Nueces Bay Marsh Restoration – Post Construction Assessment

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Executive Summary

The purpose of this study was to assess the effectiveness of the Nueces Bay Marsh Restoration led by the Coastal Bend Bays and Estuaries Program. In 2009, I completed a survey comparing the natural marshes present in Nueces Bay to the adjacent mud bottom habitats allocated for building of new marsh habitats. No vegetation was found in the non-marsh areas in the 2009 survey, and fauna was significantly less abundant and diverse in these areas as compared to nearby natural marsh sites where vegetation was abundant. The Coastal Bend Bays and Estuaries Program constructed ~160 acres of new marsh habitat by building terraces or mounds at elevations suitable for *Spartina alterniflora* (smooth cordgrass, hereafter *Spartina*), the foundation species in marsh habitats in the Gulf of Mexico. *Spartina* has become established on the constructed terraces, in large part due to several volunteer plantings of *Spartina* completed post construction. In September 2015, I revisited the Nueces Bay Marsh and collected fish, crabs, and shrimp in both natural and restored sites to assess the effectiveness of the restoration effort. Collections were made in monoculture stands of *Spartina*, and the density of *Spartina* stems counted. *Spartina* stem density was higher in restored than natural marsh sites (35 m^2 vs. 44 m^2), although these values were not significantly different. Unlike 2009, faunal differences between natural and restored sites were minimal. Shrimp were the most abundant organisms collected and were not significant different between natural and restored sites. Few fish species were collected in the study, and their abundance was not different between natural and restored sites. Natural sites had significantly more blue crabs than did restored sites, but overall community differences were not significantly different. Like abundance, biomass of marsh fauna was not significantly different between natural and restored areas. These findings indicate that the restored marsh sites are similar to adjacent natural areas and that the Nueces Bay Marsh restoration has been successful. Nueces Bay communities were significantly different than nearby marsh habitats in Redfish and Aransas Bays having lower species richness and abundance. Nueces Bay has been more heavily impacted than these other marshes, which may explain, in part, the differences in communities. This finding makes continued restoration efforts, such as the one marsh restoration completed by CBBEP, in Nueces Bay of significant importance. Continued monitoring of the site would be useful for evaluating long term restoration success.

Introduction

Salt marshes provide essential habitats for many estuarine organisms, including several species of economic importance (Turner 1976, Pennings and Bertness 2001). Salt marshes protect coastal areas from erosion and storms, filter sediments and minerals from the water column, and enhance habitat quality and biodiversity of adjacent marine habitats (Bertness 1999, Pennings and Bertness 2001, Grabowski et al. 2005). Due to their importance, salt marshes are designated as critically important coastal natural resource areas by the Texas General Land Office.

Prior to 2009, salt marshes in Nueces Bay were limited to shallow water areas near the shoreline and on several smaller islands created from dredge spoil. Most of Nueces Bay is too deep for *Spartina alterniflora* (smooth cordgrass, hereafter *Spartina*) to grow (McKee and Patrick 1988), but it was traditionally inhabited by extensive oyster reef communities. Oysters in Nueces Bay were dredged to obtain shells needed for road construction (Doran 1965). Since this disturbance, Nueces Bay lost much of its structured habitat and contains large expanses of unstructured sand and mud bottom.

To compensate for habitat loss and to recover ecosystem services from Nueces Bay, the Coastal Bend Bays and Estuaries Program (CBBEP) created 160 acres of salt marsh. Mounds or terraces were constructed from dredge material taken from the bay bottom and designed to be of appropriate depth to support *Spartina* at low tidal elevations and other vegetation common along the Nueces Bay shoreline (e.g., *Spartina patens*, *Salicornia virginica*). *Spartina* has been planted on many of the mounds by community volunteers.

The purpose of this study was to measure *Spartina* density and associated marsh fauna with the restored Nueces Bay Marsh and on adjacent, natural marsh areas. By comparing natural and restored areas, I was able to ascertain if the restoration effort has been effective in creating habitat similar to that in natural areas. I also compared *Spartina* density in Nueces Bay to other marsh sites in Redfish Bay, Mud Island, and the Aransas Wildlife Refuge.

Methods

Vegetation and faunal surveys in natural and restored marsh sites within Nueces Bay were performed on September 4, 2015. The methods described below commenced at noon and ended by 5:00 PM. *Spartina* in all areas were submerged during sampling to depths of 0.4 to 0.6 m. Winds were from the SSE at 10-15 mph with occasional gusts of ~ 25 mph and a brief rain storm occurred during sampling. Waves were minimal in the study area. Air temperature was 35^{o} C when sampling began. Water quality parameters were measured using a Hydrolab Data Sonde at a depth of 0.5 m near the center of the restored marsh sites. Salinity was 17.5 ppt, water temperature 32^{o} C, dissolved oxygen 8.3 mg/l, turbidity 10 NTU, and pH 7.9.

Using a modified throw trap (i.e. drop sampler, Figure 1, sensu Smee 2010), I collected nekton from 20 locations in Nueces Bay: 10 from natural marsh habitats and 10 from the restored marsh site. In the natural site, all marsh samples were taken at least 100 m apart. In the restored marsh site, 10 different mounds (i.e. terraces) were sampled (Figure 2). The throw trap consisted of a mesh net and an aluminum skirting that is inserted into the mud to prevent organisms from escaping. Once the throw trap was placed, nets were used to remove all organisms from within the trap. Organisms were taken from the throw trap and placed in 95% ethanol. They were taken to TAMU-CC for sorting, identification, and enumeration. Sorting and species identification occurred from September 2015 through February 2016.

Communities of organisms were compared between natural and restored sites using multivariate analysis including analysis of similarity (ANOSIM), SIMPER, and multi-dimensional scaling (MDS) using PRIMER™. The total abundances of grass shrimp, brown shrimp, crabs, fish and the densities of *Spartina* were compared separately between natural and restored areas with one way ANOVA. I also used one way ANOVA to compare *Spartina* densities in Nueces Bay to natural marshes in three other locations: Aransas Wildlife Refuge, Mud Island in Aransas Bay, and Redfish Bay (Figure 3). ANOVAs were performed with the JMP Pro 12.0 statistical program.

Figure 1. Modified throw trap (i.e. drop sampler) used for nekton sampling. Undergraduate volunteers Pam Parnell, Ariana Kavandi, and Tiffany Hawkins are pictured collecting a sample from a natural marsh site.

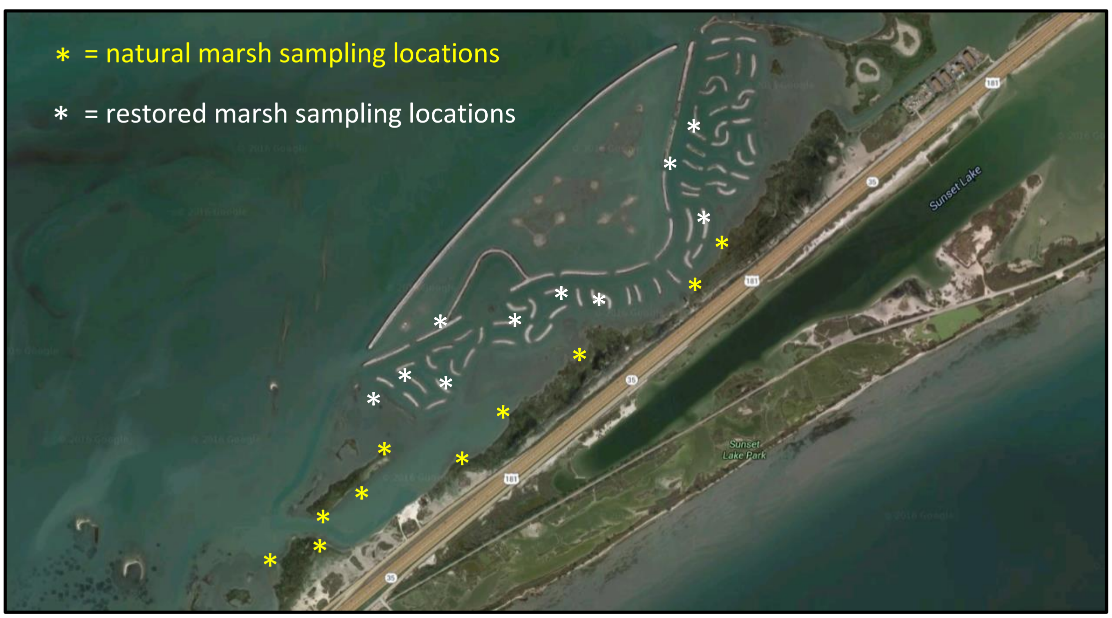
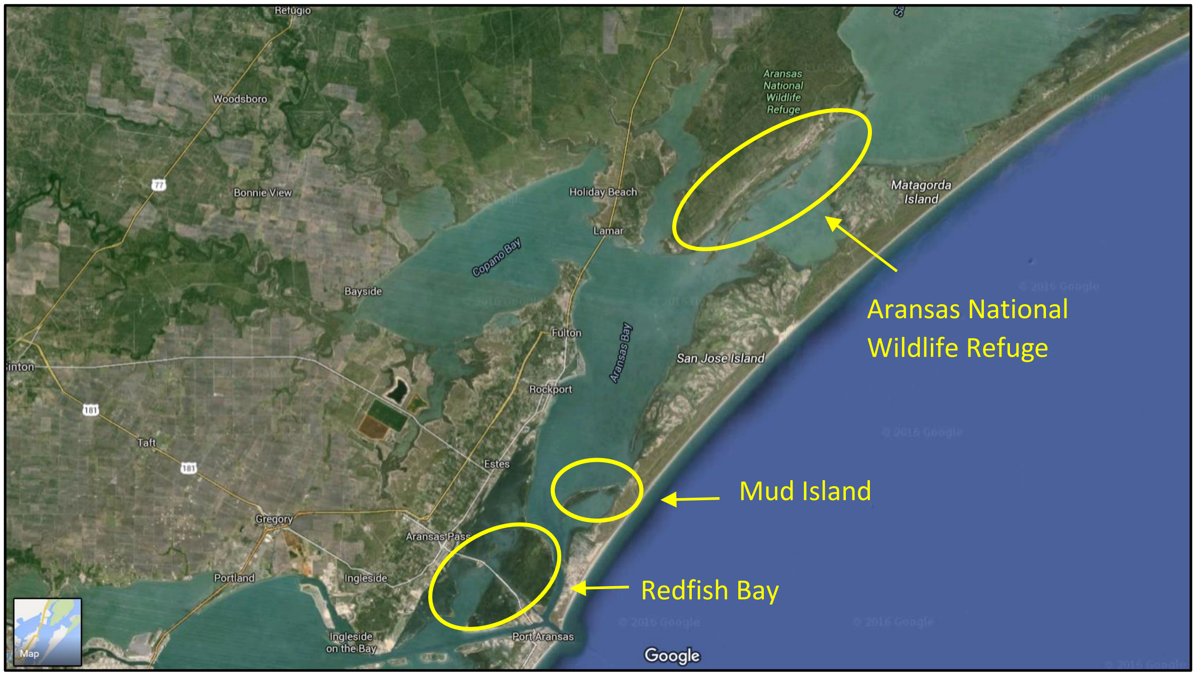


Figure 2. Map of study area with sampling locations indicated.



<u>Figure 3.</u> Locations of *Spartina* shoot density measurements made to compare with those in restored areas of Nueces Bay. Yellow ovals show sampling locations from Redfish Bay, Mud Island, and the Aransas Wildlife Refuge.

Results

ANOSIM indicated that communities between natural and restored marsh sites within Nueces Bay were not significantly different (R = 0.032, p = 0.25). The R value ranges from 0-1, with 1 indicating all variation is explained by a factor (natural vs. restored) and 0 indicated this factor explains no variation among samples. The calculate R value is near 0, further indicating that community differences between natural and restored marsh sites was minimal. Metric MDS further illustrates that natural and restored marsh communities were not different.

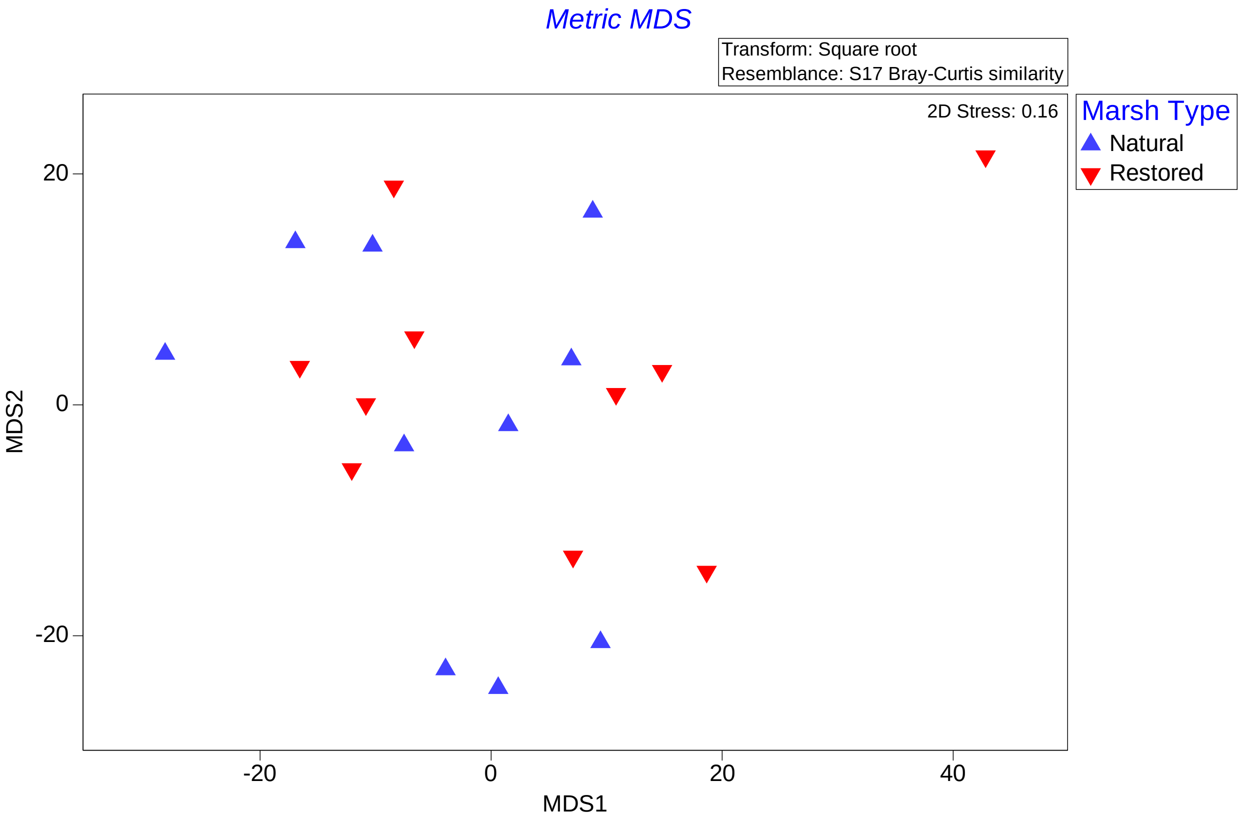


Figure 4. Metric MDS plot showing distances between community samples from natural and restored marsh sites.

I also compared the abundances of four of the most common organisms collected between natural and restored marshes: grass shrimp, brown shrimp, crabs, and fish. Blue crabs (*Callinectes sapidus*) were the only crabs collected. Nearly all the fish collected were naked gobies (*Gobiosoma bosci*). Significant differences in grass shrimp, brown, shrimp, and fish abundance and biomass were not found between natural and restored areas (p>0.2, Table 1). Blue crabs were significantly more abundant and their total biomass significantly higher in natural marsh sites (p< 0.05, Table 1). *Spartina* stem density was 35 and 44 stems m^2 in natural and restored marshes respectively. These values were not significantly different ($F_{1,18} = 2.01$, p = 0.17, Figure 5). Spartina stem density was significantly lower in Nueces Bay natural areas than at Mud Island in Aransas Bay, but, stem density in restored areas was not significantly different from that measured in other natural marsh sites ($F_{4,39} = 2.95$, p = 0.03, Figure 6).

Table 1. ANOVA

Abundance				
Organism Type	DF	Error	F Ratio	P =
Grass Shrimp	1	18	0.07	0.81
Brown Shrimp	1	18	0.07	0.79
Blue Crab	1	18	5.13	0.04*
Fish	1	18	1.62	0.22
Total Abundance	1	18	0.08	0.78
Biomass (g)				
Grass Shrimp	1	18	0.06	0.81
Brown Shrimp	1	18	0.34	0.56
Blue Crab	1	18	7.61	0.01*
Fish	1	18	1.60	0.22
Total biomass	1	18	0.01	0.99

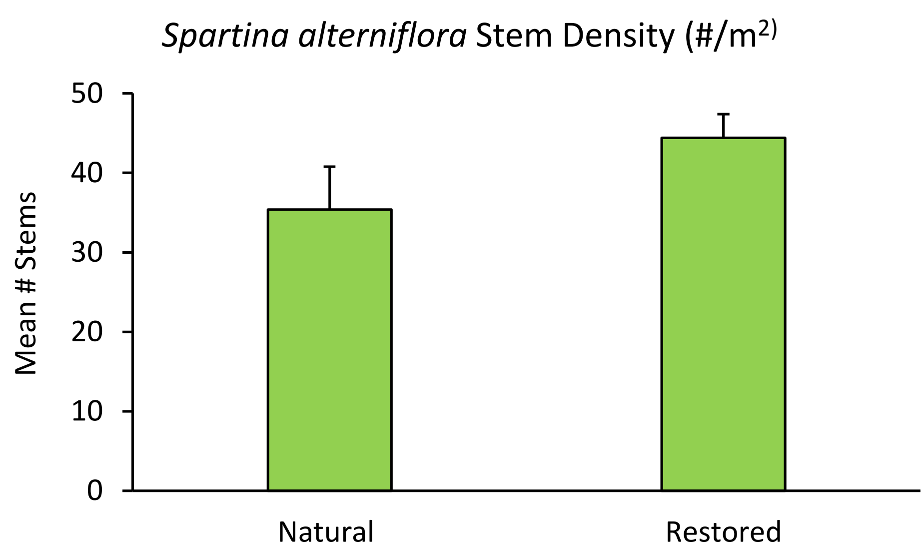


Figure 5. Mean + SE number *Spartina* stems m^2. Significant differences in stem density were not found between natural and restored marsh sites (p = 0.17).

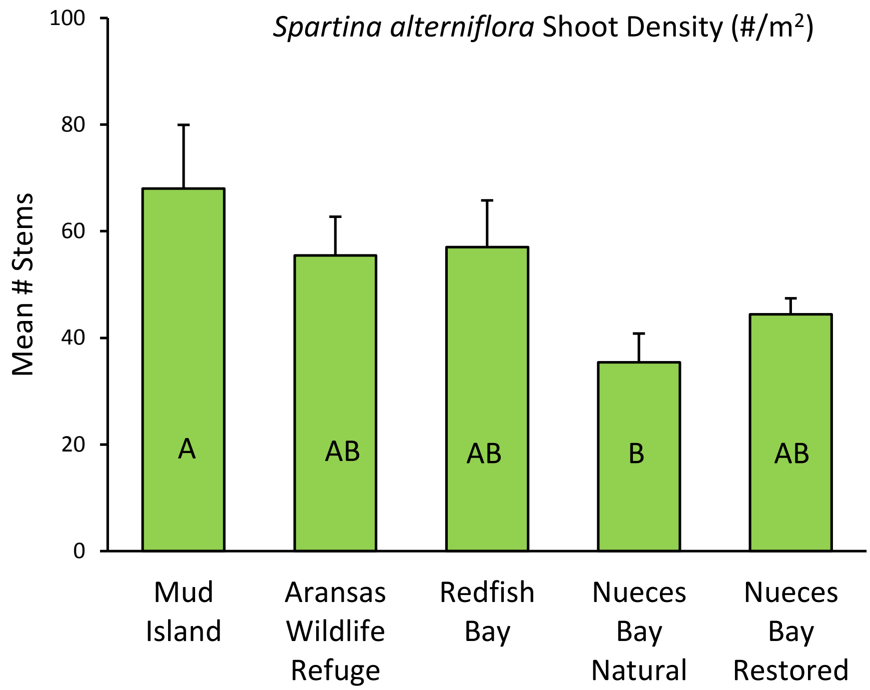


Figure 6. Mean + SE number *Spartina* stems m^2. Significant differences in stem density were found between natural areas in Nueces Bay and Mud Island (in Aransas Bay). Letters denote significant pairwise differences from Tukey-s post hoc test. Stem density in restored sites was not significantly different from other natural marsh areas.

Conclusion

Vegetation density was not significantly different between restored and natural marsh sites in Nueces Bay. *Spartina* density in the restored marsh sites were not significantly different from other natural marsh areas in Texas Coastal Bend including Red Fish Bay, Mud Island in Aransas Bay, and the Aransas Wildlife Refuge. Total faunal abundance and biomass as well as the individual abundances and biomasses of grass shrimp, brown shrimp, and fish were not significantly different between natural and restored marsh sites. Blue crabs were the only organisms found to be significantly different between natural and restored marsh areas and were more abundant in natural marsh sites. Before construction of the mounds and planting of *Spartina*, no vegetation was present in the construction area and nekton was sparse (Smee 2010). My findings show that vegetation and associated fauna are now present this area, and are similar in composition and abundance to adjacent natural marsh areas. Thus, the Nueces Bay Marsh restoration has been successful. Continued evaluation of the site is recommended however to measure ongoing benefits of CBBEP's significant investment in Nueces Bay.

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Appendix I
Abundance of Organisms

Marsh Type	Grass Shrimp	Brown Shrimp	Snapping Shrimp	Mysid Shrimp	Blue Crab	Naked Goby	Gulf Killifish	Sheepshead Minnow	Pipefish	Spotted Seatrout	Gulf Toadfish	Inland Silverside
Natural	94	4	0	0	1	0	0	0	0	0	0	0
Natural	58	9	0	0	1	0	0	0	0	0	0	0
Natural	66	25	0	0	7	1	0	0	0	0	0	0
Natural	85	4	0	0	1	0	0	0	0	0	0	0
Natural	148	42	0	0	14	2	0	0	0	1	0	0
Restored	70	34	0	0	1	4	0	0	0	0	0	0
Restored	130	26	0	0	7	7	0	0	0	0	0	0
Restored	154	13	0	0	7	1	0	0	0	0	0	0
Restored	122	14	0	0	5	4	0	1	0	1	0	0
Restored	193	18	0	0	4	5	0	0	0	1	0	0
Restored	65	24	1	1	2	2	0	0	0	0	0	0
Restored	144	51	3	0	10	8	0	0	0	0	0	0
Restored	58	6	0	0	1	2	0	0	0	0	1	1
Restored	2	17	0	0	1	2	0	0	0	1	0	1
Restored	80	10	0	0	0	3	0	0	0	0	0	0
Natural	109	14	0	0	7	5	2	0	0	0	0	0
Natural	191	10	1	2	18	9	1	0	1	0	0	0
Natural	36	37	0	0	10	3	0	0	0	0	0	0
Natural	225	37	0	0	19	1	0	0	0	0	0	0
Natural	71	14	0	0	17	2	0	0	0	0	0	0

Total Abundance

Marsh Type	Total Abundance	Total Shrimp	Total Crabs	Total Fish	Total Gastropods
Natural	99	98	1	0	2
Natural	68	67	1	0	2
Natural	99	91	7	1	0
Natural	90	89	1	0	0
Natural	207	190	14	3	5
Restored	109	104	1	4	0
Restored	170	156	7	7	2
Restored	175	167	7	1	1
Restored	147	136	5	6	0
Restored	221	211	4	6	0
Restored	95	91	2	2	0
Restored	216	198	10	8	0
Restored	69	64	1	4	1
Restored	24	19	1	4	0
Restored	93	90	0	3	0
Natural	137	123	7	7	1
Natural	233	204	18	11	3
Natural	86	73	10	3	1
Natural	282	262	19	1	1
Natural	104	85	17	2	2

Appendix II
Biomass (g)

Site	Marsh Type	Total	Shrimp	Fish	Blue Crab	Grass Shrimp	Brown Shrimp
1	Natural	19.04	18.74	0	0.3	13.68	5.06
2	Natural	13.62	11.57	0	1.95	8.84	2.78
3	Natural	41.27	38.21	0.11	2.95	15.08	23.08
4	Natural	20.65	20.59	0	0.06	15.52	5.07
5	Natural	57.2	48.99	1.23	6.98	27.05	21.94
6	Restored	26.24	24.48	1.22	0.54	9.9	14.58
7	Restored	52.31	49.29	0.62	2.4	26.79	22.5
8	Restored	44.61	39.81	0.07	4.73	28.63	11.18
9	Restored	39.73	35.56	1.95	2.22	22.12	13.44
10	Restored	67.7	65.14	1.37	1.19	34.59	30.55
11	Restored	32.34	29.18	1.16	2	9.47	19.71
12	Restored	89.7	81.46	5.9	2.34	16.56	64.9
13	Restored	20.33	17.84	1.89	0.3	12.47	5.37
14	Restored	12.82	10.79	1.02	1.01	0.63	10.16
15	Restored	21.34	21.03	0.31	0	10.56	10.47
16	Natural	67.33	60.24	2.01	5.08	32.46	27.78
17	Natural	45.64	33.34	3.39	8.91	24.52	6.24
18	Natural	49.98	43.63	0.62	5.71	8.92	34.95
19	Natural	63.59	54.87	0.07	8.65	25.98	28.46
20	Natural	28.69	18.48	0.07	10.14	10.25	8.23

Appendix III
Spartina Density (# Stems m^2)

Marsh Type	# Stems per m^2
Natural	41
Natural	30
Natural	18
Natural	49
Natural	46
Natural	70
Natural	36
Natural	33
Natural	18
Natural	13
Restored	33
Restored	49
Restored	41
Restored	51
Restored	53
Restored	37
Restored	51
Restored	53
Restored	26
Restored	50