	2005	2006	2007	2008
Marsh orach	*Atriplex patula*	X		X	X	X					X
Groundsel tree*	*Baccharis halimifolia*	X	X	X							
Spike grass*	*Distichlis spicata*	X	X	X	X	X					
High tide bush*	*Iva frutescens*	X	X	X	X	X	X	X	X	X	X
Panic grass*	*Panicum amarum*	X	X	X	X	X					
Virginia creeper*	*Parthenocissus cinquefolia*						X	X	X		
Common reed	*Phragmites australis*	X	X	X	X	X	X	X	X	X	X
Pearlwort	*Sagina procumbens*	X	X	X							
Glasswort	*Salicornia europa*	X	X	X	X	X					
Seaside goldenrod*	*Solidago sempervirens*	X	X	X	X	X	X				X
Smooth cordgrass*	*Spartina alterniflora*	X	X	X	X	X	X	X	X	X	X
Salt meadow grass*	*Spartina patens*	X	X	X	X	X					
Sea blite	*Sueda linearis*	X	X		X	X					
	Number of Species	12	11	11	10	10	5	4	4	3	5

*Species planted or seeded at the restoration site

6.2 Nekton

Nekton sampling results at the restoration sites and reference sites over the 5-year monitoring period is summarized in Table 9. The nekton data are not directly comparable across years, as 2004 sampling only occurred in the fall, when the marsh vegetation is at its tallest, resulting in a greater amount of sheltered habitat and higher catches of nekton during sampling. The 2006 and 2008 nekton data include spring sampling, when the water was relatively cold and the marsh plants had not reached maximum height, likely resulting in spring fish catches of an order of magnitude smaller than fall catches.

Mummichogs, striped killifish, Atlantic silversides, and grass shrimp were caught at the restoration site and reference site during the 5-year monitoring project. These four species were caught at both sites in all three sampling years, except that Atlantic silversides, although observed, were not collected in 2008. Several Atlantic silversides came up in the net at the restoration site in 2008, but they were small enough that they slipped through the ¼-inch mesh. As they could not be enumerated or measured, they were not counted as catch. A single sheepshead minnow (*Cyprinodon variegatus*) was caught at the reference site in 2006.

Nekton catches were highly variable over the 5-year monitoring period. Overall, grass shrimp and mummichog dominated the catches. Spring nekton sampling typically produced good catches of shrimp, but poor catches of fish. Fish abundance and density at both sites were generally similar over the course of monitoring, but shrimp abundance and density were greater at the restoration site in all sampling years. As previously mentioned, the reference site is more exposed to open water and experiences considerably greater wave energy from wind and boat wakes than the restoration site, which may account for differences in shrimp usage.

Table 9. Nekton Monitoring Comparisons, 2004-2008.

Parameter		Restoration Site			Reference Site		
		2004	2006	2008	2004	2006	2008
Mean Abundance per Trap Throw	Mummichog	15.5	2.2	5.9	10.8	1	5
	Striped killifish	4	1.6	2	3.4	0.5	5
	Atlantic silverside	2.1	0.2	0	1.2	0	0.6
	Sheepshead minnow	0	0	0	0	0.1	0
	Grass shrimp	52.3	13.8	33.9	33	8.2	5.8
	Mean Fish Abundance	21.6	4	7.9	15.4	1.6	10.6
Number of Fish Species		3	3	2	3	3	3
Fish Diversity Index		0.337	0.367	0.247	0.339	0.360	0.378
Mean Fish Density (fish per m^3)		40.8	7.9	19.4	23.3	4.2	23
Mean Shrimp Density (grass shrimp per m^3)		98.7	27.6	83.6	50	21.6	12.6

2006 and 2008 data include pooled spring and fall data; 2004 data are fall data only.

The chi-square test of independence was performed on the numbers of each nekton species caught during each sampling event at the restoration site. This test revealed that the nekton communities at the restoration site were significantly different across the five sampling events (x^2 =205.3; P<.001). Excluding the two spring sampling events (in 2006 and 2008), the nekton communities at the restoration site in the fall of 2004, 2006, and 2008 were still significantly different (x^2 =35.8; P<.001). Nekton communities at the reference site in 2004, 2006, and 2008 were also significantly different from each other, regardless of whether spring data were included (P<.001).

The chi-square test of independence was performed on the numbers of each nekton species caught during each sampling event at both sites, corrected for the different number of samples taken at each site. Results indicate that the nekton communities of the restoration and reference sites were significantly different (x^2 =177.4; P<.001). Excluding the apparent differences in shrimp catches, the fish communities of each site were also significantly different (x^2 =38.8; P<.001).

Nekton use of the restoration and reference sites appear to be highly variable by season and year. Water temperature probably accounts for seasonal differences. Inter-year differences at the restoration site and reference site reflect uneven catches of shrimp, mummichog and striped killifish across sampling years as well as irregular catches of Atlantic silverside. Fish sampling in salt marsh habitats is a difficult endeavor due to the robust growth habits of *Spartina alterniflora*. The throw trap method is generally an effective nekton sampling method, but areas of dense *Spartina alterniflora* and/or uneven substrate cannot be effectively sampled due to likely escape of nekton whenever trap landing does not make complete contact with the substrate. Also, nekton sampling in the high marsh at the reference site was in a done in habitat conditions that do not occur at the restoration site, namely heavy cover of floating wrack and little to no *Spartina alterniflora*.

6.3 Benthic Macroinvertebrates

Benthic macroinvertebrate sampling at the restoration sites and reference sites over the 5-year monitoring period is summarized in Table 10. The benthic data are not directly comparable across years, as 2004 sampling only occurred in the fall, while the 2006 and 2008 benthic data include spring and fall sampling. It should also be noted that the data include only species which were found within sampled quadrats. Other indications of benthic organism presence include the regular observations of raccoon footprints and

horseshoe crab eggs and adults in 2007; and the catch of a juvenile horseshoe crab during nekton sampling in 2008.

Table 10. Benthic Macroinvertebrate Monitoring Comparisons, 2004-2008.

Species		Restoration Site Mean Abundance (per ¼ m^2)			Reference Site Mean Abundance (per ¼ m^2)		
Common Name	Scientific Name	2004	2006	2008	2004	2006	2008
Mud fiddler crab	*Uca pugnax*	2.2	2.4	3.9	0.4	0.6	0.2
Green crab*	*Carcinus maenas*	0.04	0.02	0	0	0.04	0.3
Mud crab	*Neopanopeus sayi*	0	0	0	0.1	0	0.1
Asian shore crab*	*Hemigrapsus sanguineus*	0.6	0	0	1.7	0.1	0.2
Wharf roach*	*Ligia exotica*	0	0	0.2	0	0	0
Roly poly isopod	*Sphaeroma quadridentata*	0	0	0.04	0	0	0
Salt marsh snail	*Melampus bidentatus*	0	0.04	0.9	0	0.1	0
Mud snail	*Nassarius obsoletus*	25.4	40	28.9	30.6	113.1	72.9
Rough periwinkle	*Littorina saxatilis*	0.04	0.2	6.2	0	0	0.1
Ribbed mussel	*Geukensia demissa*	48.5	20.6	49.9	89.5	75.6	69.5
Striped anemone*	*Diadumene lineata*	0	0	0.1	0	0	0.07
	All Species	76.8	63.3	90.2	122.7	189.6	143.3
	Number of Species	6	6	8	5	6	8
	Diversity Index	0.349	0.350	0.470	0.285	0.305	0.320

2006 and 2008 data include pooled spring and fall data; 2004 data are fall data only.
Asterisk (*) denotes non-native invasive species.

Benthic macroinvertebrate monitoring data indicate that the restoration site supports diverse nektonic and benthic communities comparable to the reference site. Several species of macroinvertebrates not encountered by NOAA prior to restoration in 2002 are now present (marsh snail, rough periwinkle, roly poly isopod). However, sampling during the monitoring period also revealed four non-native, invasive species which have become established in Hempstead Harbor. The green crab and Asian shore crab have been found at both the restoration and reference sites in most monitoring years, though they are not abundant. In 2008, the striped anemone was found at the restoration site and reference site, and the wharf roach was found at the restoration site.

The chi-square test of independence was performed on the numbers of each benthic macroinvertebrate species caught during each of the five sampling events at the restoration site. This test revealed that the benthic communities differed significantly at the restoration site over the five sampling events (x^2 =1625.7; P<.001). Excluding the two spring sampling events (in 2006 and 2008), the fall benthic communities at the restoration site in 2004, 2006, and 2008 were still significantly different (x^2 =840.5; P<.001). Benthic communities at the reference site in 2004, 2006, and 2008 were also significantly different from each other, regardless of whether spring data were included (P<.001).

The chi-square test of independence was also performed on the numbers of each benthic macroinvertebrate species caught during each sampling event at both sites, corrected for the different number of benthic quadrats sampled at each site. This test indicates that the benthic communities of the restoration site and the reference site were different (x^2 =2340; P<.001).

Benthic communities at the restoration and reference sites appear to be highly variable by season and year. Some of the lack in similarity is certainly due to mud snails, which are found in high abundances at both sites, but have extremely patchy distribution patterns. Counts of over 200 mud snails per ¼ m quadrat occurred at both sites during spring and fall sampling. The species were much more prevalent at the reference site and had not fully colonized the restoring site. Likewise, ribbed mussels are also densely distributed, but primarily at lower marsh elevations. Sampling was conducted by random throws of the quadrat on the marsh, however, in retrospect, the use of fixed sampling stations may have been a better method to track benthic macroinvertebrate trends over time, given the distribution patterns of some salt marsh species.

6.5 Avian

Avian monitoring at the restoration sites and reference sites over the 5-year monitoring period is summarized in Table 11. Data for 2004 are not directly comparable with subsequent years, as monitoring in 2004 included the period from October to December, while data were collected year-round from 2005 to 2008. Over the 5-year monitoring period, 49 avian species were identified at the restoration site, while 24 species were identified at the reference site. Avian monitoring data indicate that the restoration site supports a diverse avian community, with songbirds and waterbirds being well represented. In contrast, waterbirds dominate the avian community of the reference site. Differences are probably due to onsite and surrounding habitat differences. The reference site lacks high marsh and coastal shoreline plant communities; instead these elevations are colonized by *Phragmites australis*. Also, the chain-link fence between the parking lot and forested portion of the reference site may limit songbird movement and use of upland portions of the reference site.

The chi-square test of independence was performed on avian abundance data for the restoration site from 2005 to 2008. The 2004 data were excluded because they were only sampled in the fall of that year, whereas the remaining years were sampled year-round. Avian communities of the restoration site from 2005 to 2008 were significantly different (x^2 =1028.7; P<.001). Avian communities of the reference site from 2005 to 2008 were also significantly different (x^2 =1060; P<.001). Avian communities at the restoration site and reference site were also significantly different (x^2 =718.8; P<.001).

Table 11. Avian Monitoring Comparisons, 2004-2008.

Species		Mean Abundance Per Sample									
		Restoration Site					Reference Site				
Common Name	Scientific Name	2004	2005	2006	2007	2008	2004	2005	2006	2007	2008
Osprey	*Pandion haliaetus*		0.05		0.07	0.02					
Brant	*Branta bernicla*					0.38					0.40
Canada goose	*Branta canadensis*		0.33	1.28	2.00	7.79		0.23	3.38	0.49	5.74
Mute swan	*Cygnus olor*	0.78	0.45	0.31	0.19	0.17		0.20	0.31	0.07	0.33
Mallard	*Anas platyrhynchos*		0.05	0.10	0.56	0.07		0.13	0.44	0.19	0.57
Red-breasted merganser	*Mergus serrator*					0.02					0.19
Common merganser	*Mergus merganser*				0.09						
Great blue heron	*Ardea herodias*		0.03	0.03			0.11				0.05
Little blue heron	*Egretta caerulea*			0.03							
Great egret	*Ardea alba*		0.03	0.08	0.49	0.36	0.11	0.10	0.13	0.30	0.36
Snowy egret	*Egretta thula*			0.05	0.09	0.14		0.03	0.05	0.05	
Black-crowned night heron	*Nycticorax nycticorax*		0.08	0.10	0.16						
Greater yellowlegs	*Tringa melanoleuca*				0.05						
Spotted sandpiper	*Actitis macularia*		0.03								
Belted kingfisher	*Ceryle alcyon*			0.05	0.14	0.12					0.02
Double-crested cormorant	*Phalacrocorax auritus*	0.22			0.02	0.05					
Herring gull	*Larus argentatus*		0.03					0.18	0.08	1.26	0.05
Great black-backed gull	*Larus marinus*		0.03				0.03		0.03	0.07	0.07
Ring-billed gull	*Larus delawarensis*		0.05	0.14		0.43			1.74	0.07	1.07
Laughing gull	*Larus atricilla*								0.05		
Common tern	*Sterna hirundo*			0.23	0.02		2.40			0.07	
Foster's tern	*Sterna forsteri*		0.08					0.03			
Killdeer	*Charadrius vociferus*		0.08			0.02					
American robin	*Turdus migratorius*			0.03	0.07	0.05					
Mourning dove	*Zenaida macroura*		0.08	0.21	0.35	0.17					
Rock dove	*Columba livia*							1.95		0.09	
Crow	*Corvus* sp.				0.02					0.02	
Common grackle	*Quiscalus quiscula*		0.30			0.07			0.03		
Red-winged blackbird	*Agelaius phoeniceus*	1.67	0.33	0.49	0.07	0.05					
European starling	*Sturnus vulgaris*		0.10		0.30	2.64	0.11	2.45	2.21	0.07	0.95

Table 11, continued.

Species		Mean Abundance Per Sample									
		Restoration Site					Reference Site				
Common Name	Scientific Name	2004	2005	2006	2007	2008	2004	2005	2006	2007	2008
Northern mockingbird	*Mimus polyglottos*	0.11		0.08	0.42	0.21	0.11				
Eastern towhee	*Pipilo erythrophthalmus*				0.02						
Eastern phoebe	*Sayornis phoebe*	0.11			0.02						
Blue jay	*Cyanocitta cristata*				0.02						
flycatcher	*Empidonax* sp.				0.02						
Willow flycatcher	*Empidonax traillii*		0.03	0.03							
Barn swallow	*Hirundo rustica*										
Chipping sparrow	*Spizella passerina*				0.07						
Field sparrow	*Spizella pusilla*	0.23			0.02	0.07	0.05	0.03		0.07		
Savannah sparrow	*Passerculus sandwichensis*			0.05	0.05						
Song sparrow	*Melospiza melodia*	0.89	0.50	0.26	0.72	0.45		0.03	0.05		0.05
Swamp sparrow	*Melospiza georgiana*		0.05		0.37			0.05			
Tree sparrow	*Spizella arborea*				0.07						
White-throated sparrow	*Zonotrichia albicollis*				0.05						
House sparrow	*Passer domesticus*		0.03	0.38		0.83					
mixed sparrows	NA				1.12	0.02					
Goldfinch	*Carduelis tristis*		0.03	0.05							
Purple finch	*Carpodacus purpureus*				0.07	0.05					
House finch	*Carpodacus mexicanus*	0.56		0.10							
Common yellowthroat	*Geothlypis trichas*				0.05	0.02					
Yellow-rumped warbler	*Dendroica coronata*	0.56	0.05								
Yellow warbler	*Dendroica petechia*				0.07						
Myrtle warbler	*Dendroica coronata*				0.19						
Palm warbler	*Dendroica palmarum*				0.02						
	Mean Abundance	4.9	3.0	3.7	8.5	14.3	0.7	7.8	8.5	3.0	9.9
	Number of Species	8	23	20	37	26	5	14	12	15	13
	Diversity Index	0.771	1.137	0.992	1.232	0.743	0.678	0.695	0.672	0.869	0.659

2004 data are for fall only (n=9); 2005 n=40; 2006 n=39; 2007 n=43; 2008 n=42

7.0 SUMMARY

The restoration site met the 85% native species vegetative cover requirement and <10% re-establishment of *Phragmites australis* and other undesirable invasive species cover starting in the third year of monitoring (2006), and these performance criteria were maintained through 2008. Quadrat sampling revealed that an average of 90.6 percent of the restoration site was covered with native vegetation in 2008. Ground cover by *Phragmites australis* was limited to 1.0 percent of the restoration site in 2008. Comparisons with NOAA pre-restoration monitoring indicate substantially greater coverage of the restoration site with native wetland vegetation, and the near-total eradication of *Phragmites australis*. In 2002, prior to the restoration, only 47 percent of the site had vegetative cover, nearly a third of which consisted of *Phragmites australis*. Table 12 summarizes the monitoring results for all parameters investigated at the restoration and reference sites in 2008.

Table 12. Summary of 2008 Monitoring Results

Resource	Monitoring Result	Restoration Site	Reference Site	Restoration Site compared to Reference site
Vegetation	Percent Ground Cover (excluding *Phragmites*)	90.6	73	+
	Percent Cover by *Phragmites*	1.0	12.5	+
	Number of Species	10	5	+
Nekton	Mean Fish Abundance	7.9	10.6	-
	Number of Species	2	3	-
	Diversity Index	0.247	0.378	-
	Mean Fish Density (fish per m^3)	19.4	23.0	-
	Mean Shrimp Density (grass shrimp per m^3)	83.6	12.6	+
Benthic Macroinvertebrates	Mean Abundance	90.2	143.3	-
	Number of Species	8	8	=
	Diversity Index	0.470	0.320	+
Avian	Mean Abundance	14.3	9.9	+
	Number of Species	26	13	+
	Diversity Index	0.743	0.659	+

The 2008 monitoring results indicate fish densities at the restoration site are comparable to that of the reference site, while grass shrimp densities were markedly higher at the restoration site. Only two fish species were caught at the restoration site in 2008 sampling, while several individuals of a third species, Atlantic silverside, were caught at the reference site. Atlantic silverside is a common seasonal visitor of nearshore coastal waters, and had been caught at the restoration site during 2004 and 2006 sampling. Monitoring results also suggest that the restoration site supports more diverse benthic macroinvertebrate and avian communities than the reference site. Eight species of benthic invertebrates were found in benthic sampling quadrats at both the restoration site and reference sites, though several species were unique to each site. Benthic macroinvertebrate abundance at the restoration site was considerably lower than that of the reference site, due to very high densities of ribbed mussels and mud snails in more favorable habitat conditions at the reference site. Mussel density at the restoration site is expected to increase as the clean sandy fill brought in during the site restoration continues to take on a more natural chemical and textural signature. It is important to note that the dense mussel beds at the reference site (extrapolated at over 1,000 mussels per m^2 in some areas) have likely been present for decades. Avian abundance, diversity and species richness at the restoration site are greater than that of the reference site. Differences in the composition of

the avian communities at the restoration and reference site are probably due to differences in the surrounding habitats of each site.

Table 13 summarizes the parameters monitored at the restoration site from 2004 to 2008. The vegetative monitoring data are directly comparable across years. The nekton, benthic, and avian data are not directly comparable across years, as these parameters were monitored according to different schedules. The 2004 avian data only included the period from October to December of 2004, as opposed to the year-round data collected from 2005 to 2008. Additionally, the nekton data for 2004 were only collected in the fall, when the marsh vegetation is at its tallest, resulting in a greater amount of sheltered habitat and higher catches of nekton during sampling. The 2006 and 2008 nekton data include spring sampling, when the water was relatively cold and the marsh grass was short, resulting in small catches of nekton. Likewise, the benthic data for 2006 and 2008 included spring and fall sampling, while the 2004 data only consisted of fall sampling. It should also be noted that the data include only species which were found within sampled quadrats. Other indications of benthic organism presence include the regular observations of raccoon footprints and horseshoe crab adults and eggs in 2007; and the catch of a juvenile horseshoe crab during nekton sampling in 2008.

Native plant cover at the restoration site increased every year from 2004 to 2007, and was unchanged between 2007 and 2008. The average height of *Spartina alterniflora* also increased every year from 2004 to 2007, and was essentially the same in 2007 and 2008. The number of plant species in monitoring quadrats declined slightly over time, as several opportunistic annual species initially colonized bare ground in the coastal shoreline zone but were eventually crowded out by expansion of the perennial grasses. *Phragmites* cover at the site is very low (<1%), but has doubled between 2004 and 2008. The nekton and benthic macroinvertebrate monitoring data indicate that the restoration site supports diverse nektonic and benthic communities comparable to the reference site. Several species of snails and crabs not encountered by NOAA prior to restoration in 2002 are now common inhabitants (marsh snail, rough periwinkle, mud fiddler crab). Avian monitoring data also indicate that the restoration site supports a diverse avian community, with songbirds and waterbirds being well represented.

Table 13. Restoration Site Comparisons, 2004-2008

Resource	Monitoring Result	2004	2005	2006	2007	2008
Vegetation	Percent Ground Cover (excluding *Phragmites*)	83	84	87.8	90.6	90.6
	Percent Cover by *Phragmites*	0.5	0.4	0.3	0.6	1.0
	Number of Species	12	11	11	10	10
	Mean *Spartina alterniflora* height	93	103	114	115	113
Nekton	Mean Fish Abundance	*21.6*	NS	4.0*	NS	7.9*
	Number of Fish Species	*3*	NS	3*	NS	2*
	Diversity Index	*0.337*	NS	0.367*	NS	0.247*
	Mean Fish Density (fish per m^3)	*40.8*	NS	7.9*	NS	19.4*
	Mean Shrimp Density (grass shrimp per m^3)	*98.7*	NS	27.6*	NS	83.6*
Benthic Macroinvertebrates	Mean Abundance	*76.8*	NS	63.3*	NS	90.2*
	Number of Species	*6*	NS	6*	NS	8*
	Diversity Index	*0.349*	NS	0.350*	NS	0.470
Avian	Mean Abundance	*4.9*	3	3.7	8.5	14.3
	Number of Species	*8*	23	20	37	26
	Diversity Index	*0.771*	1.137	0.992	1.232	0.743

NS=not sampled
Values followed by an asterisk (*) are results of pooled spring and fall data.
Data in italics represent Fall data only.

Management Recommendations

The five years of monitoring results indicate that restoration efforts have been successful in establishing a diverse population of salt marsh plant and animal species at the Bar Beach Lagoon site. The planted salt marsh grasses and coastal shoreline zone vegetation have become well established. Based upon monitoring results, no additional planting is warranted at the site at this time. *Phragmites australis* cover at the site was minimal, but is incrementally increasing. During the September 2008 monitoring, the stand of *Phragmites australis* along the shoreline near the boat ramp remained unaddressed, and small patches were observed in the high marsh on Transects 2, 5, and 6.

In October 2008 after receiving a permit from NYSDEC, the Town of North Hempstead hand-applied glyphosate herbicide in an effort to eradicate common reed. They also manually removed multiflora rose, Japanese knotweed, Norway maple, and common mugwort. Over 100 native shrubs and 1500 grass plugs were installed to further minimize the spread of invasive plants. Plantings included red maple, northern bayberry, American holly, switchgrass, bluestem and bitter panicgrass. Porcelainberry was observed at the edge of the mowed lawn, between T5 and the peninsula during the 2008 monitoring.

Invasive species accounted for little cover in 2008, but can be expected to increase significantly if left untreated, or if the 2008 treatments are not completely successful. The Town of North Hempstead, as owner of the property, should continue the monitoring and control of invasive plants. For example, a follow-up evaluation should be conducted at the end of each future growing season to determine the extent of success of invasive plant species control at the site. Patches of *Phragmites australis* at the restoration site should continue to be treated with glyphosate herbicide under the supervision of a qualified botanist certified in herbicide application. It can be expected that three hand-applications of herbicide may be necessary to completely kill *Phragmites australis*. Hand-removal of Japanese knotweed, multiflora rose, Norway maple, mugwort, porcelainberry, and other plant invasives should continue on an as-needed basis.

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