



# Monitoring Salt Marsh Vegetation and Nekton at Gateway National Recreation Area's Sandy Hook Unit

## *2010 Summary Report*

Natural Resource Data Series NPS/NCBN/NRDS—2011/132



**ON THE COVER**

View of salt marsh (Marsh 2) and pier ruins in the northern area of Spermaceti Cove of Sandy Hook Unit, Gateway National Recreation Area.

Photograph by: Robin Baranowski

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Data in this report were collected and analyzed using methods based on established, peer-reviewed protocols and were analyzed and interpreted within the guidelines of the protocols.

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# Contents

|                                                                                | Page |
|--------------------------------------------------------------------------------|------|
| Contents .....                                                                 | iii  |
| Figures.....                                                                   | v    |
| Tables .....                                                                   | vii  |
| Executive Summary .....                                                        | ix   |
| Acknowledgments.....                                                           | xi   |
| Introduction.....                                                              | 1    |
| Methods.....                                                                   | 3    |
| Permanent Site Selection .....                                                 | 3    |
| Nekton Sampling Station Selection and Data Collection .....                    | 3    |
| Vegetation Plot Selection and Data Collection .....                            | 5    |
| Data Summary .....                                                             | 6    |
| <i>Nekton</i> .....                                                            | 6    |
| <i>Vegetation</i> .....                                                        | 6    |
| Results.....                                                                   | 9    |
| Nekton.....                                                                    | 9    |
| Vegetation.....                                                                | 14   |
| Discussion .....                                                               | 17   |
| Nekton.....                                                                    | 17   |
| Vegetation.....                                                                | 17   |
| Literature Cited .....                                                         | 19   |
| Appendix A: Coordinates for nekton station locations at GATE-SHU in 2010.....  | 21   |
| Appendix B: Coordinates for vegetation plot locations at GATE-SHU in 2010..... | 23   |

|                                                                                                           |    |
|-----------------------------------------------------------------------------------------------------------|----|
| Appendix C: Nekton species and community density at GATE-SHU in 2010<br>summarized by site and visit..... | 27 |
| Appendix D: Nekton species richness at GATE-SHU in 2010 summarized by site and<br>visit.....              | 29 |
| Appendix E: Vegetation species observed at GATE-SHU in 2010.....                                          | 31 |

## Figures

Page

|                                                                                                                                                              |   |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------|---|
| <b>Figure 1.</b> Locations of salt marsh monitoring sites established by NCBN at Gateway National Recreation Area's Sandy Hook Unit (GATE-SHU) in 2010. .... | 4 |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------|---|



## Tables

|                                                                                                                                                                                                 | Page |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| <b>Table 1.</b> Sampling dates and total number of nekton sampling stations at two marsh sites at GATE-SHU in 2010. ....                                                                        | 5    |
| <b>Table 2.</b> Sampling dates and total number of vegetation plots sampled at three marsh sites at GATE-SHU in 2010. ....                                                                      | 5    |
| <b>Table 3.</b> Definition of standard cover type categories used in the Northeast Coastal and Barrier Network salt marsh vegetation monitoring protocol .....                                  | 6    |
| <b>Table 4.</b> Modified Braun-Blanquet scale and corresponding midpoint values for determining percent cover of each vegetation species and non-vegetation cover type. ....                    | 7    |
| <b>Table 5.</b> Nekton species and community composition (% catch) at GATE-SHU in 2010.....                                                                                                     | 10   |
| <b>Table 6.</b> Average density and standard deviation [individuals per 1 m <sup>2</sup> ± SD (total count)] of nekton captured at GATE-SHU in 2010. ....                                       | 11   |
| <b>Table 7.</b> Average density and standard deviation [individuals per 1 m <sup>2</sup> ± SD (total count)] of nekton captured for each habitat type at GATE-SHU in 2010. ....                 | 12   |
| <b>Table 8.</b> Average length [mm ± SD (no. measured)] of nekton during each sample visit at GATE-SHU in 2010.....                                                                             | 13   |
| <b>Table 9.</b> Estimated nekton species richness (species richness ± SD) summarized by sampling visit at GATE-SHU in 2010. ....                                                                | 14   |
| <b>Table 10.</b> Average values for physical characteristics [Average ± SD (no. of stations)] at nekton sampling stations at GATE-SHU in 2010. ....                                             | 14   |
| <b>Table 11.</b> Average percent cover (Average percent cover % ± SD), frequency, and relative percent prevalence of each plant species and non-vegetation cover type at GATE-SHU in 2010. .... | 15   |



## Executive Summary

The Northeast Coastal and Barrier Network (NCBN) is one of 32 networks of parks created by the National Park Service (NPS) Inventory and Monitoring Program (I&M Program). The I&M Program has two components, 1) to collect baseline ecological inventory datasets and 2) to implement *Vital Signs* monitoring, a long-term ecological monitoring program, in each of the 32 networks. The Northeast Coastal and Barrier Network consists of eight parks linked by geography and shared ecological characteristics along the Northeastern Atlantic Coast. As part of the I&M Program, each network has developed detailed protocols for monitoring a select number of Vital Signs, or ecological indicators. Because the majority of parks in the NCBN are coastal parks, salt marsh monitoring was chosen as a high priority and protocols were developed for collecting long-term data on salt marsh vegetation and nekton (James-Pirri and Roman In Review-a,b). The objective of monitoring vegetation and nekton is to identify long-term trends in community structure, and to provide resource managers with a better understanding of the current status and condition of the salt marsh resources they manage.

This report summarizes the first year of vegetation and nekton data collected at Gateway National Recreation Area's Sandy Hook Unit (GATE-SHU) in 2010. The salt marsh at GATE-SHU is not very extensive, and therefore a complete sample of all salt marsh habitat was conducted. The marsh was delineated into three monitoring sites ranging from approximately 6.5 to 15 ha in size. Monitoring data will be collected at these sites biennially.

Fifty vegetation plots were sampled at each of the three marsh sites in August of 2010. The percent cover of each vegetation species and non-vegetation cover type within each 1 m<sup>2</sup> plot was visually estimated using a revised Braun-Blanquet method (Kent and Coker 1992). Twenty-eight vegetation species and five non-vegetation cover types were recorded during sampling in 2010. Non-vegetation cover types recorded included wrack & litter, bare ground, rock, water, and trash. *Spartina alterniflora* (salt marsh cordgrass) was by far the most abundant and frequently observed species.

A total of 18 nekton stations were sampled at two marsh sites. The third site was not suitable for nekton sampling. Nekton in marsh pools (Site 3) and large tidal creeks (Site 1) were sampled with a 1m<sup>2</sup> aluminum throw trap (Kushlan 1981, Sogard & Able 1991, Raposa and Roman 2001). A total of 12 species of nekton were recorded at GATE-SHU in 2010, including eight fish species, two crab species, and two shrimp species. Examination of percent catch data indicates that two species account for approximately 95% of all nekton captured. The most prevalent species, *Fundulus heteroclitus* (common mummichog), accounts for approximately 59% of all nekton recorded at GATE-SHU in 2010. The second most common species, *Menidia menidia* (Atlantic silverside), accounts for approximately 25% of all nekton recorded and was much more abundant in June than in August. *Palaemonetes pugio* (daggerblade grass shrimp) accounts for approximately 11% of all nekton recorded and was more abundant in August. Substantial differences in abundances and species composition between the two sampling visits are to be expected and reinforce our decision to sample nekton twice during the summer.



## **Acknowledgments**

We would like to thank Charles T. Roman and Mary-Jane James-Pirri for the development of the salt marsh monitoring protocols and Dennis Skidds for his work on the salt marsh monitoring database and data management support. We would also like to thank the 2010 field crew members, Robin Baranowski, Zachary Bourassa, Daphne Forster, Brandon Haynes, and Casey Nolan, for their hard work and, of course, the staff at Sandy Hook for providing support to the NCBN field crew.

## Introduction

National Park Service (NPS) managers need accurate information about how, when and why natural systems change over time in order to make sound management decisions. To address this need, the NPS initiated natural resource monitoring through the Natural Resource Challenge funded by Congress in 2000. The Inventory and Monitoring Program (I&M), the key component of this effort, organizes 270 park units into 32 networks tasked with conducting long-term ecological monitoring. Networks were required to develop a monitoring plan addressing the implementation of long-term monitoring of key ecological indicators or “vital signs.” Vital signs are defined as measurable, early warning signals that may indicate change in the long-term health of natural systems. Early detection of potential problems allows park managers to take steps in restoring or maintaining ecological health of park resources.

The Northeast Coastal and Barrier Network (NCBN) is made up of eight parks: Assateague Island National Seashore (ASIS, coastal Maryland and Virginia), Thomas Stone National Historic Site (THST, Charles County, MD), Cape Cod National Seashore (CACO, Cape Cod, MA), Gateway National Recreation Area (GATE, New York, NY and Sandy Hook, NJ), Fire Island National Seashore (FIIS, Long Island, NY), Sagamore Hill National Historic Site (SAHI, Oyster Bay, NY), Colonial National Historical Park (COLO, Virginia Peninsula), and George Washington Birthplace National Monument (GEWA, Westmoreland County, VA). Vital Signs chosen as part of the Network’s monitoring plan include salt marsh vegetation communities, nekton communities, essential estuarine water quality parameters and specific coastal geomorphologic features (Stevens et al. 2005). Detailed monitoring protocols have been developed and implemented in the eight parks. This annual report summarizes salt marsh vegetation and nekton community data collected at Gateway National Recreation Area’s Sandy Hook Unit (GATE-SHU) in 2010 according to two protocols developed by James-Pirri and Roman, *Monitoring Nekton in Salt Marshes: A Protocol for the National Park Service’s Long-Term Monitoring Program, Northeast Coastal and Barrier Network* and *Monitoring Salt Marsh Vegetation: A Protocol for the National Park Service’s Long-Term Monitoring Program, Northeast Coastal and Barrier Network* (In Review-a,b).

The objective of salt marsh monitoring is to identify long-term trends in community structure, which will provide a better understanding of the current status and condition of salt marsh within the parks. Because salt marshes are located in coastal areas and many of the plant species are sensitive to subtle changes in soil salinity and saturation, changes in the percent cover and prevalence of some species will be important primary indicators of change in salt marsh condition. Trends in the percent cover and prevalence of bare ground and water will also provide information about changes in the overall condition of the salt marsh and whether or not it may transition to mud flat due to climate change (*e.g.*, sea level rise, changes in temperature). Long-term monitoring data will provide park managers with the scientific data they need to make informed decisions regarding the management and continued protection of this rare and valuable coastal resource.



## Methods

### Permanent Site Selection

The salt marsh at GATE-SHU is not very extensive, and therefore a complete sample of all salt marsh habitat was conducted. The marsh was delineated into three permanent monitoring sites (Figure 1). Detailed information about the site selection process and sampling design can be found in the salt marsh monitoring protocols (James-Pirri and Roman In Review-a,b).

Vegetation sampling was conducted at all three sites. Nekton sampling was only conducted at Sites 1 and 3, due to lack of appropriate habitat at Site 2. Vegetation and nekton data will be collected at each site on a biennial basis.

### Nekton Sampling Station Selection and Data Collection

Six nekton sampling stations were established within pools at Site 3, and 12 nekton stations were established along the creek at Site 1. All sampling stations were randomly located along the perimeter of a pool or the length of the creek so that inference can apply to all fishable water within each site and can be biologically extended to the park as a whole. Nekton stations were sampled twice, once in early summer (late June) and once in late summer (mid August) (Table 1). Universal Transverse Mercator (UTM) coordinates for each station are provided in Appendix A.

Nekton in marsh pools and creeks less than 1 m deep were sampled with a 1 m<sup>2</sup> aluminum throw trap (Kushlan 1981, Sogard and Able 1991, Raposa and Roman 2001). The throw trap is an enclosure sampler that has excellent capture efficiency and provides quantitative, repeatable results (Rozas and Minello 1997). The trap has an open top and bottom, is 0.5 m in height and 1m square, and the sides are covered with 3 mm (1/8 in) wire mesh. All nekton were collected from the trap with a 1 mm mesh dip net that fit snugly within the opposite sides of the trap.

All fish and decapods were identified and enumerated. A representative number (up to 15 individuals) of each species collected was measured for length (fish – total length; crabs – carapace width; shrimp – total length). Once identified and measured, all organisms were returned to the location from which they were collected.



**Figure 1.** Locations of salt marsh monitoring sites established by NCBN at Gateway National Recreation Area's Sandy Hook Unit (GATE-SHU) in 2010. These three sites will be monitored biennially.

**Table 1.** Sampling dates and total number of nekton sampling stations at two marsh sites at GATE-SHU in 2010. Sampling stations are displayed by habitat type.

| Site | Visit | Dates                | Habitat     |              | Total |
|------|-------|----------------------|-------------|--------------|-------|
|      |       |                      | Tidal Creek | Pool / Panne |       |
| 1    | 1     | 6/29/2010, 6/30/2010 | 12          | 0            | 12    |
|      | 2     | 8/17/2010            | 11          | 0            | 11    |
| 3    | 1     | 6/29/2010, 6/30/2010 | 0           | 6            | 6     |
|      | 2     | 8/17/2010, 8/18/2010 | 0           | 6            | 6     |

### **Vegetation Plot Selection and Data Collection**

Vegetation was sampled in 1 m<sup>2</sup> plots randomly located within each marsh. Transects—extending from creek bank to upland—were systematically placed throughout the site based on a single random start. Plots were then randomly located by treating all transects as a single transect and randomly selecting 50 points along this total length. This combination of systematic transects and replicate plots is necessary to ensure interspersions of the plots throughout the marsh study area, thus providing a representative sample of all salt marsh communities (*e.g.*, low marsh, high marsh).

Vegetation sampling was conducted at GATE-SHU in August 2010 (Table 2). Fifty, 1 m<sup>2</sup> plots were sampled at each site. Each plot was visited once during the summer. For each plot, all vegetation species and non-vegetation cover types were recorded (Table 3), and the estimated percent cover was visually estimated using a modified Braun-Blanquet cover scale (0: 0%; 1: <1%; 2: 1-5%; 3: 6-25%; 4: 26-50%; 5: 51-75%; 6: 76-100%), (Kent and Coker 1992).

**Table 2.** Sampling dates and total number of vegetation plots sampled at three marsh sites at GATE-SHU in 2010.

| Site | Dates                | Total |
|------|----------------------|-------|
| 1    | 8/18/2010            | 50    |
| 2    | 8/17/2010            | 50    |
| 3    | 8/17/2010, 8/18/2010 | 50    |

**Table 3.** Definition of standard cover type categories used in the Northeast Coastal and Barrier Network salt marsh vegetation monitoring protocol (James-Pirri and Roman In Review-b).

|                                            |                                                                                                                                                                                                                                                                                                                                                                                                               |
|--------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Live vascular plants</b>                | Identified by species (herbaceous and shrubs).                                                                                                                                                                                                                                                                                                                                                                |
| <b>Standing non-living vascular plants</b> | Identified by species (e.g., <i>S. alterniflora</i> Not Living). This category only includes standing dead (attached) plants that are from a previous year's growth. There may be some dead leaves from this year's growth (e.g., the ends of leaves or leaves that are being replaced by new growth, etc.). In cases where dead leaves are from the current growing season, plant cover is recorded as live. |
| <b>Macroalgae</b>                          | Identified by species. This category generally includes the rockweeds (e.g., <i>Fucus</i> , <i>Ascophyllum</i> ). Microalgae (e.g., diatom mats) and fine filamentous algae are not included in this category.                                                                                                                                                                                                |
| <b>Bare ground</b>                         | Includes mud, sand, microalgae cover, etc. These are areas that are not flooded with water and are devoid of standing live, standing dead, or macroalgae. There can be a thin film of surface water within the bare ground category.                                                                                                                                                                          |
| <b>Water</b>                               | Permanent standing water is identified in plots that are partly within a creek, ditch, marsh pool, or flooded panne.                                                                                                                                                                                                                                                                                          |
| <b>Wrack/litter</b>                        | Wrack is material that has floated into the plot. This is generally dead (not attached) plant material, but could also be trash. Litter is dead plant material that is highly decomposed and is no longer attached.                                                                                                                                                                                           |
| <b>Trash</b>                               | Items such as logs, old piers, tires, etc.                                                                                                                                                                                                                                                                                                                                                                    |
| <b>Rock</b>                                | Boulders or rocks can be found on the surface of northern New England marshes.                                                                                                                                                                                                                                                                                                                                |

## Data Summary

### ***Nekton***

Species composition, average density, average length of nekton, and standard deviations were all calculated using standard formulae. The same is true of the average values of the physical characteristics calculated for each habitat type during each visit. Details can be found in the Analysis and Reporting Standard Operating Procedure of James-Pirri et al. (In Review-a). Species richness was calculated using the algorithm described in Heltshe and Forester (1983). An explanation and example of using the algorithm is provided in the Analysis and Reporting Standard Operating Protocol of James-Pirri et al. (In Review-a).

### ***Vegetation***

Vegetation data were recorded using the modified Braun-Blanquet scale as described above (Kent and Coker 1992). For summary purposes, each Braun-Blanquet value was converted to the midpoint of the percent range it represented (Table 4) as described in Wikum and Shanholtzer (1978).

**Table 4.** Modified Braun-Blanquet scale and corresponding midpoint values for determining percent cover of each vegetation species and non-vegetation cover type.

| BB Value | Percent Cover | Midpoint |
|----------|---------------|----------|
| 0        | 0%            | 0%       |
| 1        | < 1%          | 0.50%    |
| 2        | 1 - 5%        | 3%       |
| 3        | 6 - 25%       | 15.50%   |
| 4        | 26 - 50%      | 38%      |
| 5        | 51 - 75%      | 63%      |
| 6        | 76 - 100%     | 88%      |

Wikum and Shanholtzer (1978) outline a method for calculating an importance value for each species. So as not to confuse this value with ecological importance, we rename it a ‘relative prevalence’ value. The calculation is essentially identical to that described in Wikum and Shanholtzer’s publication. Although Wikum and Shanholtzer (1978) present their importance value as a sum of the percent frequency and percent cover values, this report takes the average of these values so that relative prevalence is on a more readily interpretable percent scale. We estimated the relative percent prevalence for each species and non-vegetation cover type present, which is equal to the average of the relative percent cover and the relative percent frequency.

Relative percent cover is the percentage of all plots that each species covers relative to all other species present in the plots. The sum of all relative percent cover values for all species and non-vegetation cover types equals 100%. Relative percent frequency is the number of plots where each species is present, relative to all other species observed in the plots. The sum of the relative percent frequency values for all species and non-vegetation cover type equals 100%. Appendix E provides the frequency (number of plots) of each species observed at each marsh in 2010.

Taking the average of the relative percent cover and the relative percent frequency gives the *relative percent prevalence* for each species and non-vegetation cover type. Because the relative percent prevalence incorporates both percent frequency and percent cover, it is likely to differ substantially from the average percent cover for a given species or non-vegetation cover type. The relative percent prevalence of a species provides information about how a species is distributed (*i.e.*, its ‘patchiness’) throughout the salt marsh. We also report the average percent cover of each species for all plots combined.

Lastly, if any vegetation species observed in the plots are listed by the United States Department of Agriculture (USDA), or the State of New Jersey as exotic, invasive, threatened, endangered, or rare, these species are noted in the vegetation table. Individual plots that were found to contain a species listed as exotic, invasive, threatened, endangered, or rare, will be noted in Appendix B, which includes a table of all vegetation plots and their respective Universal Transverse Mercator (UTM) coordinates. Information about plants listed by each state as exotic, invasive, threatened, endangered, or rare is available online (USDA 2010). In some cases, more specific information may be available on state websites. Information about plants listed by the State of New Jersey as exotic or invasive is available online (New Jersey Natural Heritage Program).



## Results

### Nekton

Twelve nekton species consisting of eight fish and four decapod species were captured at GATE-SHU during the summer of 2010 at two marsh sites. Examination of nekton species and composition (% catch) indicates that two fish species, *Fundulus heteroclitus* and *Menidia menidia*, account for approximately 84% of all nekton recorded during summer sampling at GATE-SHU in 2010 (Table 5). Community composition percentages show that fish comprised approximately 97% and 66% of all nekton caught during visit 1 and visit 2, respectively. Decapods comprised approximately 3% of all nekton caught during visit 1 and approximately 34% during visit 2.

The average density of each species and community for each sampling visit is presented in Table 6. *F. heteroclitus* had the highest density of all species captured in 2010, with *Menidia menidia* following respectively. A majority of the species were present in larger numbers during the first sampling visit (June), with the exception of *Palaemonetes pugio* which had a total number of individuals approximately six times higher in August than in June. Differences between sampling visits are expected, and this is the primary reason for sampling the nekton community twice each summer. Species and community densities for each sampling visit at each site are presented in Appendix C.

Species and community density summarized by sampling visit and habitat type (pool or creek) are shown in Table 7. While the most frequently observed species were present in both pool and creek stations, there were a few species that were only observed in one habitat. For example, *Apeltes quadracus* (fourspine stickleback) were present in relatively low numbers during both visits, but were only present in pool stations at Site 3. Other species, such as *Anguilla rostrata* (American eel) were only observed in the tidal creek at Site 1. Differences between habitat types are to be expected due to habitat preferences of individual species (*e.g.*, sand vs. mud). Average length of each species, is summarized in Table 8.

Calculating species richness provided additional information about the two sampling visits. There was a decrease in species richness from visit 1 to visit 2 (Table 9). While the number of species observed between visits did not change drastically, there were a few differences in the species observed during each visit (Table 5). Species richness summarized by site and visit can be found in Appendix D.

Physical characteristics of nekton sampling stations were recorded during each visit. These measures provide limited insight into differences between habitats and visits that may affect nekton (Table 10). Currently, these data are collected to help explain anomalies in nekton observed at a particular location during a specific visit (*e.g.*, presence/absence of a particular species). These parameters would need to be measured over the course of the field season in order to lend any real insight into observed changes in the nekton community.

**Table 5.** Nekton species and community composition (% catch) at GATE-SHU in 2010. Data are shown for each visit separately and both visits combined. n = total number of nekton caught during that visit. ‘-’ indicates species was not present.

| Community/Species            | Common Name              | Community/Species Composition (%) |                       |                            |
|------------------------------|--------------------------|-----------------------------------|-----------------------|----------------------------|
|                              |                          | Visit 1<br>(n = 3339)             | Visit 2<br>(n = 1465) | Visits 1 & 2<br>(n = 4804) |
| <b>Fish</b>                  |                          | <b>96.6</b>                       | <b>66.1</b>           | <b>87.3</b>                |
| <i>Fundulus heteroclitus</i> | Common mummichog         | 57.4                              | 61.8                  | 58.7                       |
| <i>Menidia menidia</i>       | Atlantic silverside      | 34.7                              | 2.7                   | 25.0                       |
| <i>Fundulus majalis</i>      | Striped killifish        | 3.5                               | 0.8                   | 2.7                        |
| <i>Mugil cephalus</i>        | Striped mullet           | 0.7                               | 0.1                   | 0.5                        |
| <i>Apeltes quadracus</i>     | Fourspine stickleback    | 0.3                               | 0.3                   | 0.3                        |
| <i>Gobiidae</i> species      | Goby species             | -                                 | 0.3                   | 0.1                        |
| <i>Anguilla rostrata</i>     | American eel             | 0.1                               | -                     | < 0.05                     |
| <i>Cyprinodon variegatus</i> | Sheepshead minnow        | 0.1                               | -                     | < 0.05                     |
| <b>Decapods</b>              |                          | <b>3.4</b>                        | <b>33.9</b>           | <b>12.7</b>                |
| <i>Palaemonetes pugio</i>    | Daggerblade grass shrimp | 2.2                               | 31.3                  | 11.1                       |
| <i>Callinectes sapidus</i>   | Blue crab                | 1.0                               | 1.3                   | 1.1                        |
| <i>Crangon septemspinosa</i> | Sand shrimp              | -                                 | 1.4                   | 0.4                        |
| <i>Xanthidae</i> species     | Mud crab species         | 0.1                               | -                     | < 0.05                     |

**Table 6.** Average density and standard deviation [individuals per 1 m<sup>2</sup> ± SD (total count)] of nekton captured at GATE-SHU in 2010. n = number of nekton stations sampled. The difference in the number of stations sampled between visits was due to one station being dry. '-' indicates species was not present.

| Community/Species            | Common Name              | Average Density<br>[individuals per 1 m <sup>2</sup> ± SD (total count)] |                            |                             |
|------------------------------|--------------------------|--------------------------------------------------------------------------|----------------------------|-----------------------------|
|                              |                          | Visit<br>(n = 18)                                                        | Visit 2<br>(n = 17)        | Visits 1 & 2<br>(n = 18)    |
| <b>Fish</b>                  |                          | <b>179.3 ± 326.1 (3227)</b>                                              | <b>56.9 ± 125.6 (968)</b>  | <b>119.9 ± 253.9 (4195)</b> |
| <i>Fundulus heteroclitus</i> | Common mummichog         | 106.4 ± 214.9 (1915)                                                     | 53.2 ± 125.1 (905)         | 80.6 ± 176.6 (2820)         |
| <i>Menidia menidia</i>       | Atlantic silverside      | 64.4 ± 251.9 (1160)                                                      | 2.4 ± 4.0 (40)             | 34.3 ± 180.9 (1200)         |
| <i>Fundulus majalis</i>      | Striped killifish        | 6.4 ± 23.7 (116)                                                         | 0.7 ± 2.2 (12)             | 3.7 ± 17 (128)              |
| <i>Mugil cephalus</i>        | Striped mullet           | 1.2 ± 4.7 (22)                                                           | 0.1 ± 0.3 (2)              | 0.7 ± 3.4 (24)              |
| <i>Apeltes quadracus</i>     | Fourspine stickleback    | 0.6 ± 2.4 (10)                                                           | 0.3 ± 0.8 (5)              | 0.4 ± 1.8 (15)              |
| <i>Gobiidae</i> species      | Goby species             | -                                                                        | 0.2 ± 0.7 (4)              | 0.1 ± 0.5 (4)               |
| <i>Anguilla rostrata</i>     | American eel             | 0.1 ± 0.5 (2)                                                            | -                          | 0.1 ± 0.3 (2)               |
| <i>Cyprinodon variegatus</i> | Sheepshead minnow        | 0.1 ± 0.5 (2)                                                            | -                          | 0.1 ± 0.3 (2)               |
| <b>Decapods</b>              |                          | <b>6.2 ± 12.7 (112)</b>                                                  | <b>29.2 ± 32.8 (497)</b>   | <b>17.4 ± 26.9 (609)</b>    |
| <i>Palaemonetes pugio</i>    | Daggerblade grass shrimp | 4.2 ± 12.2 (75)                                                          | 26.9 ± 33.3 (458)          | 15.2 ± 27 (533)             |
| <i>Callinectes sapidus</i>   | Blue crab                | 1.9 ± 3.2 (35)                                                           | 1.1 ± 1.2 (19)             | 1.5 ± 2.4 (54)              |
| <i>Crangon septemspinosa</i> | Sand shrimp              | -                                                                        | 1.2 ± 2.5 (20)             | 0.6 ± 1.8 (20)              |
| <i>Xanthidae</i> species     | Mud crab species         | 0.1 ± 0.3 (2)                                                            | -                          | 0.1 ± 0.2 (2)               |
| <b>Total Nekton</b>          |                          | <b>185.5 ± 334.2 (3339)</b>                                              | <b>86.2 ± 124.2 (1465)</b> | <b>137.3 ± 256.2 (4804)</b> |

**Table 7.** Average density and standard deviation [individuals per 1 m<sup>2</sup> ± SD (total count)] of nekton captured for each habitat type at GATE-SHU in 2010. n = number of nekton stations sampled. One creek station was dry during visit 2. '-' indicates species was not present.

| Community/Species            | Common Name              | Average Density [individuals per 1 m <sup>2</sup> ± SD (total count)] |                             |                          |                             |
|------------------------------|--------------------------|-----------------------------------------------------------------------|-----------------------------|--------------------------|-----------------------------|
|                              |                          | Visit 1                                                               |                             | Visit 2                  |                             |
|                              |                          | Pool<br>(n = 6)                                                       | Tidal Creek<br>(n = 12)     | Pool<br>(n = 6)          | Tidal Creek<br>(n = 11)     |
| <b>Fish</b>                  |                          | <b>224.2 ± 424.7 (1345)</b>                                           | <b>156.8 ± 284.2 (1882)</b> | <b>17.2 ± 29.2 (103)</b> | <b>78.6 ± 152.9 (865)</b>   |
| <i>Fundulus heteroclitus</i> | Common mummichog         | 28.5 ± 43.8 (171)                                                     | 145.3 ± 256.0 (1744)        | 13.7 ± 25.8 (82)         | 74.8 ± 152.5 (823)          |
| <i>Menidia menidia</i>       | Atlantic silverside      | 192.0 ± 431.8 (1152)                                                  | 0.7 ± 1.8 (8)               | 1.3 ± 2.8 (8)            | 2.9 ± 4.5 (32)              |
| <i>Fundulus majalis</i>      | Striped killifish        | 1.7 ± 2.4 (10)                                                        | 8.8 ± 29 (106)              | 0.5 ± 0.5 (3)            | 0.8 ± 2.7 (9)               |
| <i>Mugil cephalus</i>        | Striped mullet           | -                                                                     | 1.8 ± 5.7 (22)              | 0.2 ± 0.4 (1)            | 0.1 ± 0.3 (1)               |
| <i>Apeltes quadracus</i>     | Fourspine stickleback    | 1.7 ± 4.1 (10)                                                        | -                           | 0.8 ± 1.2 (5)            | -                           |
| Gobiidae species             | Goby species             | -                                                                     | -                           | 0.7 ± 1.0 (4)            | -                           |
| <i>Anguilla rostrata</i>     | American eel             | -                                                                     | 0.2 ± 0.6 (2)               | -                        | -                           |
| <i>Cyprinodon variegatus</i> | Sheepshead minnow        | 0.3 ± 0.8 (2)                                                         | -                           | -                        | -                           |
| <b>Decapods</b>              |                          | <b>13.3 ± 20.3 (80)</b>                                               | <b>2.7 ± 4.3 (32)</b>       | <b>32.2 ± 37.8 (193)</b> | <b>27.6 ± 31.6 (304)</b>    |
| <i>Palaemonetes pugio</i>    | Daggerblade grass shrimp | 12.2 ± 19.7 (73)                                                      | 0.2 ± 0.4 (2)               | 28.2 ± 40.3 (169)        | 26.3 ± 31.0 (289)           |
| <i>Callinectes sapidus</i>   | Blue crab                | 1.2 ± 1.0 (7)                                                         | 2.3 ± 3.8 (28)              | 0.7 ± 0.8 (4)            | 1.4 ± 1.3 (15)              |
| <i>Crangon septemspinosa</i> | Sand shrimp              | -                                                                     | -                           | 3.3 ± 3.4 (20)           | -                           |
| Xanthidae species            | Mud crab species         | -                                                                     | 0.2 ± 0.4 (2)               | -                        | -                           |
| <b>Total Nekton</b>          |                          | <b>237.5 ± 444.1 (1425)</b>                                           | <b>159.5 ± 284.1 (1914)</b> | <b>49.3 ± 58.1 (296)</b> | <b>106.3 ± 147.4 (1169)</b> |

**Table 8.** Average length [mm  $\pm$  SD (no. measured)] of nekton during each sample visit at GATE-SHU in 2010. Length data for each species was summarized over all stations sampled during each visit. '-' indicates that a species was not present.

|                              |                          | Average Length [mm ± SD (no. measured)] |                   |                   |
|------------------------------|--------------------------|-----------------------------------------|-------------------|-------------------|
| Community/Species            | Common Name              | Visit 1                                 | Visit 2           | Visits 1 & 2      |
| Fish                         |                          |                                         |                   |                   |
| <i>Anguilla rostrata</i>     | American eel             | 78.0 ± 4.2 (2)                          | -                 | 78.0 ± 4.2 (2)    |
| <i>Apeltes quadracus</i>     | Fourspine stickleback    | 23.1 ± 8.7 (9)                          | 30.4 ± 2.1 (5)    | 25.7 ± 7.8 (14)   |
| <i>Cyprinodon variegatus</i> | Sheepshead minnow        | 30.0 ± 1.4 (2)                          | -                 | 30.0 ± 1.4 (2)    |
| <i>Fundulus heteroclitus</i> | Common mummichog         | 24.3 ± 15.1 (238)                       | 34.6 ± 13.7 (153) | 28.4 ± 15.4 (391) |
| <i>Fundulus majalis</i>      | Striped killifish        | 25.7 ± 7.7 (29)                         | 40.6 ± 8.2 (12)   | 30.0 ± 10.3 (41)  |
| <i>Gobiidae</i> species      | Goby species             | -                                       | 26.8 ± 3.8 (4)    | 26.8 ± 3.8 (4)    |
| <i>Menidia menidia</i>       | Atlantic silverside      | 22.6 ± 8.8 (38)                         | 40.3 ± 15.1 (38)  | 31.5 ± 15.2 (76)  |
| <i>Mugil cephalus</i>        | Striped mullet           | 65.2 ± 19.1 (18)                        | 88.0 ± 2.8 (2)    | 67.5 ± 19.4 (20)  |
| Decapods                     |                          |                                         |                   |                   |
| <i>Callinectes sapidus</i>   | Blue crab                | 37.2 ± 26.3 (35)                        | 63.9 ± 33.9 (19)  | 46.6 ± 31.6 (54)  |
| <i>Crangon septemspinosa</i> | Sand shrimp              | -                                       | 24.5 ± 4.8 (19)   | 24.5 ± 4.8 (19)   |
| <i>Palaemonetes pugio</i>    | Daggerblade grass shrimp | 35.5 ± 6.9 (34)                         | 25.1 ± 7.5 (155)  | 27 ± 8.4 (189)    |
| <i>Xanthidae</i> species     | Mud crab species         | 12.5 ± 7.8 (2)                          | -                 | 12.5 ± 7.8 (2)    |

**Table 9.** Estimated nekton species richness (species richness  $\pm$  SD) summarized by sampling visit at GATE-SHU in 2010. One station was dry during visit 2.

| Visit | No. of Stations | Observed No. of Species | Est. Species Richness $\pm$ SD |
|-------|-----------------|-------------------------|--------------------------------|
| 1     | 18              | 10                      | 12.8 $\pm$ 2.1                 |
| 2     | 17              | 9                       | 9.0                            |
| 1 & 2 | 18              | 12                      | 13.9 $\pm$ 1.3                 |

**Table 10.** Average values for physical characteristics [Average  $\pm$  SD (no. of stations)] at nekton sampling stations at GATE-SHU in 2010. Not all parameters were measured all at stations. Data are summarized over Site 1 and 2 for each habitat type within each visit separately.

|                             | Average $\pm$ SD (no. of stations) |                      |                    |                      |
|-----------------------------|------------------------------------|----------------------|--------------------|----------------------|
|                             | Visit 1                            |                      | Visit 2            |                      |
|                             | Pool                               | Tidal Creek          | Pool               | Tidal Creek          |
| Depth (cm)                  | 26.2 $\pm$ 14.9 (6)                | 28.1 $\pm$ 11.2 (12) | 37.5 $\pm$ 4.8 (6) | 29.8 $\pm$ 13.2 (11) |
| Temperature ( $^{\circ}$ C) | 24.4 $\pm$ 3.2 (6)                 | 26.4 $\pm$ 4.1 (12)  | 25.0 $\pm$ 1.5 (6) | 26.7 $\pm$ 3.2 (10)  |
| Salinity (ppt)              | 23.4 $\pm$ 0.4 (6)                 | 23.7 $\pm$ 0.6 (12)  | 26.5 $\pm$ 0.8 (6) | 24.8 $\pm$ 1.3 (10)  |
| Dissolved Oxygen (mg/L)     | 3.4 $\pm$ 1.5 (6)                  | 4.4 $\pm$ 2.5 (12)   | -                  | 3.0 $\pm$ 1.5 (4)    |

## Vegetation

Twenty-eight vegetation species and five non-vegetation cover types (bare ground, water, rock, trash, wrack and litter) were recorded at three marsh sites at GATE-SHU in 2010 (Table 11). The average percent cover and the relative percent prevalence of each species or non-vegetation cover type are shown in Table 11.

Data are sorted by average percent cover of living vegetation species. Average percent cover of non-living vegetation (if present) is also shown for each species. As explained in the Data Summary section, the relative percent prevalence combines information about how much area each species covers relative to all other species present, and how frequently it appears throughout the sites relative to all others present. The species with the highest living percent cover, *S. alterniflora*, dwarfs the percent cover of all other species at 30.3  $\pm$  38.9, but its relative percent prevalence of 23.4, while still high, is substantially lower. This is an indication that *S. alterniflora* is present in large patches as opposed to being well dispersed throughout all of the sites. The number of plots (frequency) that each species was present in is provided in Appendix E.

None of the vegetation species observed in the 2010 plots are federally listed by the USDA as exotic, invasive, threatened, endangered, or rare (USDA 2010). None of the vegetation species are listed by the State of New Jersey as rare, exotic, or invasive (New Jersey Natural Heritage Program).

**Table 11.** Average percent cover (Average percent cover %  $\pm$  SD), frequency, and relative percent prevalence of each plant species and non-vegetation cover type at GATE-SHU in 2010. Data were summarized over all 150 plots. Percent cover was estimated using the midpoint values of Braun-Blanquet percent ranges (Table 4). (NL) indicates standing non-living vegetation. <sup>+</sup> *Salicornia europea*, an invalid synonym was used on the field data sheet; the accepted synonym *Salicornia maritima* was retrieved from the ITIS database (December 2010).

| Species/Cover Type                 | Common Name                | Average Cover % $\pm$ SD | Frequency | Relative Prevalence % |
|------------------------------------|----------------------------|--------------------------|-----------|-----------------------|
| <i>Spartina alterniflora</i>       | Salt marsh cordgrass       | 30.3 $\pm$ 38.9          | 64        | 23.4                  |
| <i>S. alterniflora</i> (NL)        | Salt marsh cordgrass (NL)  | 1.8 $\pm$ 7.2            | 14        | 2.8                   |
| Water                              | Water                      | 21.4 $\pm$ 37.2          | 40        | 15.8                  |
| Bare ground                        | Bare ground                | 14.5 $\pm$ 28.8          | 43        | 12.9                  |
| Wrack/Litter                       | Wrack/Litter               | 10.3 $\pm$ 18.7          | 81        | 16.1                  |
| <i>Spartina patens</i>             | Salt meadow cordgrass      | 6.4 $\pm$ 20.9           | 21        | 6.0                   |
| <i>S. patens</i> (NL)              | Salt meadow cordgrass (NL) | 2.2 $\pm$ 12.1           | 7         | 2.0                   |
| <i>Iva frutescens</i>              | Marsh elder                | 4.3 $\pm$ 18.0           | 12        | 3.7                   |
| <i>I. frutescens</i> (NL)          | Marsh elder (NL)           | 0.2 $\pm$ 1.8            | 3         | 0.5                   |
| <i>Distichlis spicata</i>          | Distichlis spicata         | 3.3 $\pm$ 14.0           | 11        | 3.1                   |
| <i>D. spicata</i> (NL)             | Distichlis spicata (NL)    | 0.1 $\pm$ 1.3            | 1         | 0.2                   |
| <i>Ulva lactuca</i>                | Sea lettuce                | 1.9 $\pm$ 11.7           | 6         | 1.7                   |
| <i>Salicornia virginica</i>        | Virginia glasswort         | 1.0 $\pm$ 7.9            | 4         | 1.0                   |
| <i>Suaeda linearis</i>             | Slender sea-blite          | 0.8 $\pm$ 4.7            | 10        | 1.8                   |
| <i>Parthenocissus quinquefolia</i> | Virginia creeper           | 0.8 $\pm$ 6.1            | 3         | 0.8                   |
| <i>Toxicodendron radicans</i>      | Poison ivy                 | 0.6 $\pm$ 7.2            | 3         | 0.7                   |
| <i>Solidago sempervirens</i>       | Seaside goldenrod          | 0.6 $\pm$ 3.0            | 6         | 1.1                   |
| <i>S. sempervirens</i> (NL)        | Seaside goldenrod (NL)     | 0.1 $\pm$ 0.4            | 3         | 0.4                   |
| <i>Celtis occidentalis</i>         | Common Hackberry           | 0.6 $\pm$ 7.2            | 1         | 0.4                   |
| <i>Ammophila breviligulata</i>     | American beachgrass        | 0.5 $\pm$ 5.3            | 3         | 0.7                   |
| + <i>Salicornia maritima</i>       | Slender glasswort          | 0.4 $\pm$ 3.3            | 3         | 0.6                   |
| <i>Limonium carolinianum</i>       | Sea lavender               | 0.3 $\pm$ 3.1            | 5         | 0.8                   |
| <i>Cakile edentula</i>             | Sea rocket                 | 0.3 $\pm$ 3.1            | 2         | 0.4                   |
| <i>Phytolacca Americana</i>        | American pokeweed          | 0.3 $\pm$ 3.1            | 1         | 0.3                   |

**Table 11.** Average percent cover (Average percent cover %  $\pm$  SD), frequency, and relative percent prevalence of each plant species and non-vegetation cover type at GATE-SHU in 2010. Data were summarized over all 150 plots. Percent cover was estimated using the midpoint values of Braun-Blanquet percent ranges (Table 4). (NL) indicates standing non-living vegetation. <sup>+</sup> *Salicornia europea*, an invalid synonym was used on the field data sheet; the accepted synonym *Salicornia maritima* was retrieved from the ITIS database (December 2010). (continued)

| Species/Cover Type                           | Common Name             | Average Cover % $\pm$ SD | Frequency | Relative Prevalence % |
|----------------------------------------------|-------------------------|--------------------------|-----------|-----------------------|
| <i>Bassia hyssopifolia</i>                   | Fivehook bassia         | 0.2 $\pm$ 1.8            | 3         | 0.5                   |
| <i>Atriplex cristata</i>                     | Crested saltbush        | 0.1 $\pm$ 1.3            | 2         | 0.3                   |
| <i>Atriplex patula</i>                       | Spear saltbush          | 0.1 $\pm$ 1.3            | 2         | 0.3                   |
| <i>Juniperus virginiana</i>                  | Eastern red-cedar       | 0.1 $\pm$ 1.3            | 1         | 0.2                   |
| <i>Rhus copallinum</i> var. <i>latifolia</i> | Winged sumac            | 0.1 $\pm$ 1.3            | 1         | 0.2                   |
| <i>Suaeda maritima</i>                       | Herbaceous seepweed     | 0.1 $\pm$ 1.3            | 1         | 0.2                   |
| <i>Agardhiella tenera</i>                    | Red weed                | < 0.05                   | 1         | 0.1                   |
| <i>Calystegia sepium</i>                     | Hedge bindweed          | < 0.05                   | 1         | 0.1                   |
| <i>Cenchrus longispinus</i>                  | Longspine Sandbur       | < 0.05                   | 1         | 0.1                   |
| <i>Mirabilis nyctaginea</i>                  | Heart-leaf four-o'clock | < 0.05                   | 1         | 0.1                   |
| Rock                                         | Rock                    | < 0.05                   | 1         | 0.1                   |
| <i>Salsola kali</i>                          | Russian thistle         | < 0.05                   | 1         | 0.1                   |
| Trash                                        | Trash                   | < 0.05                   | 1         | 0.1                   |
| <i>Xanthium strumarium</i>                   | Rough cocklebur         | < 0.05                   | 1         | 0.1                   |

## Discussion

### Nekton

The most notable results of the 2010 sampling season were the decreases in many nekton densities between the first and second sampling visit and the increase in abundance of one species, *P. pugio* during the second sampling visit. Based on what we know about the life history of nekton species, seasonal differences are to be expected. The extent of change in density between visits will be one of the variables monitored over time in looking for trends. Extent of seasonal change in abundance, species richness and nekton community structure is subject to variability due to expected year to year climate differences. This annual variability will make trends difficult to isolate in the short term. Long term trends in sea-level rise associated with climate change, however, are likely to result in identifiable changes in the extent of seasonal difference in nekton density and species richness. With this goal in mind, the nekton data collected at GATE in 2010 provide an informative baseline to which future data will be compared.

### Vegetation

This first year of vegetation monitoring at GATE provides essential information about the species present and how prevalent they are. These data also include information about non-vegetation cover types such as bare ground and standing water which will be important to monitor over time. Because salt marshes are located in coastal areas and many of the plant species are sensitive to subtle changes in soil salinity and saturation, changes in the spatial distribution of some species will be important primary indicators of change in salt marsh condition. Trends in the spatial distribution of vegetation species and prevalence of bare ground and water will also provide information about changes in the overall condition of the salt marsh and whether or not it may transition to mud flat due to sea-level rise and climate change.

This first year of data establishes a baseline for monitoring trends in vegetation community structure and spatial distribution of both vegetation species and non-vegetation cover types. Long-term monitoring of salt marsh vegetation will allow us to test hypotheses about whether apparent changes are due to year to year variability or represent significant trends.



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## Appendix A: Coordinates for nekton station locations at GATE-SHU in 2010

**Table A-1.** Coordinates for nekton station locations sampled at GATE-SHU site 1 in 2010, UTM, Zone 18, NAD 83, meters.

| Plot ID        | UTM X (east) | UTM Y (north) |
|----------------|--------------|---------------|
| GSH1C_199_2010 | 584749       | 4478065       |
| GSH1C_233_2010 | 584737       | 4478090       |
| GSH1C_437_2010 | 584800       | 4478150       |
| GSH1C_46_2010  | 584871       | 4478062       |
| GSH1C_499_2010 | 584818       | 4478158       |
| GSH1C_558_2010 | 584791       | 4478205       |
| GSH1C_6_2010   | 584899       | 4478043       |
| GSH1C_642_2010 | 584719       | 4478196       |
| GSH1C_81_2010  | 584844       | 4478040       |
| GSH1C_821_2010 | 584655       | 4478120       |
| GSH1C_844_2010 | 584640       | 4478124       |
| GSH1C_865_2010 | 584619       | 4478136       |

**Table A-2.** Coordinates for nekton station locations sampled at GATE-SHU site 3 in 2010, UTM, Zone 18, NAD 83, meters.

| Plot ID         | UTM X (east) | UTM Y (north) |
|-----------------|--------------|---------------|
| GSH3P1_164_2010 | 586534       | 4473444       |
| GSH3P1_226_2010 | 586497       | 4473542       |
| GSH3P1_99_2010  | 586605       | 4473560       |
| GSH3P2_199_2010 | 586582       | 4473223       |
| GSH3P2_248_2010 | 586556       | 4473239       |
| GSH3P2_74_2010  | 586660       | 4473291       |



## Appendix B: Coordinates for vegetation plot locations at GATE-SHU in 2010

**Table B-1.** Coordinates for vegetation plot locations sampled GATE-SHU site 1 in 2010, UTM, Zone 18, NAD 83, meters.

| Plot ID        | UTM X<br>(east) | UTM Y<br>(north) | Plot ID        | UTM X<br>(east) | UTM Y<br>(north) |
|----------------|-----------------|------------------|----------------|-----------------|------------------|
| GSH1V1010_2010 | 584709          | 4478151          | GSH1V3410_2010 | 584724          | 4478052          |
| GSH1V110_2010  | 584649          | 4478193          | GSH1V3610_2010 | 584582          | 4478062          |
| GSH1V1110_2010 | 584758          | 4478032          | GSH1V3710_2010 | 584746          | 4478076          |
| GSH1V1210_2010 | 584732          | 4478061          | GSH1V3810_2010 | 584605          | 4478085          |
| GSH1V1310_2010 | 584651          | 4478199          | GSH1V3910_2010 | 584759          | 4478152          |
| GSH1V1410_2010 | 584779          | 4478181          | GSH1V4010_2010 | 584759          | 4478028          |
| GSH1V1510_2010 | 584866          | 4478107          | GSH1V410_2010  | 584620          | 4478282          |
| GSH1V1610_2010 | 584717          | 4478103          | GSH1V4110_2010 | 584642          | 4478188          |
| GSH1V1810_2010 | 584781          | 4478179          | GSH1V4210_2010 | 584740          | 4478189          |
| GSH1V1910_2010 | 584599          | 4478080          | GSH1V4410_2010 | 584643          | 4478190          |
| GSH1V2010_2010 | 584635          | 4478121          | GSH1V4510_2010 | 584629          | 4478115          |
| GSH1V210_2010  | 584705          | 4478146          | GSH1V4610_2010 | 584616          | 4478157          |
| GSH1V2110_2010 | 584628          | 4478292          | GSH1V4710_2010 | 584882          | 4478059          |
| GSH1V2210_2010 | 584636          | 4478307          | GSH1V4810_2010 | 584620          | 4478104          |
| GSH1V2310_2010 | 584871          | 4478106          | GSH1V4910_2010 | 584638          | 4478126          |
| GSH1V2510_2010 | 584680          | 4478115          | GSH1V5010_2010 | 584849          | 4478023          |
| GSH1V2610_2010 | 584653          | 4478200          | GSH1V510_2010  | 584755          | 4478146          |
| GSH1V2710_2010 | 584716          | 4478222          | GSH1V5110_2010 | 584868          | 4478044          |
| GSH1V2810_2010 | 584625          | 4478168          | GSH1V5210_2010 | 584772          | 4478108          |
| GSH1V2910_2010 | 584623          | 4478225          | GSH1V5310_2010 | 584720          | 4478104          |
| GSH1V3010_2010 | 584634          | 4478177          | GSH1V5410_2010 | 584801          | 4478083          |
| GSH1V310_2010  | 584606          | 4478082          | GSH1V5910_2010 | 584841          | 4478130          |
| GSH1V3110_2010 | 584569          | 4478101          | GSH1V710_2010  | 584667          | 4478044          |
| GSH1V3210_2010 | 584861          | 4478034          | GSH1V810_2010  | 584619          | 4478276          |
| GSH1V3310_2010 | 584843          | 4478078          | GSH1V910_2010  | 584859          | 4478095          |

**Table B-2.** Coordinates for vegetation plot locations sampled GATE-SHU site 2 in 2010, UTM, Zone 18, NAD 83, meters.

| Plot ID        | UTM X<br>(east) | UTM Y<br>(north) | Plot ID        | UTM X<br>(east) | UTM Y<br>(north) |
|----------------|-----------------|------------------|----------------|-----------------|------------------|
| GSH2V1010_2010 | 585884          | 4475670          | GSH2V3210_2010 | 586150          | 4474715          |
| GSH2V110_2010  | 586073          | 4474892          | GSH2V3310_2010 | 586028          | 4475307          |
| GSH2V1110_2010 | 585559          | 4476169          | GSH2V3410_2010 | 586220          | 4474528          |
| GSH2V1210_2010 | 586058          | 4475100          | GSH2V3510_2010 | 586038          | 4475310          |
| GSH2V1310_2010 | 585591          | 4475967          | GSH2V3610_2010 | 586185          | 4474731          |
| GSH2V1410_2010 | 585884          | 4475671          | GSH2V3710_2010 | 586216          | 4474528          |
| GSH2V1510_2010 | 585561          | 4476170          | GSH2V3810_2010 | 586222          | 4474527          |
| GSH2V1610_2010 | 585669          | 4476003          | GSH2V3910_2010 | 585926          | 4474821          |
| GSH2V1710_2010 | 585590          | 4475967          | GSH2V4010_2010 | 586005          | 4475513          |
| GSH2V1810_2010 | 585878          | 4475666          | GSH2V410_2010  | 586028          | 4475088          |
| GSH2V1910_2010 | 585352          | 4476070          | GSH2V4110_2010 | 585887          | 4475669          |
| GSH2V2010_2010 | 585547          | 4475944          | GSH2V4210_2010 | 586033          | 4475307          |
| GSH2V210_2010  | 585678          | 4476010          | GSH2V4310_2010 | 585645          | 4475994          |
| GSH2V2110_2010 | 585663          | 4476001          | GSH2V4410_2010 | 585349          | 4476068          |
| GSH2V2210_2010 | 585931          | 4474825          | GSH2V4510_2010 | 586099          | 4474689          |
| GSH2V2310_2010 | 586175          | 4474724          | GSH2V4610_2010 | 585628          | 4475981          |
| GSH2V2410_2010 | 585676          | 4476006          | GSH2V4710_2010 | 585364          | 4476075          |
| GSH2V2510_2010 | 585378          | 4476084          | GSH2V4810_2010 | 585934          | 4474828          |
| GSH2V2610_2010 | 585857          | 4475657          | GSH2V4910_2010 | 585911          | 4474816          |
| GSH2V2710_2010 | 586137          | 4474710          | GSH2V5010_2010 | 586163          | 4474718          |
| GSH2V2810_2010 | 585978          | 4475498          | GSH2V510_2010  | 586023          | 4474870          |
| GSH2V2910_2010 | 585405          | 4476096          | GSH2V610_2010  | 585931          | 4474825          |
| GSH2V3010_2010 | 585936          | 4474826          | GSH2V710_2010  | 586031          | 4474874          |
| GSH2V310_2010  | 585760          | 4475828          | GSH2V810_2010  | 586180          | 4474725          |
| GSH2V3110_2010 | 585433          | 4475894          | GSH2V910_2010  | 586052          | 4474885          |

**Table B-3.** Coordinates for vegetation plot locations sampled GATE-SHU site 3 in 2010, UTM, Zone 18, NAD 83, meters.

| Plot ID        | UTM X<br>(east) | UTM Y<br>(north) | Plot ID        | UTM X<br>(east) | UTM Y<br>(north) |
|----------------|-----------------|------------------|----------------|-----------------|------------------|
| GSH3V1010_2010 | 586625          | 4473151          | GSH3V3310_2010 | 586544          | 4473452          |
| GSH3V110_2010  | 586583          | 4473592          | GSH3V3410_2010 | 586591          | 4473656          |
| GSH3V1110_2010 | 586539          | 4473509          | GSH3V3510_2010 | 586668          | 4473166          |
| GSH3V1210_2010 | 586589          | 4473205          | GSH3V3610_2010 | 586471          | 4473361          |
| GSH3V1310_2010 | 586641          | 4473158          | GSH3V3710_2010 | 586452          | 4473354          |
| GSH3V1410_2010 | 586626          | 4473537          | GSH3V3810_2010 | 586481          | 4473685          |
| GSH3V1510_2010 | 586621          | 4473151          | GSH3V3910_2010 | 586477          | 4473552          |
| GSH3V1610_2010 | 586498          | 4473687          | GSH3V4010_2010 | 586599          | 4473208          |
| GSH3V1710_2010 | 586635          | 4473283          | GSH3V410_2010  | 586590          | 4473400          |
| GSH3V1810_2010 | 586465          | 4473615          | GSH3V4110_2010 | 586437          | 4473414          |
| GSH3V2010_2010 | 586609          | 4473211          | GSH3V4210_2010 | 586472          | 4473363          |
| GSH3V210_2010  | 586619          | 4473278          | GSH3V4310_2010 | 586501          | 4473499          |
| GSH3V2110_2010 | 586616          | 4473277          | GSH3V4410_2010 | 586617          | 4473471          |
| GSH3V2210_2010 | 586558          | 4473515          | GSH3V4610_2010 | 586430          | 4473665          |
| GSH3V2310_2010 | 586547          | 4473640          | GSH3V4710_2010 | 586508          | 4473500          |
| GSH3V2410_2010 | 586618          | 4473536          | GSH3V4810_2010 | 586586          | 4473460          |
| GSH3V2510_2010 | 586572          | 4473519          | GSH3V4910_2010 | 586477          | 4473682          |
| GSH3V2610_2010 | 586657          | 4473164          | GSH3V5010_2010 | 586551          | 4473256          |
| GSH3V2710_2010 | 586453          | 4473549          | GSH3V510_2010  | 586590          | 4473268          |
| GSH3V2810_2010 | 586412          | 4473596          | GSH3V5110_2010 | 586517          | 4473631          |
| GSH3V2910_2010 | 586625          | 4473475          | GSH3V5510_2010 | 586540          | 4473702          |
| GSH3V3010_2010 | 586472          | 4473491          | GSH3V610_2010  | 586532          | 4473445          |
| GSH3V310_2010  | 586520          | 4473567          | GSH3V710_2010  | 586541          | 4473574          |
| GSH3V3110_2010 | 586528          | 4473505          | GSH3V810_2010  | 586528          | 4473442          |
| GSH3V3210_2010 | 586586          | 4473202          | GSH3V910_2010  | 586638          | 4473350          |



## Appendix C: Nekton species and community density at GATE-SHU in 2010 summarized by site and visit.

**Table C-1.** Average density and standard deviation [individuals per 1 m<sup>2</sup> ± SD (total count)] of nekton captured for each site and visit at GATE-SHU in 2010. '-' indicates that a species was not present.

| Community/Species            | Common Name              | Average Density [individuals per 1 m <sup>2</sup> ± SD (total count)] |                             |                             |                          |
|------------------------------|--------------------------|-----------------------------------------------------------------------|-----------------------------|-----------------------------|--------------------------|
|                              |                          | Site 1                                                                |                             | Site 3                      |                          |
|                              |                          | Visit 1                                                               | Visit 2                     | Visit 1                     | Visit 2                  |
| <b>Fish</b>                  |                          | <b>156.8 ± 284.2 (1882)</b>                                           | <b>78.6 ± 152.9 (865)</b>   | <b>224.2 ± 424.7 (1345)</b> | <b>17.2 ± 29.2 (103)</b> |
| <i>Fundulus heteroclitus</i> | Common mummichog         | 145.3 ± 256.0 (1744)                                                  | 74.8 ± 152.5 (823)          | 28.5 ± 43.8 (171)           | 13.7 ± 25.8 (82)         |
| <i>Menidia menidia</i>       | Atlantic silverside      | 0.7 ± 1.8 (8)                                                         | 2.9 ± 4.5 (32)              | 192.0 ± 431.8 (1152)        | 1.3 ± 2.8 (8)            |
| <i>Fundulus majalis</i>      | Striped killifish        | 8.8 ± 29.0 (106)                                                      | 0.8 ± 2.7 (9)               | 1.7 ± 2.4 (10)              | 0.5 ± 0.5 (3)            |
| <i>Mugil cephalus</i>        | Striped mullet           | 1.8 ± 5.7 (22)                                                        | 0.1 ± 0.3 (1)               | -                           | 0.2 ± 0.4 (1)            |
| <i>Apeltes quadracus</i>     | Fourspine stickleback    | -                                                                     | -                           | 1.7 ± 4.1 (10)              | 0.8 ± 1.2 (5)            |
| <i>Gobiidae</i> species      | Goby species             | -                                                                     | -                           | -                           | 0.7 ± 1.0 (4)            |
| <i>Anguilla rostrata</i>     | American eel             | 0.2 ± 0.6 (2)                                                         | -                           | -                           | -                        |
| <i>Cyprinodon variegatus</i> | Sheepshead minnow        | -                                                                     | -                           | 0.3 ± 0.8 (2)               | -                        |
| <b>Decapods</b>              |                          | <b>2.7 ± 4.3 (32)</b>                                                 | <b>27.6 ± 31.6 (304)</b>    | <b>13.3 ± 20.3 (80)</b>     | <b>32.2 ± 37.8 (193)</b> |
| <i>Palaemonetes pugio</i>    | Daggerblade grass shrimp | 0.2 ± 0.4 (2)                                                         | 26.3 ± 31 (289)             | 12.2 ± 19.7 (73)            | 28.2 ± 40.3 (169)        |
| <i>Callinectes sapidus</i>   | Blue crab                | 2.3 ± 3.8 (28)                                                        | 1.4 ± 1.3 (15)              | 1.2 ± 1.0 (7)               | 0.7 ± 0.8 (4)            |
| <i>Crangon septemspinosa</i> | Sand shrimp              | -                                                                     | -                           | -                           | 3.3 ± 3.4 (20)           |
| <i>Xanthidae</i> species     | Mud crab species         | 0.2 ± 0.4 (2)                                                         | -                           | -                           | -                        |
| <b>Total</b>                 |                          | <b>159.5 ± 284.1 (1914)</b>                                           | <b>106.3 ± 147.4 (1169)</b> | <b>237.5 ± 444.1 (1425)</b> | <b>49.3 ± 58.1 (296)</b> |



## Appendix D: Nekton species richness at GATE-SHU in 2010 summarized by site and visit

**Table D-1.** Estimated nekton species richness (Est. Species Richness  $\pm$  SD) summarized by site and visit at GATE-SHU in 2010.

| Site | Visit | No. of Stations | Observed No. of Species | Est. Species Richness $\pm$ SD |
|------|-------|-----------------|-------------------------|--------------------------------|
| 1    | 1     | 12              | 8                       | $8.9 \pm 0.9$                  |
|      | 2     | 11              | 6                       | $7.8 \pm 1.2$                  |
| 3    | 1     | 6               | 7                       | $8.7 \pm 1.7$                  |
|      | 2     | 6               | 9                       | $9.8 \pm 0.8$                  |



## Appendix E: Vegetation species observed at GATE-SHU in 2010.

**Table E-1.** Species and cover type frequency by site, GATE-SHU 2010. \* *Salicornia europea*, an invalid synonym was used on the field data sheet; the accepted synonym *Salicornia maritima* was retrieved from the ITIS database (December 2010).

| Species/Cover Type                 | Common Name                | Site (no. of plots) |        |        |          |
|------------------------------------|----------------------------|---------------------|--------|--------|----------|
|                                    |                            | 1 (50)              | 2 (50) | 3 (50) | All (50) |
| Wrack/Litter                       | Wrack/Litter               | 32                  | 36     | 13     | 81       |
| <i>Spartina alterniflora</i>       | Salt marsh cordgrass       | 30                  | 23     | 11     | 64       |
| <i>S. alterniflora</i> (NL)        | Salt marsh cordgrass (NL)  | 10                  | 1      | 3      | 14       |
| Bare ground                        | Bare ground                | 9                   | 15     | 19     | 43       |
| Water                              | Water                      | 10                  | 4      | 26     | 40       |
| <i>Spartina patens</i>             | Salt meadow cordgrass      | 4                   | 13     | 4      | 21       |
| <i>S. patens</i> (NL)              | Salt meadow cordgrass (NL) | 0                   | 3      | 4      | 7        |
| <i>Iva frutescens</i>              | Marsh elder                | 7                   | 5      | 0      | 12       |
| <i>Iva frutescens</i> (NL)         | Marsh elder (NL)           | 0                   | 3      | 0      | 3        |
| <i>Distichlis spicata</i>          | Distichlis spicata         | 2                   | 7      | 2      | 11       |
| <i>D. spicata</i> (NL)             | Distichlis spicata (NL)    | 0                   | 0      | 1      | 1        |
| <i>Suaeda linearis</i>             | Slender sea-blite          | 4                   | 6      | 0      | 10       |
| <i>Solidago sempervirens</i>       | Seaside goldenrod          | 3                   | 1      | 2      | 6        |
| <i>S. sempervirens</i> (NL)        | Seaside goldenrod (NL)     | 1                   | 1      | 1      | 3        |
| <i>Ulva lactuca</i>                | Sea lettuce                | 2                   | 2      | 2      | 6        |
| <i>Limonium carolinianum</i>       | Sea lavender               | 2                   | 1      | 2      | 5        |
| <i>Salicornia virginica</i>        | Virginia glasswort         | 1                   | 3      | 0      | 4        |
| <i>Ammophila breviligulata</i>     | American beachgrass        | 3                   | 0      | 0      | 3        |
| <i>Bassia hyssopifolia</i>         | Fivehook bassia            | 0                   | 1      | 2      | 3        |
| <i>Parthenocissus quinquefolia</i> | Virginia creeper           | 3                   | 0      | 0      | 3        |
| + <i>Salicornia maritima</i>       | Slender glasswort          | 3                   | 0      | 0      | 3        |
| <i>Toxicodendron radicans</i>      | Poison ivy                 | 1                   | 1      | 1      | 3        |

**Table E-1.** Species and cover type frequency by site, GATE-SHU 2010. <sup>+</sup> *Salicornia europea*, an invalid synonym was used on the field data sheet; the accepted synonym *Salicornia maritima* was retrieved from the ITIS database (December 2010) . (continued)

| Species/Cover Type                           | Common Name             | Site (no. of plots) |        |        |          |
|----------------------------------------------|-------------------------|---------------------|--------|--------|----------|
|                                              |                         | 1 (50)              | 2 (50) | 3 (50) | All (50) |
| <i>Atriplex cristata</i>                     | Crested saltbush        | 0                   | 2      | 0      | 2        |
| <i>Atriplex patula</i>                       | Spear saltbush          | 2                   | 0      | 0      | 2        |
| <i>Cakile edentula</i>                       | Sea rocket              | 0                   | 2      | 0      | 2        |
| <i>Agardhiella tenera</i>                    | Red weed                | 0                   | 0      | 1      | 1        |
| <i>Calystegia sepium</i>                     | Hedge bindweed          | 1                   | 0      | 0      | 1        |
| <i>Celtis occidentalis</i>                   | Common Hackberry        | 1                   | 0      | 0      | 1        |
| <i>Cenchrus longispinus</i>                  | Longspine Sandbur       | 1                   | 0      | 0      | 1        |
| <i>Juniperus virginiana</i>                  | Eastern red-cedar       | 0                   | 1      | 0      | 1        |
| <i>Mirabilis nyctaginea</i>                  | Heart-leaf four-o'clock | 1                   | 0      | 0      | 1        |
| <i>Phytolacca americana</i>                  | American pokeweed       | 1                   | 0      | 0      | 1        |
| <i>Rhus copallinum</i> var. <i>latifolia</i> | Winged sumac            | 0                   | 1      | 0      | 1        |
| Rock                                         | Rock                    | 0                   | 0      | 1      | 1        |
| <i>Salsola kali</i>                          | Russian thistle         | 1                   | 0      | 0      | 1        |
| <i>Suaeda maritima</i>                       | Herbaceous seepweed     | 1                   | 0      | 0      | 1        |
| Trash                                        | Trash                   | 0                   | 0      | 1      | 1        |
| <i>Xanthium strumarium</i>                   | Rough cocklebur         | 1                   | 0      | 0      | 1        |