

***Implementing Long-Term Monitoring of Salt
Marsh Communities within the Northeast Coastal
and Barrier Network of the National Park Service***

**Year 3: Monitoring at Assateague Island National Seashore
and George Washington Birthplace National Monument**

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Chapter 1 - Introduction

The National Park Service has recently implemented a program to develop monitoring protocols in an effort to collect long-term data on natural and cultural resources. Cape Cod National Seashore (Massachusetts) was designated as the prototype park for the Atlantic and Gulf Coast biogeographic region where protocols were designed and tested. Two of these protocols, Monitoring Nekton in Shallow Estuarine Habitats (James-Pirri *et al.* In Review-b; Raposa & Roman 2001a) and Monitoring Salt Marsh Vegetation (James-Pirri *et al.* In Review-a; Roman *et al.* 2001) have been completed and are currently implemented on several US Fish and Wildlife Refuges along the Atlantic Coast (James-Pirri *et al.* 2005) (Figure 1-1). This is a 3 year study that will implement the salt marsh and nekton monitoring protocols at National Park Service units within the Northeast Coastal and Barrier Network as well as additional coastal Parks (Figure 1-1).

This progress report summarizes the field sampling for year 3 conducted in 2005 at Assateague Island National Seashore (ASIS) and George Washington Birthplace National Monument (GEWA).

Overview

The Park units within the Northeast Coastal and Barrier Network where salt marsh vegetation and nekton communities were monitored were: Assateague Island National Seashore (ASIS, coastal Maryland and Virginia), Colonial National Historic Park (COLO, Virginia Peninsula), Fire Island National Seashore (FIIS, Long Island, NY), Gateway National Recreation Area (GATE, New York City, NY and Sandy Hook, NJ), George Washington Birthplace National Monument (GEWA, Westmoreland County, VA), and Sagamore Hill National Historic Site (SAHI, Oyster Bay, NY). Additionally, vegetation and nekton were also sampled at Boston Harbor Islands National Park Area (BOHA, Boston, MA), Cape Cod National Seashore (CACO, Cape Cod, MA), and Saugus Ironworks National Historic Site (SAIR, Saugus, MA).

Monitoring was established at each of the selected Park units over a 3 year period, with an average of 3 Parks sampled each year (Table 1-1). In 2005, monitoring of saltmarsh nekton and vegetation were conducted at ASIS and GEWA.

Sampling Methods

Nekton (Fish and Decapods)

Nekton is defined as free-swimming fish and decapod crustaceans (McIvor & Rozas 1996). As common residents of salt marshes, nekton utilizes the marsh surface, creeks and ditches, and marsh pools (Able *et al.* 1996). At each study site at 10 to 25 nekton sampling locations were established. Sampling locations included marsh pools, creeks, ditches, and shoreline areas depending on the topography of the site. James-Pirri *et al.*

(In Review-b) and Raposa & Roman (2001a) offer a detailed summary of the protocol and good overview of the spatial and temporal variability, and sample size in the nekton sampling procedure. All pools (up to 15, if present) within a marsh were sampled. If there were few pools on the marsh surface, then larger tidal creeks (more than 1.5m wide) and shoreline areas were also sampled with the throw trap. All nekton sampling stations were randomly located along the perimeter of the pool, tidal creek, or shoreline.

Nekton in marsh pools, large tidal creeks, and shoreline habitats (all less than 1m deep) were sampled with a 1m² aluminum throw trap (Kushlan 1981, Sogard & Able 1991, Raposa and Roman 2001b). The throw trap is an enclosure sampler that has excellent efficiency and provides quantitative, repeatable results (Rozas & Minello 1997). The trap had an open top and bottom, was 0.5m in height and 1m square, and the sides were covered with 3mm (1/8 in) wire mesh. Each sampling location was quietly approached, and at 3m to 5m from the area to be sampled, the person throwing the trap crouched and waited a few minutes to allow any disturbed nekton to resume normal activity. The person then tossed the trap into the pool, tidal creek, or shoreline area, imbedding it in the bottom sediments and capturing any nekton within the 1m² of the trap. All nekton were collected from the trap with a 1mm mesh dip net that fit snugly within the opposite sides of the trap. The trap was considered empty when three successive attempts with the dip net produced no organisms.

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 where they were sampled. An example data sheet for the throw trap sampling method is shown in Appendix, Figure 5-1.

Nekton was sampled after the marsh surface had drained. Sampling occurred twice per year, once in early summer (June-July) and once in late summer-early fall (August – October). Species composition was recorded and density and species richness were calculated for each site using the jack-knife method (Heltshe & Forrester 1983).

Vegetation

Vegetation was monitored using 1m² plots. Plots to monitor salt marsh vegetation were located according to the salt marsh vegetation protocol (James-Pirri *et al.* In Review- a; Roman *et al.* 2001). A minimum of 20 1m² vegetation plots were sampled at each site. Transects, extending from creek bank to upland, were randomly located within each marsh and covered a representative portion of the study area. Vegetation plots (1m²) were located along each transect, with the first plot randomly located and subsequent plots spaced at systematic intervals of 10m to 50m depending on the size of the study area. Given the random starts for setting both transects and plots and a minimum of 10 m spacing between 1m² plots to maintain biological and statistical independence, it can be assumed that the individual vegetation plots were randomly located (Elzinga *et al.*, 2001). Within each plot all species were identified. The point-intercept method (Mueller-

Dombois & Ellenberg 1974) was used to estimate percent cover of herbaceous vegetation at ASIS. At GEWA the point intercept method could not be used due to tall vegetation canopy and an estimate of percent cover was based on the Braun-Blanquet system (Braun-Blanquet cover scale: 1: <5%; 2: 6-25%; 3: 26-50%; 4: 51-75%; 5: 76-100%, Kent and Coker 1992). Categories and definitions of cover types used during the vegetation monitoring are shown in Table 1-2 (taken from Roman *et al.* 2001). Example data sheets for both vegetation sampling methods (point intercept and visual cover estimation) are shown in Appendix, Figs. 5-2 and 5-3.

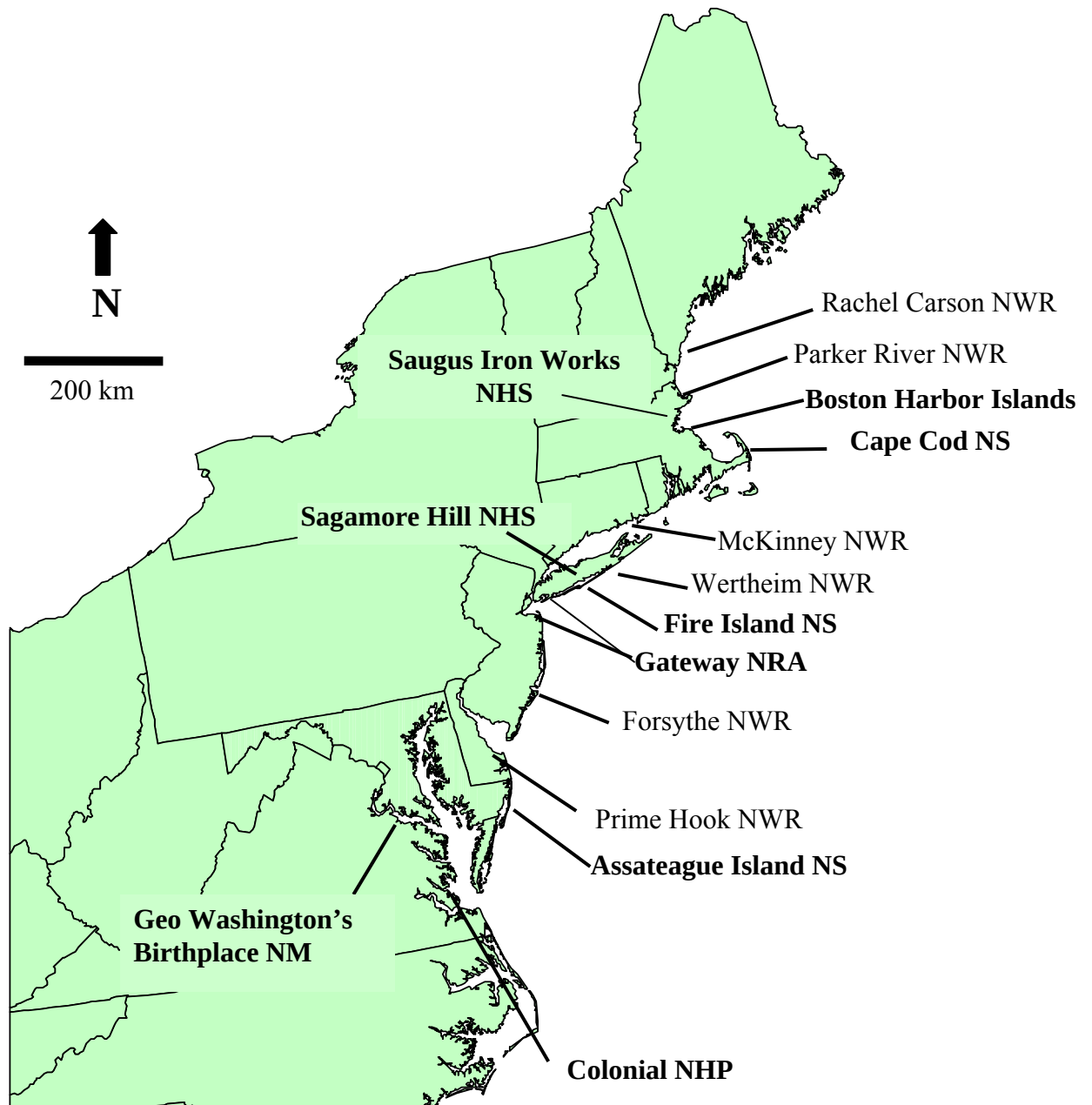


Figure 1-1. Coastal National Parks of the Northeast (in bold). Region 5 US Fish and Wildlife Refuges where salt marsh and nekton monitoring protocols have been implemented.

Table 1-1. Sampling years and sites for pilot implementation of salt marsh vegetation and nekton protocols.

Park	Year sampled	Sites sampled
ASIS	2005	3 sites : North End (vegetation only), Moderate Grazing, Valentine's
BOHA	2004	2 sites: Thompson Island, Calf Island (vegetation only)
CACO	2004	1 site: Nauset Marsh
COLO	2003	2 sites: Back River, King Creek
FIIS	2003	2 sites: Hospital Point, Watch Hill
GATE	2003	3 sites: Big Egg Control & Treatment – Jamaica Bay Unit (nekton only), Horseshoe Cove- Sandy Hook Unit
GEWA	2005	2 sites: Dancing Marsh, Longwood Swamp
SAHI	2004	1 site: Marsh adjacent to Cold Spring Harbor
SAIR	2004	1 sites: Marsh along Saugus River

Table 1-2. Definition of cover type categories used in the salt marsh vegetation monitoring program (after Roman *et al* 2001).

Live vascular plants (herbaceous and shrubs) identified by species.

Standing dead vascular plants identified by species (*e.g.*, *S. alterniflora* dead). 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.*). If you are sure these dead leaves are from the current growing season, then record as live.

Macroalgae identified by species. This category generally includes the rockweeds (*e.g.*, *Fucus*, *Ascophyllum*). Microalgae (*e.g.*, diatom mats) and fine filamentous algae are not included in this category.

Bare. 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 category.

Water. Permanent standing water is identified in plots that are partly within a creek, ditch, marsh pool, or flooded panne.

Wrack/Litter. 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.

Trash. Items such as logs, old piers, tires, *etc.*

Rock. Boulders or rocks can be found on the surface of northern New England marshes.

NOTES:

- If an intercept point has standing water that is covering a bare mud bottom, this point should be recorded as standing water. It is assumed that the bottom is bare and there is no need to record this.
 - If macroalgae or submerged aquatic vegetation are hit at the intercept point in a standing water habitat, then both the plant and water should be recorded.
 - If a plot is at the edge of a marsh pool (water), *Spartina* overhangs the water, and the intercept point hits the *Spartina* and water, then both *Spartina* and water should be recorded.
-

Chapter 2 - Assateague Island National Seashore

Site Selection

Salt marsh monitoring sites were randomly selected at ASIS using a grid method. All salt marsh habitat within ASIS, as identified by GIS, was overlaid with a grid (grid cells were 1.5km²). The island was then divided into 3 sections from North to South. These sections corresponded to grazing intensity by the island ungulates (e.g., wild ponies and Sitka deer), with high grazing intensity occurring in the north end of the island, moderate grazing intensity in the middle section, and low intensity grazing at the southern most section. All grids containing salt marsh habitat were numbered within each section and three grids from each section were randomly chosen. One grid was then selected from the three randomly selected grids based on feasibility of access. Once the grid was chosen a 5-10 ha study site was selected from within the 1.5km² grid. Selection of the study site was based on accessibility, availability of appropriate habitat (salt marsh pools and shoreline for nekton sampling), and topography (amount of salt marsh). Study sites sampled were denoted as the North End, located in the northern section of park (high grazing intensity), the moderate grazing site located in the middle section of the park near Life of the Dunes Nature trail (moderate grazing intensity), and Valentine's marsh located in the southern section of the park (low intensity grazing) (Figure 2-1).

Sampling and Sampling Stations

In 2005, salt marsh nekton and vegetation monitoring were conducted at ASIS within three randomly selected study sites: North End, moderate grazing site, and Valentine's (Figures 2-2 to 2-4). At North End only vegetation was sampled due to lack of appropriate nekton habitat. At the moderate grazing site and Valentine's, nekton was sampled twice, once in June and once in August; vegetation was sampled in July (Table 2-1). Table 2-2 shows the number of vegetation plots per transect and distance between plots. UTM coordinates of sampling locations are given in the Appendix, Table 5-1.

The North End sampling area was accessed via four-wheel drive from the ocean beach. At the North End a total of 23 vegetation plots oriented along 5 transects were sampled using the point intercept method (50 points per 1m²) on August 3, 2005 (Table 2-2, Figure 2-2). One plot on transect 1 (1-90) was not sampled because it was inside the existing enclosure. Nekton were not sampled at the North End because there was no appropriate nekton habitat (marsh pools, tidal creeks, or shoreline contiguous with the marsh).

The moderate grazing site was accessed by walking through upland areas adjacent to the marsh via unmarked trails. At the moderate grazing site a total of 29 vegetation plots oriented along 5 transects were sampled using the point intercept method (50 points per 1m²) on August 3, 2005 (Table 2-2, Figure 2-3). A total of 28 nekton stations were sampled (15 on June 28 and 13 on August 30) (Figure 2-3).

Valentine's was accessed via four-wheel drive on an established unpaved park road. At Valentine's a total of 26 vegetation plots oriented along 5 transects were sampled using the point intercept method (50 points per 1m²) on August 2, 2005 (Table 2-2, Figure 2-3). A total of 29 nekton stations were sampled (15 on June 29 and 14 on August 31) (Figure 2-3).

Nekton

Nekton community composition and abundance and percent of catch for moderate grazing site and Valentine's marsh are shown in Tables 2-3 and 2-4, and total fish, decapod, and nekton densities are shown in Table 2-5. Average lengths of nekton are given in Table 2-6. Physical variables (water temperature, salinity, and dissolved oxygen) taken at nekton stations are given in Table 2-7.

At the moderate grazing area 10 species (6 fish and 4 decapods) were recorded (Table 2-3). Approximately 90% of the catch was represented by *Fundulus heteroclitus*, *Palaemonetes pugio*, *Menidia beryllina*, and *F. majalis* (Table 2-4). The species richness (jack-knife estimation, Heltshe and Forrester 1983) value for the sampled nekton was 13.89.

At Valentines marsh 9 species (5 fish and 4 decapods) were recorded (Table 2-3). Approximately 90% of the catch was represented by *F. heteroclitus*, *F. majalis*, *Cyprinodon variegatus*, and *M. menidia* (Table 2-4). The species richness (jack-knife estimation, Heltshe and Forrester 1983) value for the sampled nekton was 9.0.

Vegetation

At the North End 14 cover types were recorded during vegetation sampling (Table 2-8). The dominant species, comprising more than 90% of the total cover, were: *Spartina alterniflora* (live), *Schoenoplectus pungens* (live), *Distichlis spicata* (live), and *Spartina patens*.

At the moderate grazing site 9 cover types were recorded during vegetation sampling (Table 2-8). The dominate species was *Spartina alterniflora* (live) which comprised approximately 70% of the total cover.

At Valentines marsh 8 cover types were recorded during vegetation sampling (Table 2-8). The dominate species, comprising more than 80% of the total cover, was *Spartina alterniflora* (live and dead).

Table 2-1. Dates of nekton and vegetation sampling in 2005 at ASIS.

Site	Nekton	Vegetation
North End	Not sampled	Aug 3
Moderate grazing site	June 28 and Aug 30	Aug 3
Valentine's	June 29 and Aug 31	Aug 2

Table 2-2. Vegetation plots sampled in 2005 at ASIS. UTM coordinates for each plot are listed in Appendix, Table 5-1. * Plot 1-90 was inside an existing enclosure (to exclude grazing by ungulates) and was not sampled.

Study Area	Transect	Distance between plots (m)	Plot ID	Total number of plots
North End (23 plots)	1	30	1-00 to 1-150	5*
	2	30	2-00 to 2-180	7
	3	30	3-00 to 3-120	5
	4	30	4-00 to 4-150	6
Moderate grazing site (29 plots)	1	30	1-00 to 1-150	6
	2	30	2-00 to 2-180	7
	3	30	3-00 to 3-120	5
	4	30	4-00 to 4-150	6
	5	30	5-00 to 5-120	5
Valentine's (26 plots)	1	25	1-00 to 1-125	6
	2	25	2-00 to 2-175	8
	3	25	3-00 to 3-125	6
	4	25	4-00 to 1-75	4
	5	25	5-00 to 5-25	2

Table 2-3. Average density [number m⁻² ±SD (total count)] of nekton sampled at ASIS in 2005. Total number of stations sampled (June and August sampling combined) is indicated after marsh name. * Crab was too small to positively identify. “-” indicates species not recorded.

Species	Common Name	Average density per 1m ² ±SD (total count)	
		Moderate Grazing (n=28)	Valentine's (n=29)
<i>Anguilla rostrata</i>	American Eel	0.1 ± 0.4 (2)	0.03 ± 0.2 (1)
<i>Callinectes sapidus</i>	Blue Crab	0.2 ± 0.5 (5)	0.1 ± 0.4 (4)
<i>Crangon septemspinosa</i>	Sevenspine Bay Shrimp	0.3 ± 1.2 (8)	0.1 ± 0.6 (3)
<i>Cyprinodon variegatus</i>	Sheepshead Minnow	0.6 ± 2.8 (17)	2.3 ± 8.8 (67)
<i>Fundulus heteroclitus</i>	Mummichog	7.1 ± 21.1 (198)	5.6 ± 17.0 (163)
<i>Fundulus majalis</i>	Striped Killifish	1.7 ± 3.7 (47)	3.0 ± 10.1 (86)
<i>Menidia beryllina</i>	Inland Silverside	3.4 ± 17.8 (94)	-
<i>Menidia menidia</i>	Atlantic Silverside	0.7 ± 1.8 (20)	1.5 ± 2.8 (43)
<i>Palaemonetes pugio</i>	Daggerblade Grass Shrimp	4.3 ± 10.0 (121)	0.7 ± 2.8 (21)
<i>Palaemonetes vulgaris</i>	Marsh Grass Shrimp	-	0.03 ± 0.2 (1)
Unknown crab*	Unknown Crab	0.04 ± 0.2 (1)	-

Table 2-4. Percent of catch of nekton sampled at ASIS in 2005. “-” indicates species not recorded.

Species	Common Name	Percent (%) of Catch	
		Moderate Grazing	Valentine's
<i>Anguilla rostrata</i>	American Eel	0.4	0.3
<i>Callinectes sapidus</i>	Blue Crab	1.0	1.0
<i>Crangon septemspinosa</i>	Sevenspine Bay Shrimp	1.6	0.8
<i>Cyprinodon variegatus</i>	Sheepshead Minnow	3.3	17.2
<i>Fundulus heteroclitus</i>	Mummichog	38.6	41.9
<i>Fundulus majalis</i>	Striped Killifish	9.2	22.1
<i>Menidia beryllina</i>	Inland Silverside	18.3	-
<i>Menidia menidia</i>	Atlantic Silverside	3.9	11.1
<i>Palaemonetes pugio</i>	Daggerblade Grass Shrimp	23.6	5.4
<i>Palaemonetes vulgaris</i>	Marsh Grass Shrimp	-	0.3
Unknown crab*	Unknown Crab	0.2	-

Table 2-5. Average density [number m⁻² ±SD (total count)] of fish, decapods, and total nekton sampled at ASIS in 2005. Total number of stations sampled (June and August sampling combined) is indicated after marsh name.

Community	Average density per 1m ² ± SD (total count)	
	Moderate Grazing (n=28)	Valentine's (n=29)
Fish density	13.5 ± 29.5 (378)	12.4 ± 28.0 (360)
Decapod density	4.8 ± 10.4 (135)	1.0 ± 3.4 (29)
Nekton density	18.3 ± 32.9 (513)	13.4 ± 30.0 (389)

Table 2-6. Average length [mm ± SD (n)] for nekton species sampled at ASIS in 2005. “-” indicates species not recorded. * Crab was too small to positively identify

Species	Average length mm ± SD (n)	
	Moderate Grazing	Valentine's
<i>Anguilla rostrata</i>	58.5 ± 13.4 (2)	170 (1)
<i>Callinectes sapidus</i>	57 ± 4.4 (4)	43.5 ± 38.4 (4)
<i>Crangon septemspinosus</i>	36.9 ± 6.5 (8)	43.7 ± 10.4 (3)
<i>Cyprinodon variegatus</i>	25.7 ± 2.8 (16)	26.6 ± 10.9 (36)
<i>Fundulus heteroclitus</i>	28.9 ± 11.2 (85)	21.7 ± 7.3 (64)
<i>Fundulus majalis</i>	20.3 ± 6.9 (47)	15.7 ± 7.2 (45)
<i>Menidia beryllina</i>	24.2 ± 6.8 (15)	-
<i>Menidia menidia</i>	34.6 ± 15.6 (19)	34.7 ± 12.9 (43)
<i>Palaemonetes pugio</i>	17.0 ± 6.9 (76)	24.8 ± 9.7 (21)
<i>Palaemonetes vulgaris</i>	-	37 (1)
Unknown crab	4 (1)	-

Table 2-7. Physical characteristics [average ± SD (n)] of nekton sampling stations at ASIS.

Variable	Moderate Grazing	Valentine's
Water Temperature (°C)	29.1 ± 1.4 (28)	26.4 ± 1.0 (21)
Salinity (ppt)	24.2 ± 4.5 (27)	25.2 ± 2.8 (29)
Dissolved Oxygen (mg/l)	4.9 ± 2.3 (22)	3.2 ± 1.5 (12)

Table 2-8. Percent composition of salt marsh vegetation communities (calculated from average cover of all plots) from three marshes within ASIS sampled in 2005. Number of vegetation plots sampled is given in parentheses after site name. “-” indicates species not recorded.

Species	Common Name	North End (n=23)	Moderate Grazing (n=28)	Valentine's (n=26)
<i>Distichlis spicata</i>	Spikegrass	15.7	3.9	3.0
<i>Distichlis spicata</i> (dead)	Spikegrass (dead)	0.2	1.9	0.2
<i>Iva frutescens</i>	Marsh elder	1.0	-	-
<i>Salicornia europaea</i>	Glasswort	0.1	0.4	0.1
<i>Salicornia europaea</i> (dead)	Glasswort (dead)	-	0.1	0.4
<i>Schoenoplectus pungens</i>	Three-square Bulrush	19.3	-	-
<i>Schoenoplectus pungens</i> (dead)	Three-square Bulrush (dead)	1.9	-	-
<i>Solidago sempervirens</i>	Seaside Goldenrod	2.1	-	-
<i>Spartina alterniflora</i>	Saltmarsh Cordgrass	42.3	69.1	52.5
<i>Spartina alterniflora</i> (dead)	Saltmarsh Cordgrass (dead)	0.2	6.2	30.4
<i>Spartina patens</i>	Salt Meadow Cordgrass	15.3	7.1	-
Unidentified grass	Unidentified Grass	0.5	-	-
Bare Ground	Bare Ground	0.9	5.2	3.2
Water	Water	0.5	6.2	10.2
Wrack	Wrack	0.1	-	-

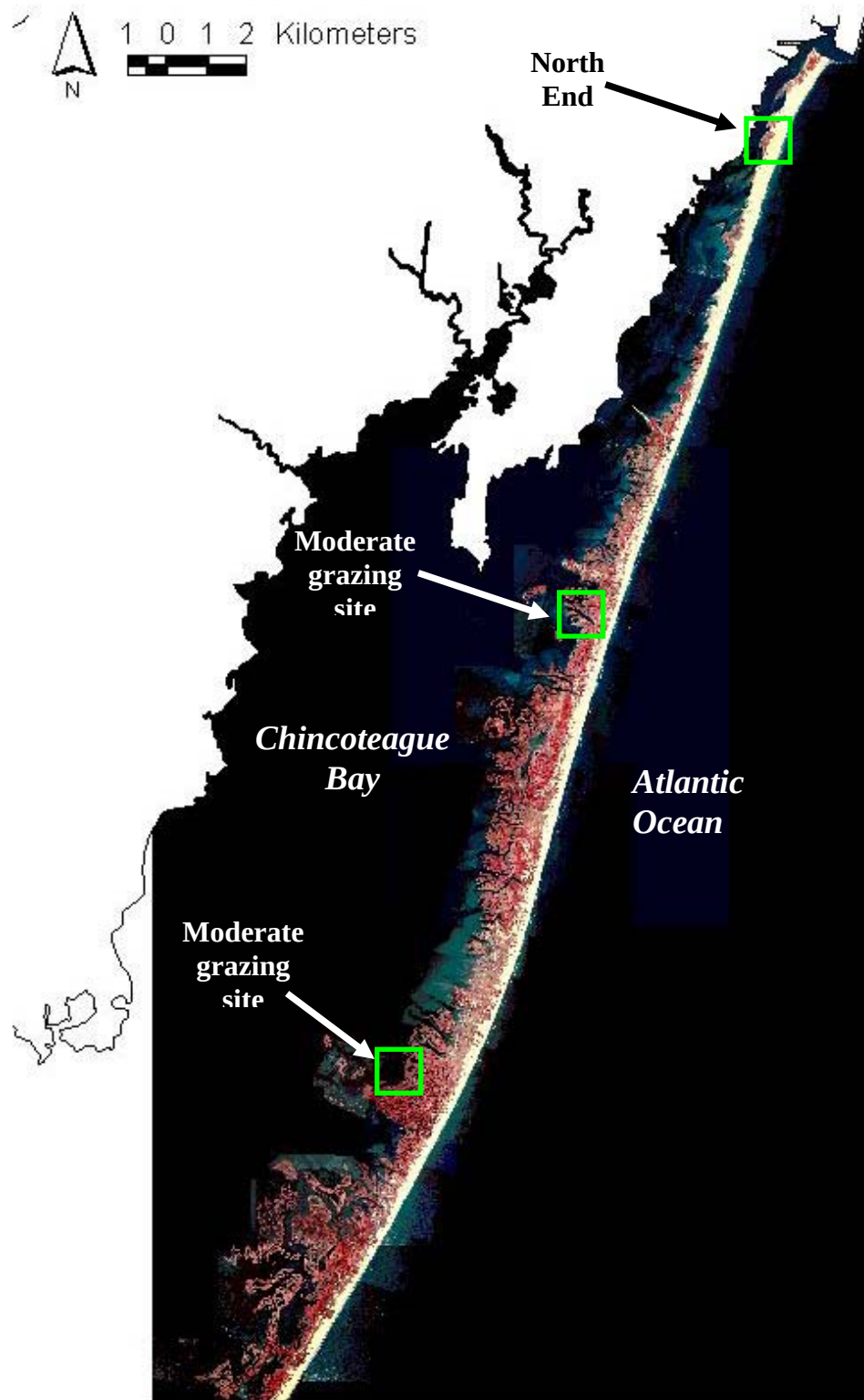


Figure 2-1. Study site locations at ASIS.

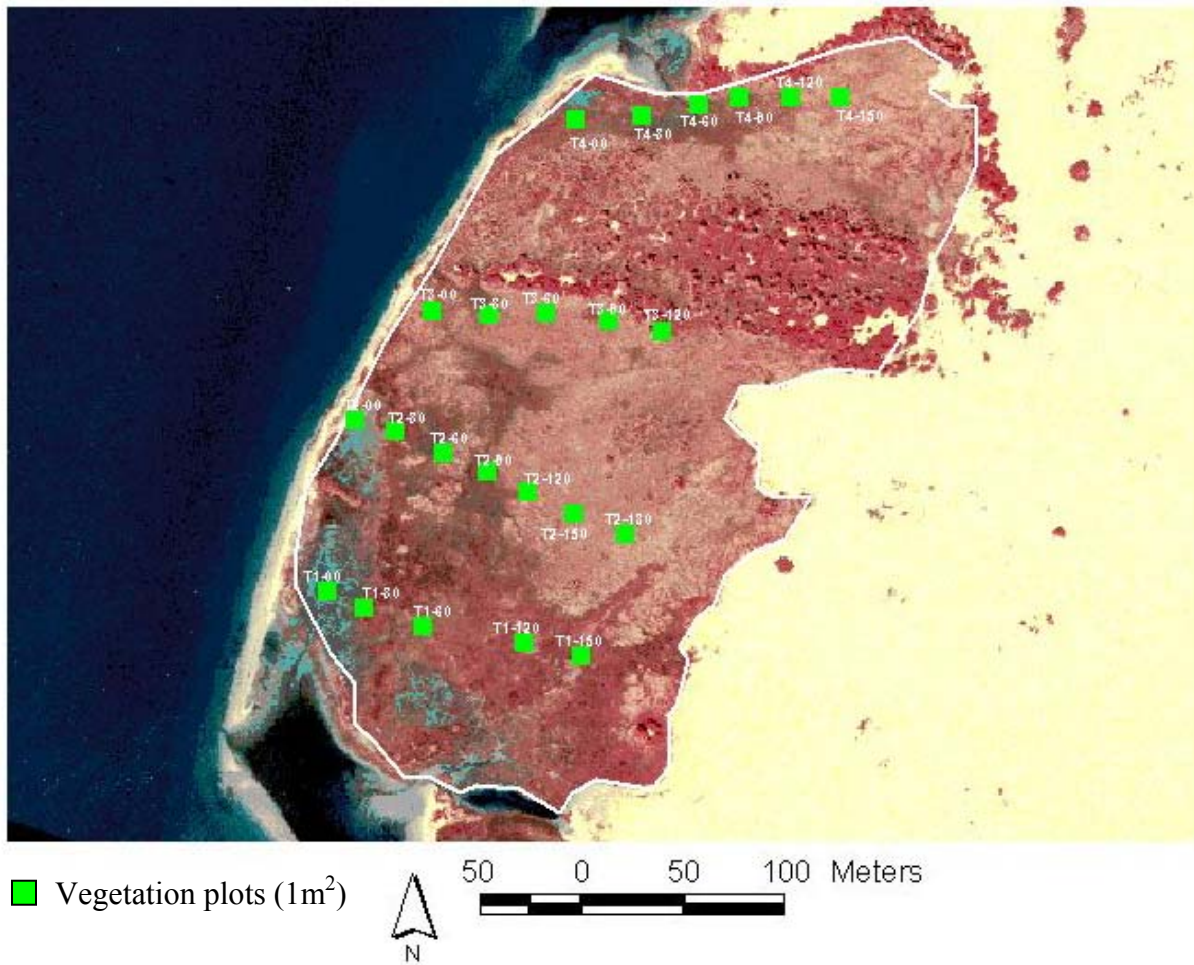


Figure 2-2. Map of North End sampling site showing location of vegetation plots (2005).

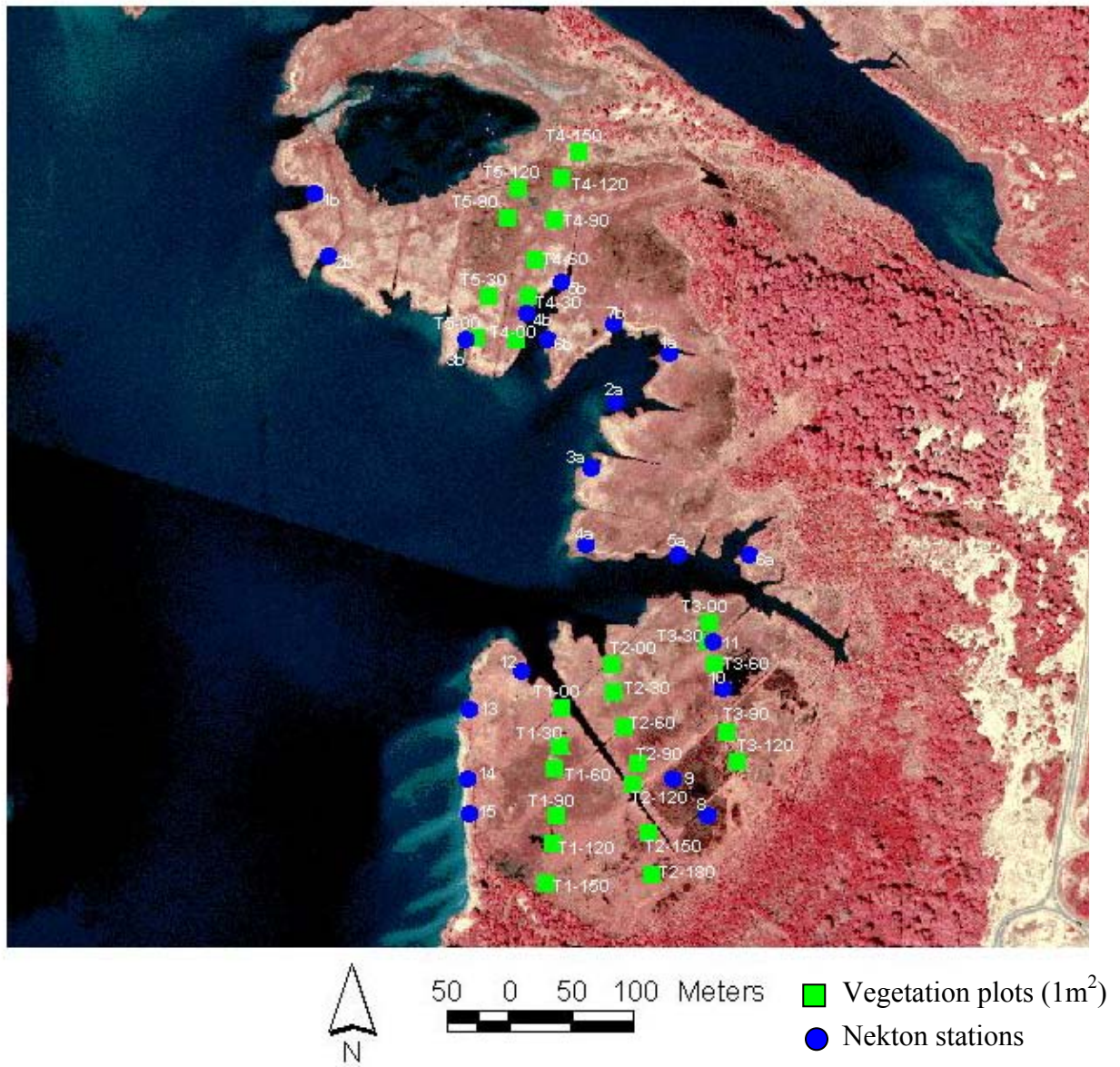


Figure 2-3. Map of moderate grazing site showing location of nekton sampling stations and vegetation plots (2005).

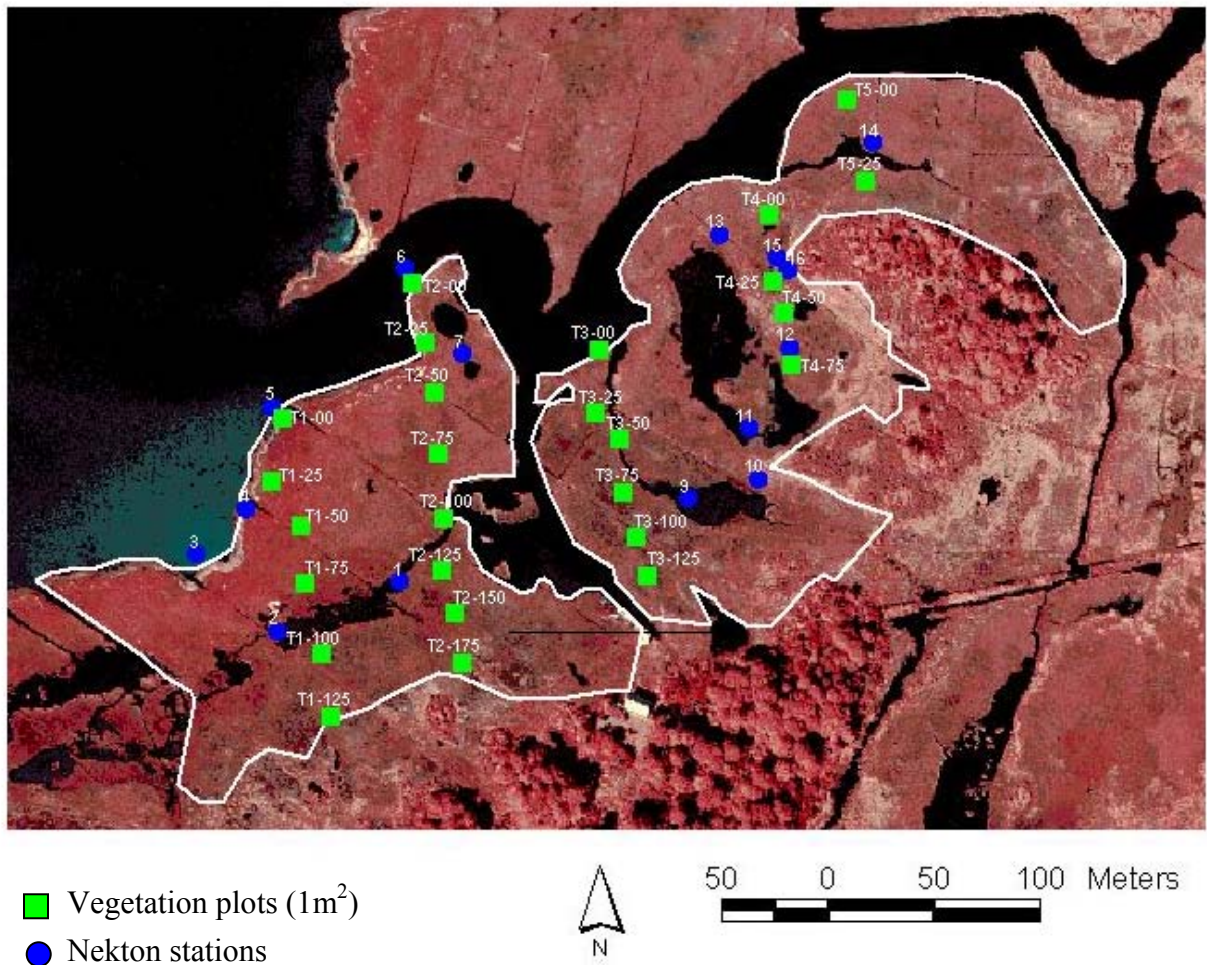


Figure 2-4. Map of Valentine's site showing location of nekton sampling stations and vegetation plots (2005).

Chapter 3 – George Washington Birthplace National Monument

Site Selection

At GEWA there were only 2 salt marsh areas within the park boundary, Longwood Swamp and Dancing Marsh (Figure 3-1). Both these locations were sampled.

Sampling and Sampling Stations

In 2005, salt marsh nekton and vegetation monitoring was conducted at GEWA within Dancing Marsh and Longwood Swamp (Figures 3-2 and 3-3). Nekton was sampled twice, once in June and once in August; vegetation was sampled in July (Table 3-1). Table 3-2 shows the number of vegetation plots per transect and distance between plots. UTM coordinates of sampling locations are given in the Appendix, Table 5-2.

Dancing Marsh was accessed via the shoreline of Pope's Creek and from a park trail adjacent to the marsh. At Dancing Marsh a total of 22 vegetation plots oriented along 5 transects were sampled (Table 3-2). Due to the tall vegetation canopy, the visual cover estimate method was used to estimate percent cover (Braun-Blanquet cover scale: 1: <5%; 2: 6-25%; 3: 26-50%; 4: 51-75%; 5: 76-100%, Kent and Coker 1992) on August 17, 2005 (Figure 3-2). A total of 22 nekton stations were sampled (11 on June 21-22 and 11 on August 16-17) (Figure 2-3).

All sampling stations within Longwood Swamp were accessed via canoe. At Longwood Swamp a total of 21 vegetation plots were sampled (Table 3-2). Longwood Swamp consists of a series of islands located within Pope's Creek and originally vegetation transects were going to be randomly located within each island. However, the vegetation of the islands (primarily salt marsh elder, *Iva frutescens*) proved to be impenetrable due to the both the size and density of the vegetation. As a result vegetation plots were randomly located along the perimeters of the islands. Due to the tall vegetation canopy, the visual cover estimate method was used to estimate percent cover (Braun-Blanquet cover scale: 1: <5%; 2: 6-25%; 3: 26-50%; 4: 51-75%; 5: 76-100%, Kent and Coker 1992) on August 16, 2005 (Figure 3-3). A total of 30 nekton stations were sampled (16 on June 22 and 14 on August 16-17) (Figure 2-3).

Nekton

Nekton community composition and abundance and percent of catch for Dancing Marsh and Longwood Swamp are shown in Tables 3-3 and 3-4, and total fish, decapod, and nekton densities are shown in Table 3-5. Average lengths of nekton are given in Table 3-6. Physical variables (water temperature, salinity, and dissolved oxygen) taken at nekton stations are given in Table 3-7.

At Dancing Marsh a total of 8 species (5 fish and 3 crustacean) were recorded (Table 3-3). Approximately 85% of the catch was comprised of *Fundulus heteroclitus* and

Palaemonetes pugio (Table 3-4). The species richness (jack-knife estimation, Heltshe and Forrester 1983) value for the sampled nekton was 8.95.

At Longwood Swamp a total of 8 species (6 fish and 2 crustacean) were recorded (Table 3-3). Approximately 90% of the catch was comprised of *Palaemonetes pugio*, *Menidia beryllina*, *Fundulus heteroclitus*, *Crangon septemspinosa*, and *Menidia menidia* (Table 3-4). The species richness (jack-knife estimation, Heltshe and Forrester 1983) value for the sampled nekton was 11.9.

Vegetation

At Dancing Marsh six cover types were observed. Approximately 90% of the observed vegetation cover was comprised by *Spartina cynosuroides*, *Amaranthus cannabinus*, *Kosteletzkya virginica*, and *Polygonum hydropiperoides* (Table 3-8).

At Longwood Swamp seven cover types were observed. Approximately 90% of the observed vegetation cover was comprised by *Spartina cynosuroides*, *Iva frutescens*, *Amaranthus cannabinus*, and *Polygonum hydropiperoides* (Table 3-8).

Table 3-1. Dates of nekton and vegetation sampling in 2005 at GEWA.

Site	Nekton	Vegetation
Dancing Marsh	June 21-22 and Aug 16-17	Aug 17
Longwood Swamp	June 22 and Aug 16-17	Aug 16

Table 3-2. Vegetation plots sampled in 2005 at GEWA. UTM coordinates for each plot are listed in Appendix, Table 5-2.

Study Area	Transect	Distance between plots (m)	Plot ID	Total number of plots
Dancing Marsh (22 plots)	1	20	1-00 to 1-60	4
	2	20	2-00 to 2-80	5
	3	20	3-00 to 3-60	4
	4	20	4-00 to 4-60	4
	5	20	5-00 to 5-80	5
Longwood Swamp (21 plots)	n/a	> 10m	1-21	21

Table 3-3. Average density [number m⁻² ±SD (total count)] of nekton sampled at GEWA in 2005. Total number of stations sampled (June and August sampling combined) is indicated after marsh name. “-” indicates species not recorded. * indicates individuals were too small to positively identify.

Species	Common Name	Average density per 1m ² ± SD (total count)	
		Dancing Marsh (n=22)	Longwood Swamp (n=30)
<i>Anguilla rostrata</i>	American Eel	0.3 ± 1.0 (7)	0.0 ± 0.2 (1)
<i>Carcinus maenas</i>	Green Crab	0.1 ± 0.4 (2)	-
<i>Crangon septemspinosa</i>	Sevenspine Bay Shrimp	1.0 ± 4.5 (22)	2.4 ± 7.8 (71)
<i>Fundulus heteroclitus</i>	Mummichog	24.9 ± 62.3 (548)	3.1 ± 4.9 (93)
<i>Fundulus majalis</i>	Striped Killifish	0.6 ± 1.8 (13)	0.6 ± 2.2 (17)
<i>Menidia beryllina</i>	Inland Silverside	3.3 ± 12.5 (73)	3.4 ± 15.7 (101)
<i>Menidia menidia</i>	Atlantic Silverside	2.9 ± 8.1 (64)	1.5 ± 2.3 (46)
<i>Menidia species</i> *	Silverside species	-	0.2 ± 0.9 (5)
<i>Morone americana</i>	White perch	-	0.4 ± 2.2 (12)
<i>Palaemonetes pugio</i>	Daggerblade Grass Shrimp	20.5 ± 39.4 (450)	3.4 ± 5.9 (102)

Table 3-4. Percent of catch of nekton sampled at GEWA in 2005. “-” indicates species not recorded.

Species	Common Name	Percent (%) of Catch	
		Dancing Marsh	Longwood Swamp
<i>Anguilla rostrata</i>	American Eel	0.6	0.2
<i>Carcinus maenas</i>	Green Crab	0.2	-
<i>Crangon septemspinosa</i>	Sevenspine Bay Shrimp	1.9	15.8
<i>Fundulus heteroclitus</i>	Mummichog	46.5	20.8
<i>Fundulus majalis</i>	Striped Killifish	1.1	3.8
<i>Menidia beryllina</i>	Inland Silverside	6.2	22.5
<i>Menidia menidia</i>	Atlantic Silverside	5.4	10.3
<i>Menidia species</i>	Silverside species	-	1.1
<i>Morone americana</i>	White perch	-	2.7
<i>Palaemonetes pugio</i>	Daggerblade Grass Shrimp	38.2	22.8

Table 3-5. Average density [number m⁻² ± SD (total count)] of fish, decapods, and total nekton sampled at GEWA in 2005. Total number of stations sampled (June and August sampling combined) is indicated after marsh name.

Community	Average density per 1m ² ±SD (total count)	
	Dancing Marsh (n=22)	Longwood Swamp (n=30)
Fish	32.0 ± 61.9 (705)	9.2 ± 16.4 (275)
Decapod	21.5 ± 39.0 (474)	5.8 ± 12.5 (173)
Total Nekton	53.6 ± 70.7 (1179)	14.9 ± 21.8 (448)

Table 3-6. Average length [mm ± SD (n)] for nekton species sampled at GEWA in 2005. “-” indicates species not recorded.

Species	Average length mm ± SD (n)	
	Dancing Marsh	Longwood Swamp
<i>Anguilla rostrata</i>	57.0 + 10.1 (7)	65.0 + 0.0 (1)
<i>Carcinus maenas</i>	65.0 + 14.1 (2)	-
<i>Crangon septemspinosa</i>	33.7 + 4.7 (16)	37.7 + 6.2 (26)
<i>Fundulus heteroclitus</i>	20.2 + 9.6 (116)	25.1 + 13.3 (83)
<i>Fundulus majalis</i>	28.7 + 5.2 (13)	25.1 + 4.4 (16)
<i>Menidia beryllina</i>	32.7 + 5.6 (30)	29.2 + 4.7 (30)
<i>Menidia menidia</i>	17.7 + 7.2 (40)	29.6 + 13.2 (44)
<i>Menidia</i> species	-	10.2 + 6.0 (5)
<i>Morone americana</i>	-	23.3 + 4.0 (12)
<i>Palaemonetes pugio</i>	17.8 + 4.1 (132)	29.5 + 7.1 (85)

Table 3-7. Physical characteristics [average ± SD (n)] of nekton sampling stations at GEWA.

Variable	Dancing Marsh	Longwood Swamp
Temperature (°C)	25.3 +2.3 (22)	27.1 +1.8 (30)
Salinity (ppt)	4.3 +1.5 (22)	8.2 +3.3 (30)
Dissolved Oxygen (mg l ⁻¹)	2.8 +2.5 (22)	6.6 +2.7 (21)

Table 3-8. Percent composition of salt marsh vegetation communities from GEWA marshes sampled in 2005. Number of vegetation plots sampled is given in parentheses after site name. “-“ indicates species not recorded.

Species	Common name	Dancing Marsh (n=22)	Longwood Swamp (n=21)
<i>Amaranthus cannabinus</i>	Tidalmarsh Amaranth	13.3	15.2
<i>Hibiscus moscheutos</i>	Crimson-eyed Rosemallow	-	1.3
<i>Iva frutescens</i>	Marsh Elder	-	25.9
<i>Kosteletzkya virginica</i>	Virginia Saltmarsh Mallow	24.6	9.7
<i>Phragmites australis</i>	Common Reed	-	1.0
<i>Polygonum hydropiperoides</i>	Swamp Smartweed	10.2	10.4
<i>Spartina cynosuroides</i>	Big Cordgrass	42.8	36.6
mud	mud	4.2	-
water	water	4.9	-

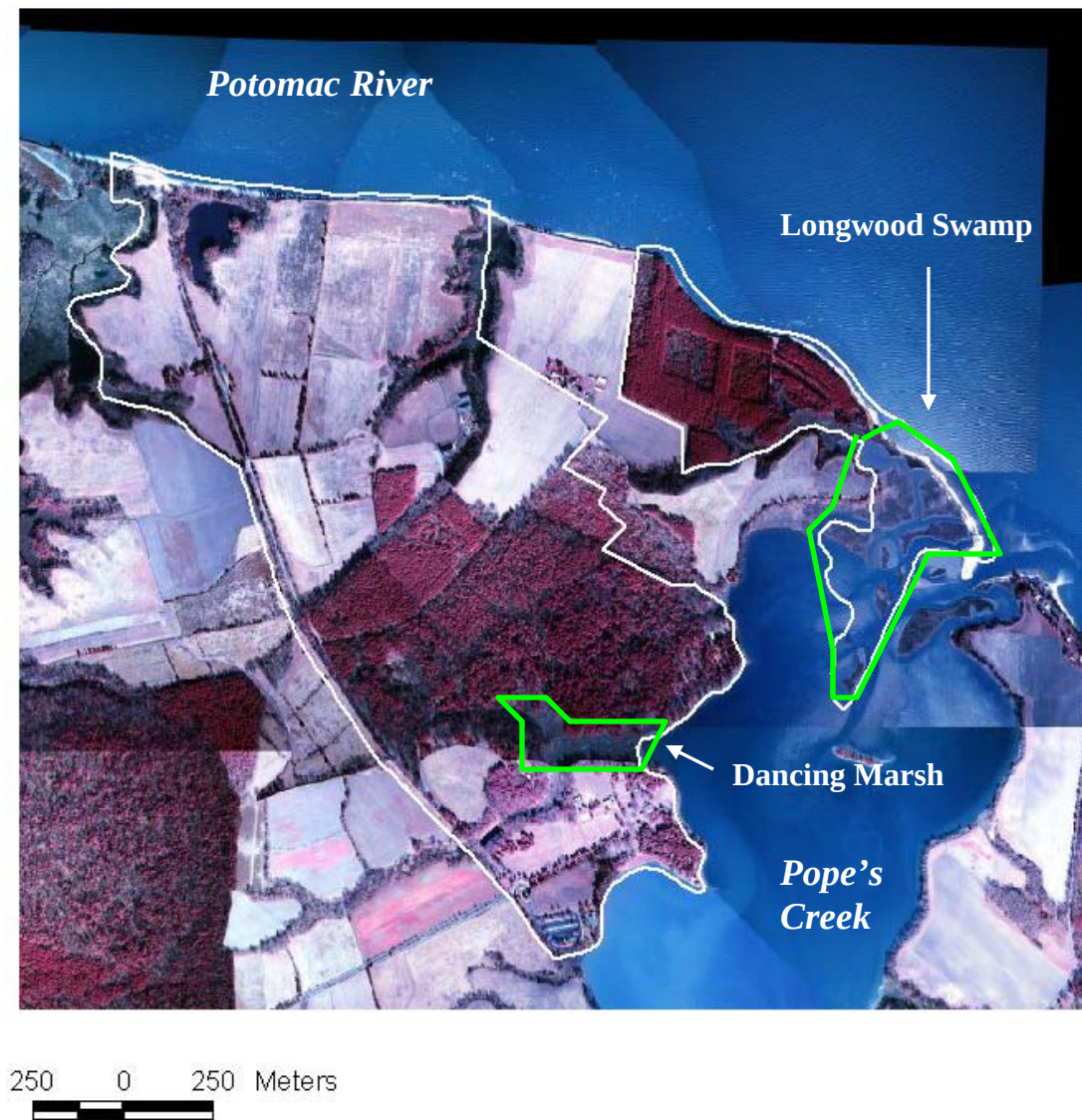


Figure 3-1. Map of George Washington Birthplace National Monument showing location of Dancing Marsh and Longwood Swamp.



Figure 3-2. Map of Longwood Swamp showing location of nekton sampling stations and vegetation plots (2005). Open squares and circles indicate stations that were estimated from maps based on field notes (GPS unit was lost during airline travel).

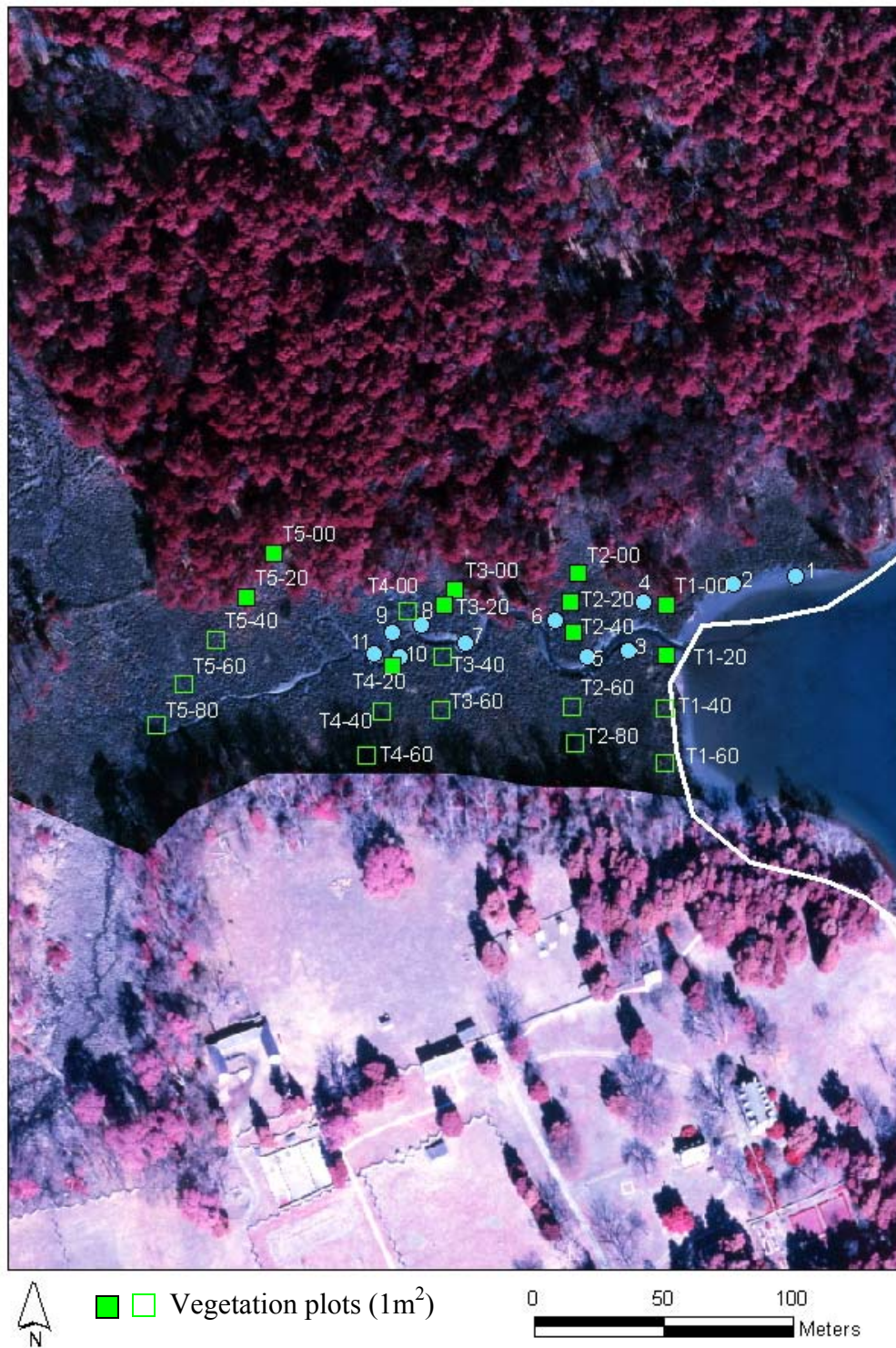


Figure 3-3. Map of Dancing Marsh showing location of nekton sampling stations and vegetation plots (2005). Open squares indicate stations that were estimated based on location of adjacent stations and field notes (GPS unit was lost during airline travel).

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Chapter 5 – Appendix

Table 5-1. Sampling station coordinates for GEWA

Table 5-2. Sampling station coordinates for ASIS

Figure 5-1. Throw trap data sheet

Figure 5-2. Point intercept vegetation data sheet

Figure 5-3. Visual cover estimate vegetation data sheet

Table 5-1 Coordinates for nekton and vegetation station locations sampled at ASIS in 2005, UTM, Zone 18, NAD 83, meters.

SITE	Sampling Variable	Station	UTM X (east)	UTM Y (north)
Moderate Grazing	Nekton	1	485778	4227475
		2	485735	4227437
		3	485715	4227384
		4	485711	4227322
		5	485785	4227314
		6	485842	4227314
		7	n/a	n/a
		8	485809	4227106
		9	485780	4227135
		10	485821	4227207
		11	485812	4227244
		12	485659	4227221
		13	485618	4227191
		14	485617	4227135
		15	485618	4227107
		1b	485494	4227603
		2b	485506	4227553
		3b	485615	4227486
		4b	485664	4227507
		5b	485691	4227532
		6b	485681	4227487
		7b	485734	4227499
	Vegetation	T1_00	485691	4227192
		T1_30	485690	4227161
		T1_60	485686	4227143
		T1_90	485687	4227105
		T1_120	485685	4227083
		T1_150	485679	4227052
		T2_00	485732	4227226
		T2_30	485734	4227204
		T2_60	485741	4227177
		T2_90	485753	4227147
		T2_120	485748	4227131
		T2_150	485761	4227092
		T2_180	485764	4227058
		T3_00	485810	4227260
		T3_30	485808	4227244

SITE	Sampling Variable	Station	UTM X (east)	UTM Y (north)
		T3_60	485814	4227227
		T3_90	485824	4227172
		T3_120	485832	4227149
		T4_00	485656	4227486
		T4_30	485665	4227521
		T4_60	485671	4227550
		T4_90	485686	4227582
		T4_120	485691	4227615
		T4_150	485706	4227637
		T5_00	485624	4227488
		T5_30	485633	4227521
		T5_90	485648	4227584
		T5_120	485657	4227608
North End	Vegetation	T1_00	490218	4239601
		T1_30	490236	4239593
		T1_60	490264	4239584
		T1-90	In exclosure	In exclosure
		T1_120	490314	4239576
		T1_150	490342	4239570
		T2_00	490231	4239685
		T2_30	490251	4239679
		T2_60	490274	4239669
		T2_90	490296	4239660
		T2_120	490316	4239650
		T2_150	490338	4239639
		T2_180	490363	4239629
		T3_00	490269	4239738
		T3_30	490297	4239736
		T3_60	490325	4239737
		T3_90	490355	4239733
		T3_120	490381	4239728
		T4_00	490339	4239831
		T4_30	490371	4239833
		T4_60	490399	4239839
		T4_90	490419	4239842
		T4_120	490444	4239842
		T4_150	490468	4239842
Valentine's	Nekton	1	481325	4216017
		2a	481267	4215994

SITE	Sampling Variable	Station	UTM X (east)	UTM Y (north)
		2b	n/a	n/a
		3	481229	4216030
		4a	481253	4216051
		4b	481246	4216042
		5	481265	4216099
		6a	481327	4216164
		6b	481340	4216150
		7	481354	4216124
		9	481460	4216056
		10	481493	4216065
		11	481489	4216089
		12	481508	4216127
		13	481475	4216180
		14	481547	4216223
		15	481502	4216169
		16	481507	4216163
Valentine	Vegetation	T1_00	481270	4216094
		T1_25	481265	4216064
		T1_50	481279	4216043
		T1_75	481280	4216016
		T1_100	481288	4215983
		T1_125	481293	4215954
		T2_00	481331	4216157
		T2_25	481337	4216129
		T2_50	481341	4216106
		T2_75	481343	4216077
		T2_100	481346	4216047
		T2_125	481345	4216022
		T2_150	481351	4216002
		T2_175	481354	4215979
		T3_00	481419	4216126
		T3_25	481417	4216096
		T3_50	481428	4216084
		T3_75	481430	4216059
		T3_100	481436	4216038
		T3_125	481441	4216020
		T4_00	481499	4216189
		T4_25	481500	4216158
		T4_50	481506	4216143
		T4_75	481509	4216119

SITE	Sampling Variable	Station	UTM X (east)	UTM Y (north)
		T5_00	481535	4216243
		T5_25	481544	4216205

Table 5-2. Coordinates for nekton and vegetation station locations sampled at ASIS in 2005, UTM, Zone 18, NAD 83, meters. * Indicates UTM coordinates of stations were estimated from GIS maps because original GPS coordinates were either unavailable (GPS unit was lost during airline travel) or did not match up with sampling locations as recalled by field technicians.

SITE	Sampling Variable	Station	UTM X (east)	UTM Y (north)
Dancing Marsh	Nekton	1	332198	4228385
		2	332174	4228382
		3	332133	4228356
		4	332139	4228375
		5	332117	4228354
		6	332105	4228368
		7	332070	4228359
		8	332053	4228366
		9	332042	4228363
		10	332045	4228354
		11	332035	4228355
	Vegetation	T1-00	332148	4228374
		T1-20	332148	4228354
		T1-40*	332148	4228334
		T1-60*	332147	4228313
		T2-00	332114	4228386
		T2-20	332111	4228375
		T2-40	332112	4228363
		T2-60*	332111	4228335
		T2-80*	332112	4228320
		T3-00	332066	4228380
		T3-20	332062	4228374
		T3-40*	332061	4228354
		T3-60*	332061	4228333
		T4-00*	332048	4228372
		T4-20	332042	4228350
		T4-40*	332037	4228333
		T4-60*	332032	4228316
		T5-00	331996	4228394
		T5-20	331985	4228377
		T5-40*	331974	4228361
		T5-60*	331961	4228343
		T5-80*	331951	4228328

SITE	Sampling Variable	Station	UTM X (east)	UTM Y (north)
Longwood	Nekton	1	332837	4228739
		2	332816	4228763
		3	332765	4228878
		4	332774	4228898
		5	332822	4228879
		6	332836	4228862
		7	332873	4228818
		8	332879	4228811
		15b	332953	4228926
		9*	332863	4229139
		10*	332882	4229123
		11*	332896	4229103
		12*	332933	4229108
		13*	332936	4229085
		14*	333038	4228971
	Vegetation	1	332861	4229118
		2	332906	4229028
		3	332838	4228950
		4	332838	4228873
		5	332821	4228848
		6	332767	4228893
		7	332824	4228791
		8	332842	4228754
		9*	332670	4228950
		10	332870	4228788
		11	332880	4228834
		12	332962	4228921
		13*	332866	4229146
		14*	332890	4229126
		15*	332899	4229111
		16*	332933	4229114
		17*	332943	4229081
		18*	333039	4228977
		19	332922	4228939
		20	332934	4228976
		21	333037	4228953

Throw Trap Data Sheet

SITE: _____ DATE: _____
 STATION #: _____ SAMPLING CREW: _____
 Coordinates: N: _____ E: _____
 Habitat Type: Pool/Panne Tidal Creek Plugged Ditch Open Ditch
 Aquatic Veg. Species & cover (if present) _____
 (cover classes: <1% 1-5% 5-10% 11-25% 26-50% 51-75% >75%)
 Time: _____ Water temp: _____ Salinity: _____ DO: _____
 Water Depth: _____ Tide: Flood or Ebb
NEKTON SPECIES & MEASUREMENTS
 SPECIES #1 _____ Total # of individuals: _____
 Talley (include measured fish): _____
 LENGTHS (15): _____
 SPECIES #2 _____ Total # of individuals: _____
 Talley (include measured fish): _____
 LENGTHS (15): _____
 SPECIES #3 _____ Total # of individuals: _____
 Talley (include measured fish): _____
 LENGTHS (15): _____
 SPECIES #4 _____ Total # of individuals: _____
 Talley (include measured fish): _____
 LENGTHS (15): _____
 SPECIES #5 _____ Total # of individuals: _____
 Talley (include measured fish): _____
 LENGTHS (15): _____

Figure 5-1. Throw trap data sheet

VEGETATION DATA SHEET (1m² point intercept method)

Site _____ Field Crew _____ Date _____ Time _____

Plot ID _____ Coord N: _____ Coord E: _____

Point-- record species, first row is for points 1-25, second row is for points 26-50.

SPECIES	1 26	2 27	3 28	4 29	5 30	6 31	7 32	8 33	9 34	10 35	11 36	12 37	13 38	14 39	15 40	16 41	17 42	18 43	19 44	20 45	21 46	22 47	23 48	24 49	25 50	Total Tally	
1.																											
2																											
3																											
4																											
5																											
6																											

Figure 5-2. Point intercept data sheet.

Visual Cover Estimate for Vegetation	
SITE _____	DATE _____
PLOT ID _____	TEAM _____
Comments _____	
Coordinates: N: _____ E: _____	
Braun-Blanquet Cover Classes: In 1996, 1998, 1999 we used cover class categories ranging from 1 to 7. In the Restoration Ecology MS we converted the 1-7 classes to 1-5 (1: <1-5%, 2: 6 to 25%)	
1: <1%	4: 10% to 25%
2: 1% to 5%	5: 26% to 50%
3: 6% to 10%	6: 51% to 75%
Species ID _____	Cover Class _____
#1 _____	_____
#2 _____	_____
#3 _____	_____
#4 _____	_____
#5 _____	_____
#6 _____	_____
#7 _____	_____
#8 _____	_____
#9 _____	_____
#10 _____	_____
#11 _____	_____
#12 _____	_____

Figure 5-3. Field data sheet for vegetation samples (visual cover estimate).