



The Distribution of Submersed Aquatic Vegetation in the Fresh and Oligohaline Tidal Potomac River, 2004

By Nancy B. Rybicki, Sarah H. Yoon, Edward R. Schenk and Julie B. Baldizar



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Conversion Factors

Multiply	By	To obtain
Length		
inch (in.)	2.54	centimeter (cm)
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
mile, nautical (nmi)	1.852	kilometer (km)
yard (yd)	0.9144	meter (m)
Area		
acre	4,047	square meter (m ²)
acre	0.4047	hectare (ha)
acre	0.4047	square hectometer (hm ²)
acre	0.004047	square kilometer (km ²)
hectare	0.01	square kilometer (km ²)
square foot (ft ²)	929	square centimeter (cm ²)
square foot (ft ²)	0.0929	square meter (m ²)
square inch (in ²)	6.452	square centimeter (cm ²)
section (640 acres or 1 square mile)	259	square hectometer (hm ²)
square mile (mi ²)	259	hectare (ha)
square mile (mi ²)	2.59	square kilometer (km ²)

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INTRODUCTION

Submersed aquatic vegetation (SAV) is a critical component of the Potomac River ecosystem. Though SAV provides important habitat for fauna and stabilizes bottom sediment, very dense beds may restrict recreational and commercial navigation. Exotic species of SAV are managed by the Metropolitan Washington Council of Governments Potomac Aquatic Plant Management Program (PAPMP). Selected beds of exotic SAV species that limit navigation are harvested mechanically. The program began in 1986 when approximately 40 acres of plants were harvested from 18 sites (Metropolitan Washington Council of Governments 1987).

Monitoring efforts are an effective means of quantifying the distribution and abundance of the exotic species, *Hydrilla verticillata* (hydrilla) and other SAV species. These annual surveys provide a basis for identifying large-scale changes throughout the ecosystem and allow managers to evaluate the effectiveness of resource management policies based on a reliable scientific foundation. The U.S. Geological Survey (USGS) has monitored the distribution and composition of SAV beds in the fresh and oligohaline (salinity 0.5 to 5) tidal Potomac River since 1978 using transect sampling (1978 to 1981, 1985 to 1987, and 2002) and shoreline surveys (1983 to 2004).

Shoreline survey data from the tidal Potomac River are incorporated into the Virginia Institute of Marine Science (VIMS) annual report on SAV distribution in Chesapeake Bay. The VIMS report and methods are available at <http://www.vims.edu/bio/sav>. Additional publications concerning SAV distribution in the Potomac River can be found at <http://water.usgs.gov/nrp/proj.bib/sav/wethome.htm>.

METHODS

The study area in the Potomac River was divided into three reaches: 1) upper tidal river (UTR) from Washington, DC to Dogue Creek, VA; 2) lower tidal river (LTR) from Dogue Creek, VA to Quantico, VA; and 3) upper oligohaline estuary (UOE) from Quantico, VA to the downriver side of Maryland Point, MD (Figs. 1 to 3).

Observations of species composition in SAV beds were done by boat at approximately low tide (± 2 hrs) so that plants were visible from the water surface.

Surveys were conducted between August and October 2004. We identified submersed plants to species level, recorded species composition of each bed, and estimated percent cover of each species within the bed. As in previous years, USGS monitored areas downriver of the Woodrow Wilson Bridge while colleagues at the Fisheries Division of the District of Columbia Department of Health (DCDOH) examined Washington, DC waters in the tidal Anacostia and Potomac River to the Maryland border near the Woodrow Wilson Bridge (Fig. 1, Rottman 1999; Ryan 2005).

The monitoring effort in 2004 consisted of a continuous survey of all shoals and observations of SAV beds within the multi-year study area (Figs. 4 to 10). SAV field beds are the isolated or contiguous SAV beds of different species composition sampled by boat. USGS personnel outlined SAV beds on 1:24,000 scale USGS quadrangle maps indicating location of all observations including unvegetated shoals (see Ruhl et al. 1998). DCDOH personnel used a global positioning system (GPS) to delineate the perimeter or length of beds and to record locations of each field bed. The SAV beds documented by the USGS and DCDOH were then entered into a geographic information system (GIS) to create maps of distribution and abundance (Figs. 1 to 10). The percent of each species, the Shannon diversity index, and the bed density for each field bed are listed in Table 1. The Shannon diversity index for each field bed is calculated as:

$$\text{Diversity} = -1 * \sum_{v=1}^M ((P_v/100) * \ln (P_v/100)) \quad 1$$

where M represents richness (the total number of species observed) and P_v represents the proportional coverage of each species. Diversity in each bed can range from 0.00 (if one species is present) to 2.49 (if all 12 species commonly found in the Potomac are present in equal percentages). Field bed observations, classified by the percent cover of *Hydrilla verticillata*, are shown in figures 1 to 3.

SAV beds shown in figures 11, 12, and 13 were delineated by VIMS based on aerial photographs, then digitized and classified for ground cover density. Density was determined using the Crown Density Scale adapted from Paine (1981). Bed densities range from one to four with one corresponding to less than 10% vegetation coverage, two representing between 10 and 40% coverage, three representing between 41 and 70% coverage and four corresponding to 71 to 100% coverage. The area and density of each photo-interpreted (PI) bed was determined by VIMS. The VIMS delineation process resulted in bed area outlines to which we have added corresponding field data on species composition. However, the VIMS SAV coverage data did not include field beds below their detection limit (approximately 5 m²).

The percent of each species in the three river reaches of the continuous shoreline survey is summarized in the results section. The area of each species is computed based on a weighted-average formula. During the shoreline survey, we made field observations of species composition within a VIMS PI bed. Using GIS software, we aligned each of the field beds with the PI beds to determine the area of each field bed and subsequently to calculate the coverage by species in each PI bed where species data were available. If more than one field observation was made in a PI bed, we sub-divided the PI bed area according to the relative size of each field bed and averaged species data proportionally to determine the percentage of each species in a PI bed and in the cumulative area of the study in each river reach (Rybicki 2000, Rybicki and Landwehr, 2007).

RESULTS

SAV coverage increased in all three river reaches between 2003 and 2004 (Figs. 14 and 15). Hydrilla dominated many of the field beds (Fig. 1 to 3). The shoreline survey included 170 observations of field beds of various sizes (12 m² to approximately 236 ha) and density (Table 1). The species and percent cover data shown in Table 1 correspond to field bed locations shown in Figs. 4 to 10. Several of the harvest sites in the UTR, LTR, and UOE had SAV densities of 70 to 100 % cover (Fig. 11 to 13) and the beds were comprised of exotic species (Table 1; Figs. 1 to 3). Of the nine species observed in the Potomac River in 2004, three are exotic (hydrilla, *Myriophyllum spicatum* [milfoil], *Najas minor* [naiad]). Hydrilla dominated (> 40 % of the coverage) the UTR and the LTR, and milfoil dominated the UOE. Naiad coverage was minimal (< 1 %) in the UTR and UOE but was 7 % of the LTR SAV coverage. Two native species, *Vallisneria americana* (wild celery) and *Ceratophyllum demersum* (coontail) were abundant but did not dominate any river segment. Wild celery comprised 15 % of the UTR, 19 % of the LTR, and only 1 % of the UOE SAV coverage. Coontail coverage was 10 % of the UTR and LTR, but only 2% of the UOE SAV coverage. Some species were relatively rare, namely the macroalga *Chara vulgaris* (muskgrass), *Najas quadalupensis* (southern naiad), *Elodea canadensis* (waterweed), and *Heteranthera dubia* (stargrass)). In 2004, precipitation and river flow were above average, yet the total SAV coverage increased.

UPPER TIDAL POTOMAC RIVER (UTR)

In the UTR, we found the following seven SAV species, in order from most to least abundant: 65 % hydrilla, 15 % wild celery, 10 % milfoil, 10 % coontail, <1 % naiad or southern naiad, and traces of muskgrass. Compared to 2003, hydrilla, coontail, and wild celery coverage increased substantially in this region.

In Washington, DC, SAV coverage fell sharply in 2003 but recovered somewhat in 2004. VIMS photo-interpretation did not register a single bed in 2004 (Fig. 11) and field observations revealed only 18 beds (Fig. 1): all less than 70 % cover (Table 1). The few beds that were present were typically single-species beds and contained either hydrilla or wild celery (Figs. 1 and 4; Table 1).

For the second year in a row, large, dense beds were absent in the middle of the Potomac River around the Woodrow Wilson Bridge and at the mouth of Hunting Creek (Figs. 5 and 11). Vegetation was patchy and consisted mostly of hydrilla along the Virginia side of the Potomac River downstream of Hunting Creek (Figs. 1, 2, 11, and 12).

Many beds on the mainstem of the Potomac were dominated by wild celery or milfoil, whereas hydrilla alone dominated beds within Broad, Piscataway, and Dogue Creeks (Figs. 2 and 6; Table 1). A substantial bed at the mouth of Dogue Creek contained 80 % wild celery (Figs. 2 and 6). Wild celery also was the dominant species in beds in the main stem of the Potomac River downstream of Dogue Creek to the end of the UTR reach (Figs. 2 and 6).

Swan Creek supported one of the few populations of muskgrass in the study area. Muskgrass was present in several beds opposite Broad Creek. Coontail rarely dominated field beds except in one site along Swan Creek. Southern naiad was present in Dogue Creek and in the mouth of Little Hunting Creek.

LOWER TIDAL POTOMAC RIVER (LTR)

In the LTR we found seven SAV species: 49 % hydrilla, 19 % wild celery, 15 % milfoil, 10 % coontail, 7 % naiad, and <1 % southern naiad or muskgrass. Wild celery, coontail, and naiad coverage increased between 2003 and 2004 at the expense of hydrilla and milfoil. In contrast to 2003, muskgrass was present and stargrass was absent in 2004.

Wild celery was dominant along the upstream shore of Gunston Cove whereas hydrilla was abundant in the large, innermost beds (Figs. 2 and 6; Table 1). The narrow, fringing beds on the downstream shore of Gunston Cove were dominated by milfoil. In 2003 milfoil dominated, but in 2004, wildcelery dominated the Maryland side of the Potomac, across from Gunston Cove and south to Pomonkey Creek (Figs. 2 and 6; Table 1).

The vegetation around Mason Neck and in Pomonkey Creek was primarily wild celery (Figs. 2, 6) as it was in 2003. SAV was sparse at Indian Head and between Pomonkey Creek and Mattawoman Creek, and consisted mainly of milfoil. Little change in species composition was observed between 2003 and 2004 (Figs. 2 and 7; Table 1).

The majority of shoals in Mattawoman Creek were vegetated in 2004, as in 2003 (Fig. 12). At the mouth of the creek, milfoil and wild celery were abundant, although dominance by hydrilla was noted for most beds further upstream (Figs. 2 and 7; Table 1). Southern naid and coontail dominated several beds in this creek.

Chicamuxen Creek was densely vegetated in 2004, as in most years, and contained large amounts of milfoil (Figs. 2, 8, and 12; Table 1). Chicamuxen Creek had some of the more diverse beds in 2004 and included southern naiad and muskgrass; two of the rarest species in the three study reaches.

Hydrilla was the most abundant species in the Occoquan River and naiad dominated Belmont Bay (Figs. 2 and 7; Table 1). Hydrilla also was the dominant species in beds at the mouth of Neabsco Creek and in Powells Creek (Figs. 2 and 7). Wild celery was the dominant SAV in outer beds and hydrilla dominated inner, nearshore beds in the Potomac River upstream of Quantico Creek (Fig. 7). Hydrilla was dominant in Quantico Creek.

UPPER OLIGOHALINE POTOMAC RIVER ESTUARY (UOE)

Seven SAV species were present in 2004 in this reach with the following composition: 63 % milfoil, 32 % hydrilla, 1 % wild celery, 2 % coontail, < 1 % naiad, and a trace of waterweed and stargrass. The percentage of milfoil has increased substantially in recent years in this river segment. In contrast to 2003, waterweed and stargrass were present in 2004 and southern naiad was absent.

Milfoil was dominant on the Maryland side of the Potomac, present within 4 km of the upstream boundary of the UOE and in the bay north of Wades Bay (Figs. 3 and 8;

Table 1). Milfoil and wild celery were common in Wades Bay (Figs. 3, 8, 9, and 10; Table 1) whereas hydrilla dominated the Mallows Bay bed (Figs. 3 and 8).

Hydrilla was the most abundant species in the cove just south of Quantico, VA. South from Quantico, for approximately 6 km, beds of hydrilla and milfoil were equally abundant or alternated dominance. Milfoil dominated the Virginia shoreline for the 6 km north of the mouth of Aquia Creek (Figs. 3, 8, and 9). Within Aquia Creek, hydrilla or milfoil were the dominant species (Figs. 3 and 9; Table 1).

Between Aquia and Potomac Creeks, and in the mouth of Potomac Creek, milfoil was common and there were small amounts of hydrilla, coontail, and naiad (Figs. 3, 9, 10; Table 1). In the upper portion of Potomac Creek, hydrilla was the lone species in 2004 (Fig. 10).

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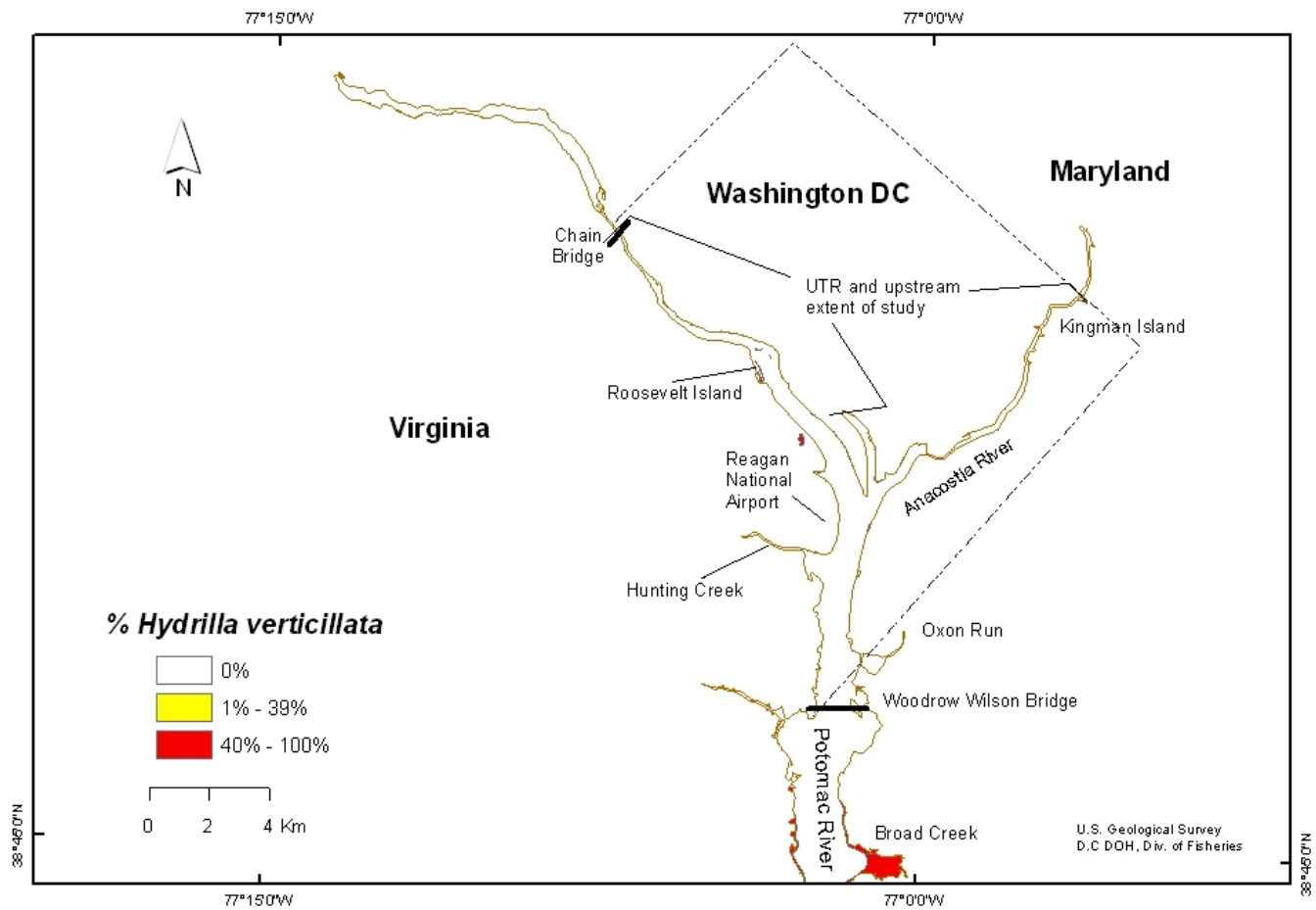


Figure 1 Percent cover of hydrilla in SAV beds located in the tidal Potomac River from Washington, DC to Broad Creek, MD, 2004. UTR is the Upper Tidal River study segment.

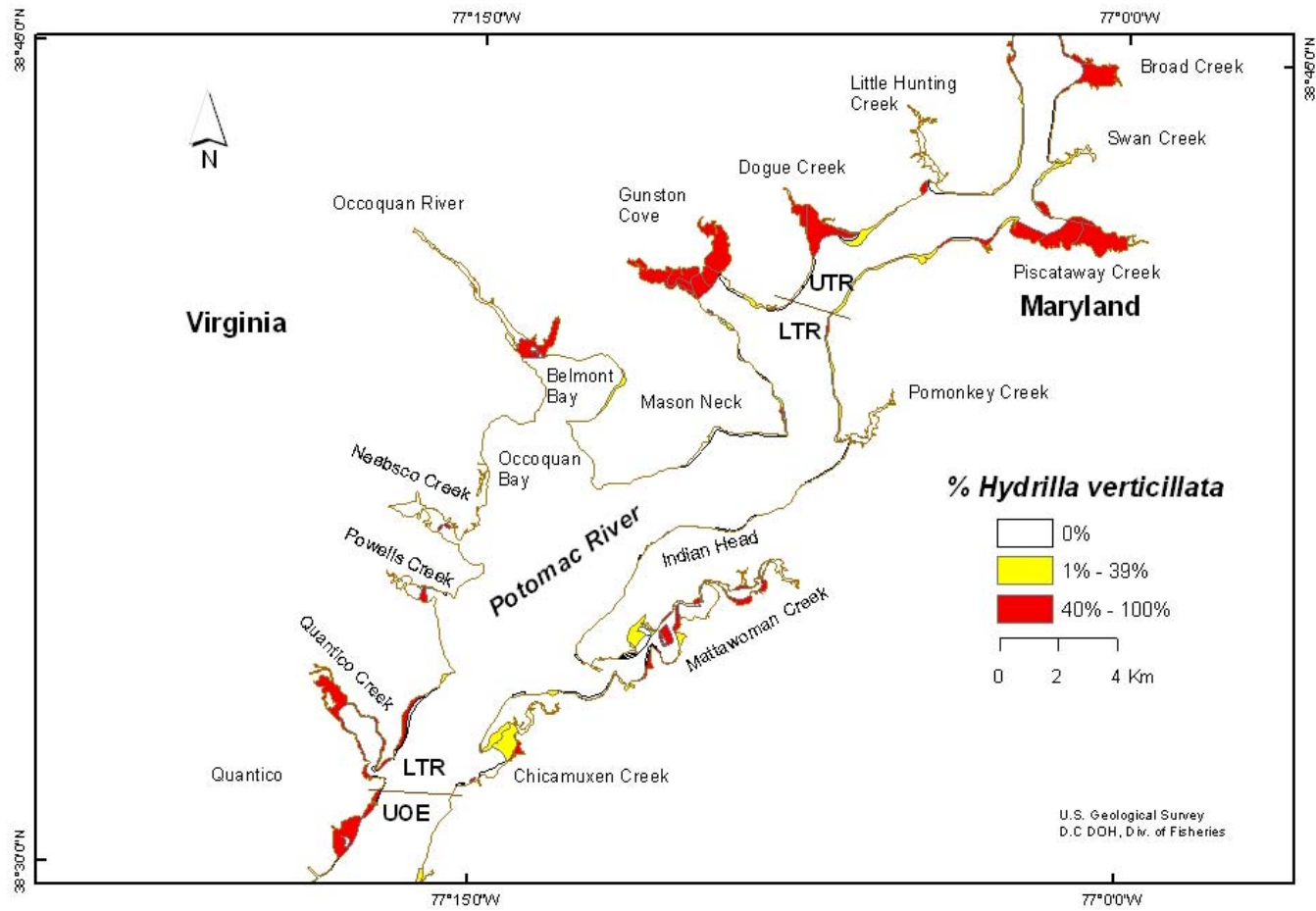


Figure 2 Percent cover of hydrilla in SAV beds located in the tidal Potomac River from Broad Creek, MD to Chicamuxen Creek, MD, 2004. Study segments are the Upper Tidal River (UTR), Lower Tidal River (LTR), and Upper Oligohaline Estuary (UOE).

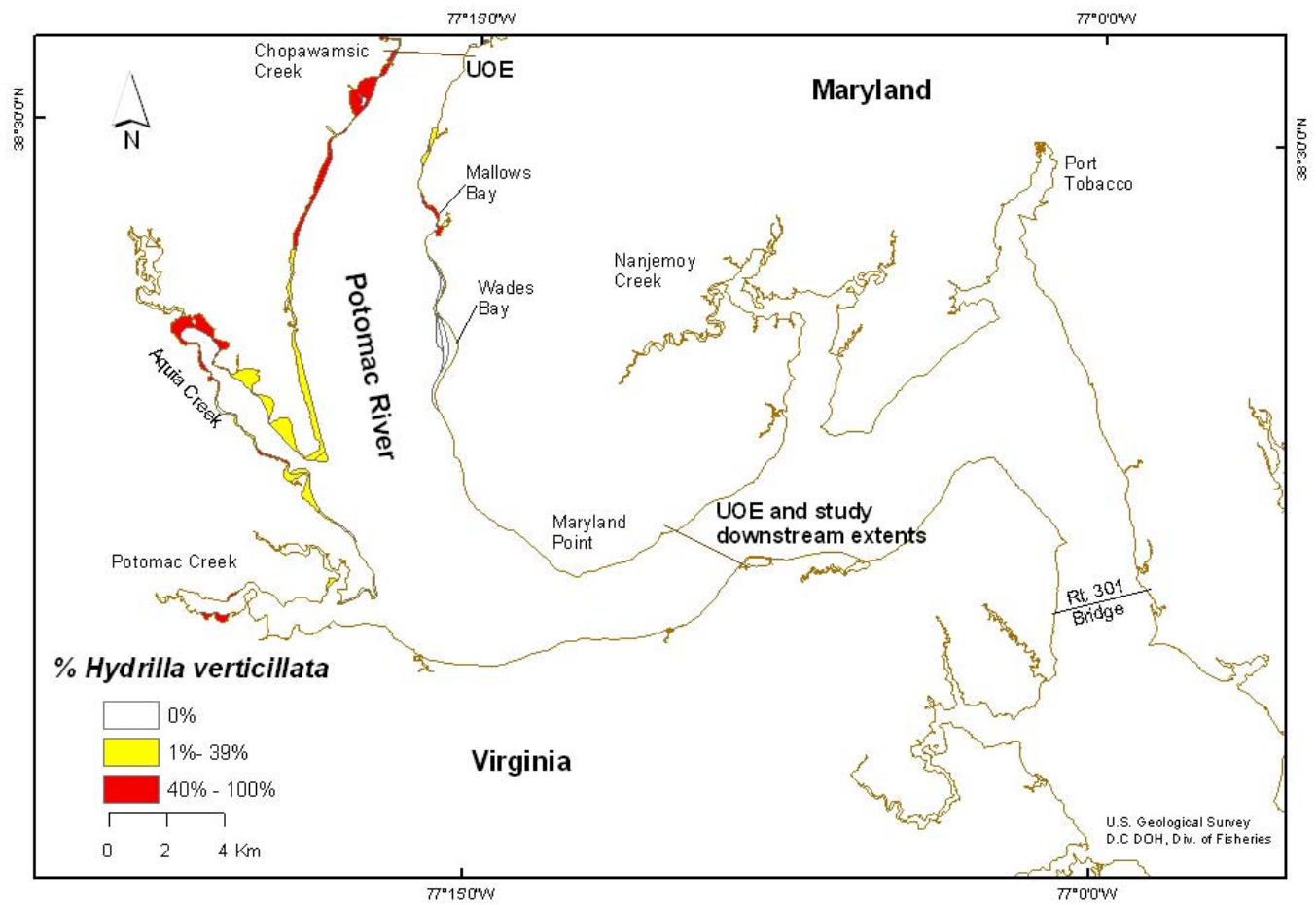


Figure 3 Percent cover of hydrilla in SAV beds located in the tidal Potomac River from Chopawamsic Creek, VA to the end of the river segment, 2004. UOE is the Upper Oligohaline Estuary study segment.

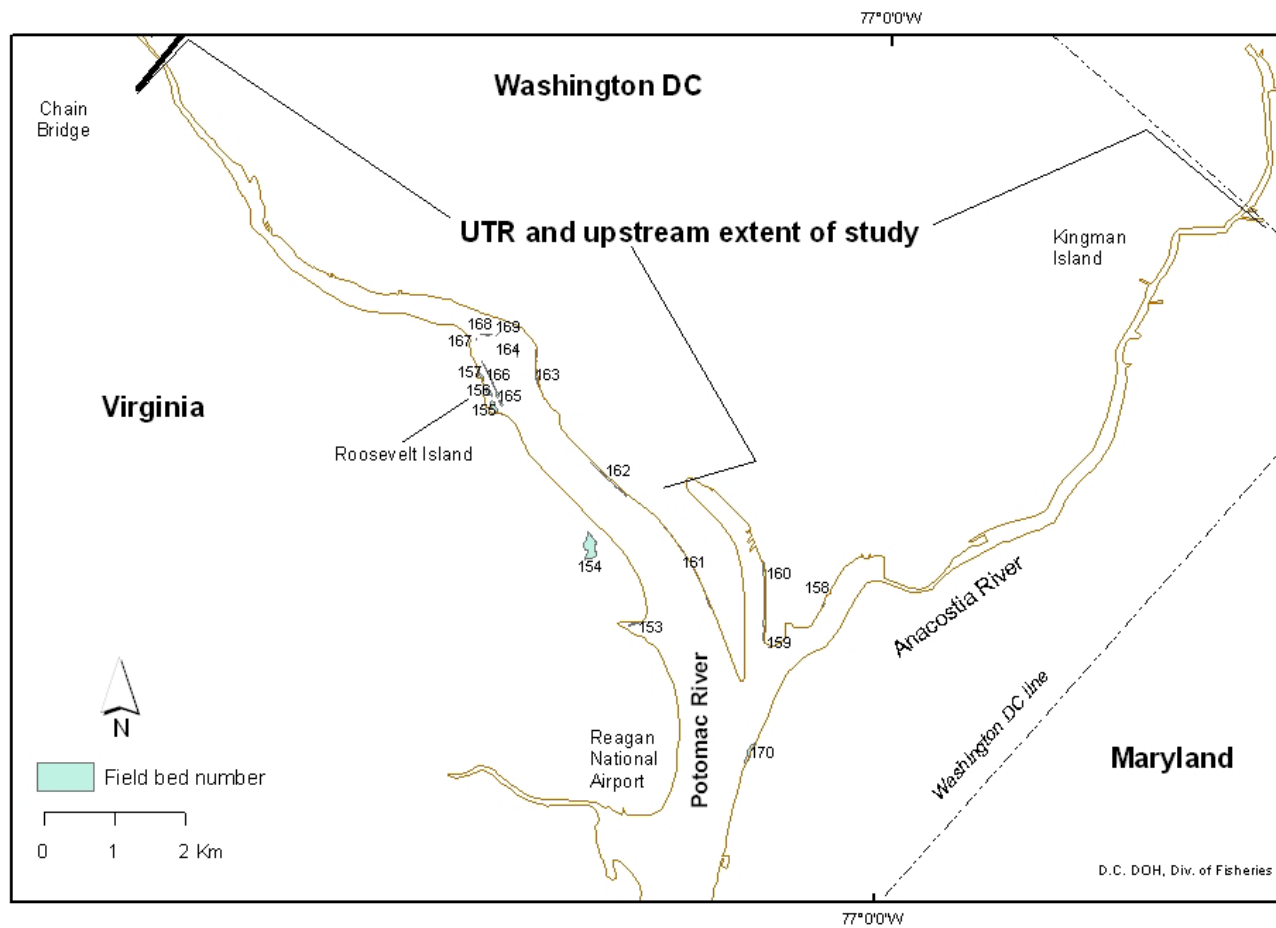


Figure 4 Location of each field bed in a continuous shoreline survey of Washington, DC, 2004. UTR is the Upper Tidal River study segment.

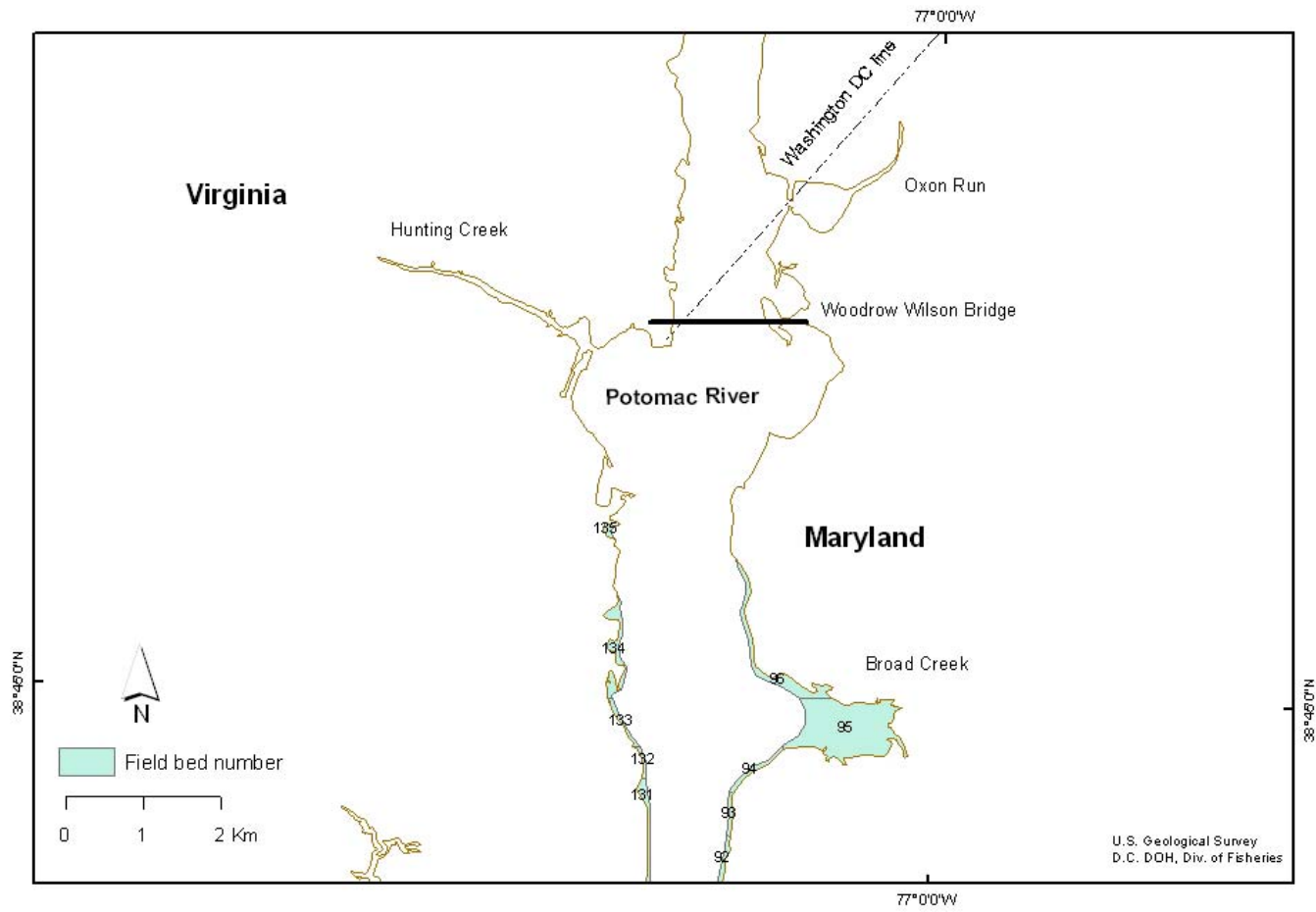


Figure 5 Location of each field bed in a continuous shoreline survey from Washington, DC to Broad Creek, MD, 2004.

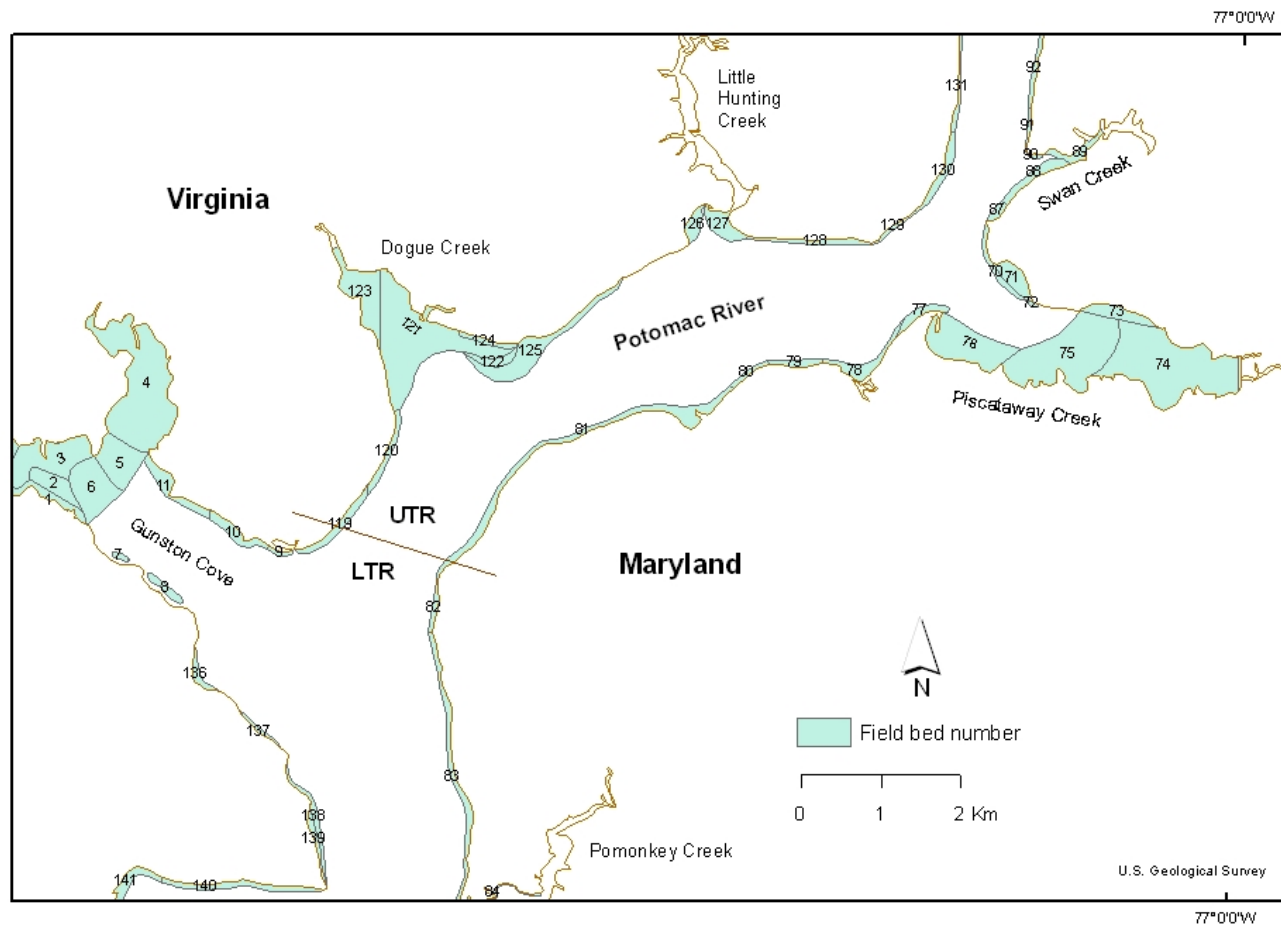


Figure 6 Location of each field bed in a continuous shoreline survey from Swan Creek, MD to Gunston Cove, VA, 2004. River segments are the Upper Tidal River (UTR) and Lower Tidal River (LTR).

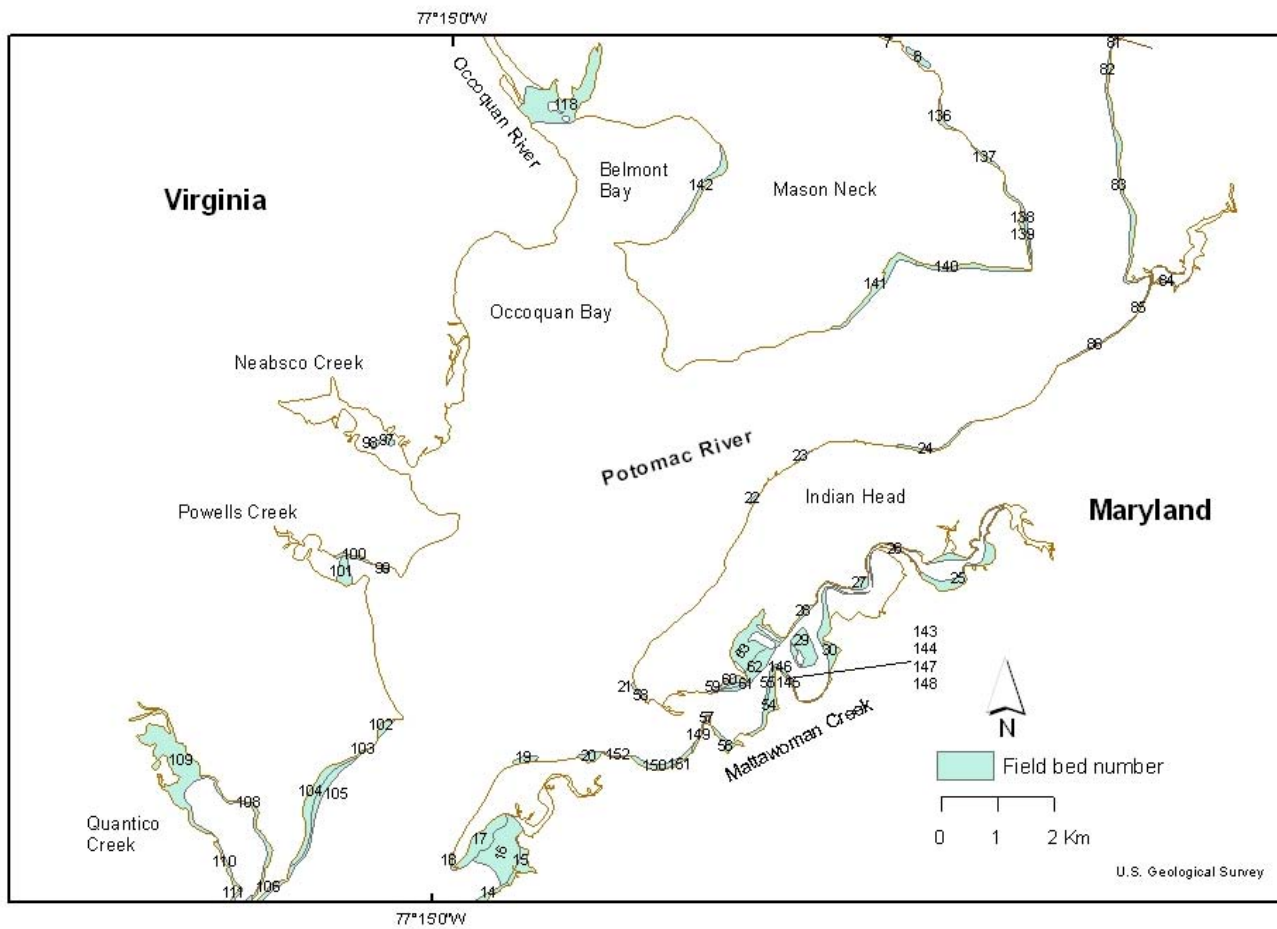


Figure 7 Location of each field bed in a continuous shoreline survey from Mason Neck, VA to Quantico Creek, VA, 2004.

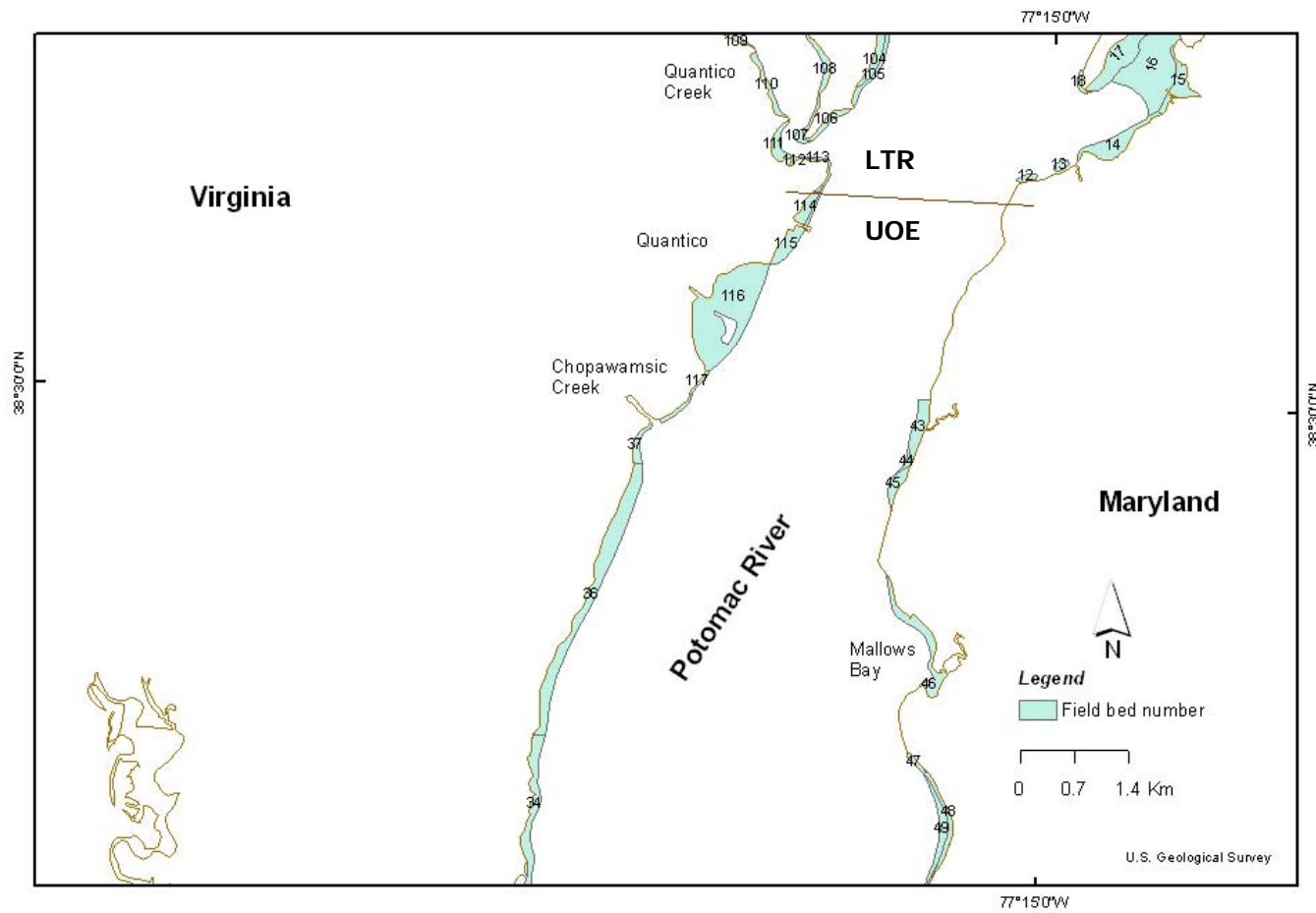


Figure 8 Location of each field bed in a continuous shoreline survey near Quantico, VA and Mallovs Bay, MD, 2004. River segments are the Lower Tidal River (LTR) and Upper Oligohaline Estuary (UOE).

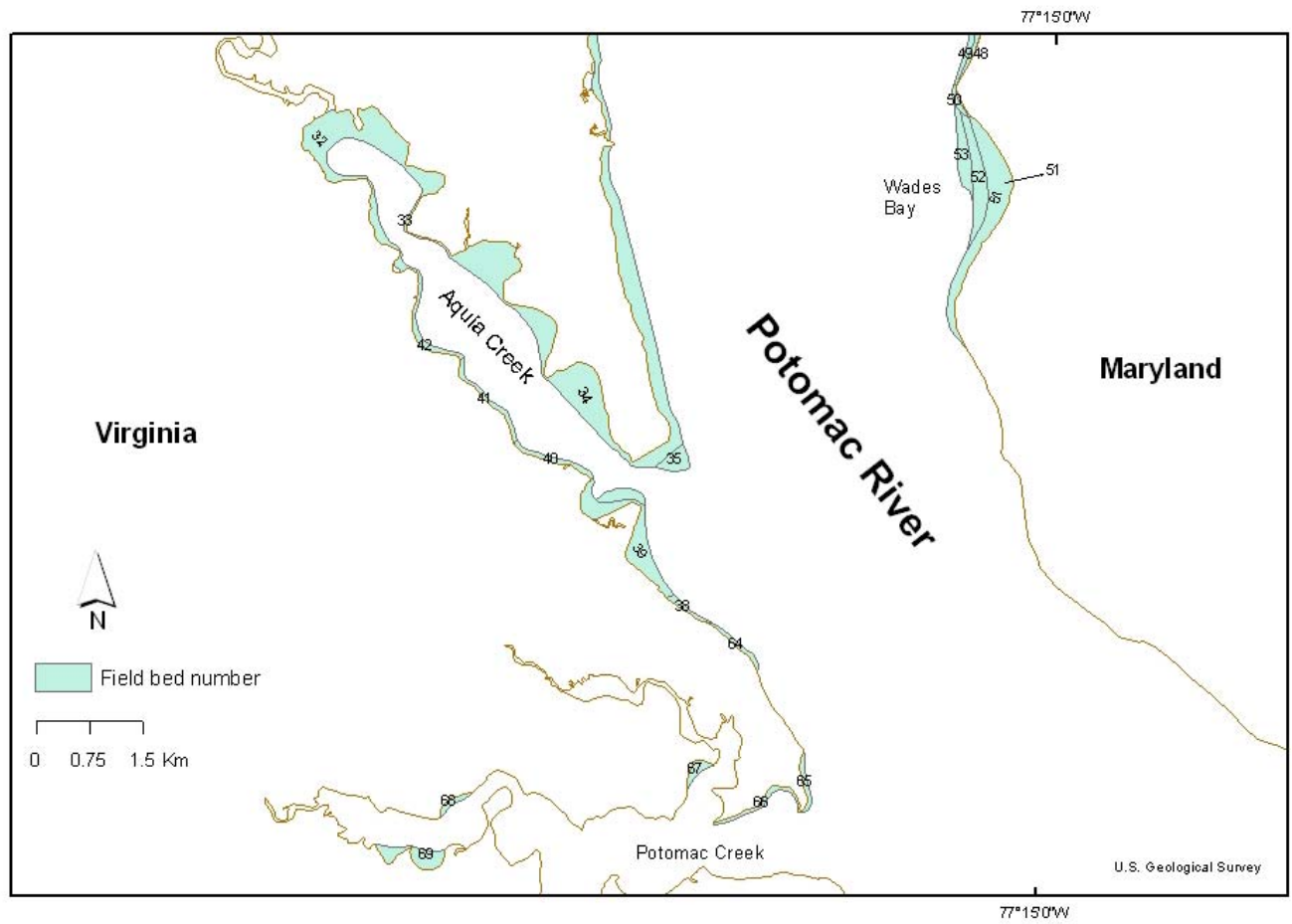


Figure 9 Location of each field bed in a continuous shoreline survey from Wades Bay, MD to Potomac Creek, VA, 2004.

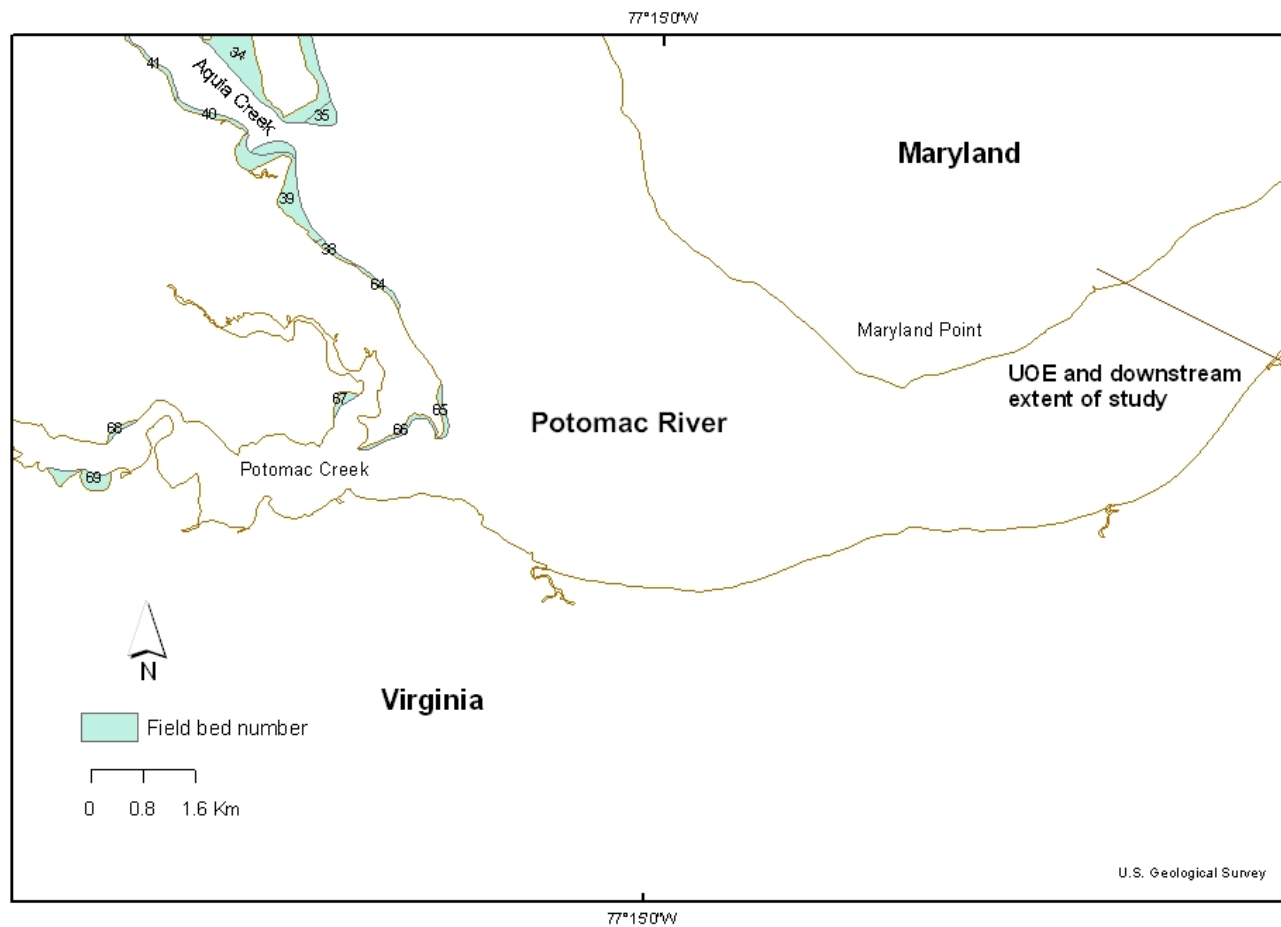


Figure 10

Location of each field bed in a continuous shoreline survey from Aquia Creek, VA to the end of the river segment, 2004. UOE is the Upper Oligohaline Estuary river segment.

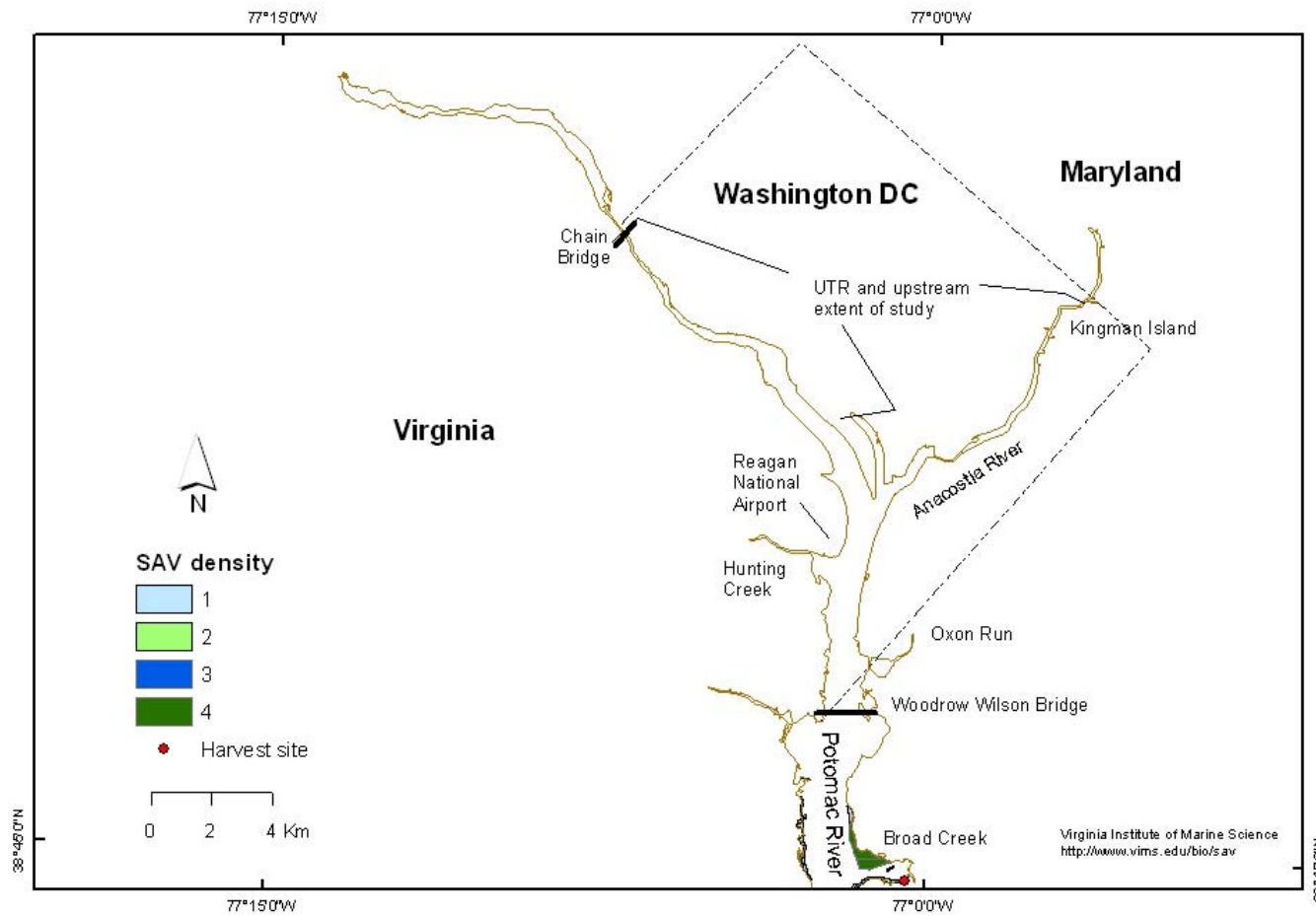


Figure 11 Distribution and density of submersed aquatic vegetation and the locations of the Aquatic Plant Management harvest sites in the tidal Potomac River from Washington, DC to Broad Creek, MD, 2004. UTR is the Upper Tidal River study segment.

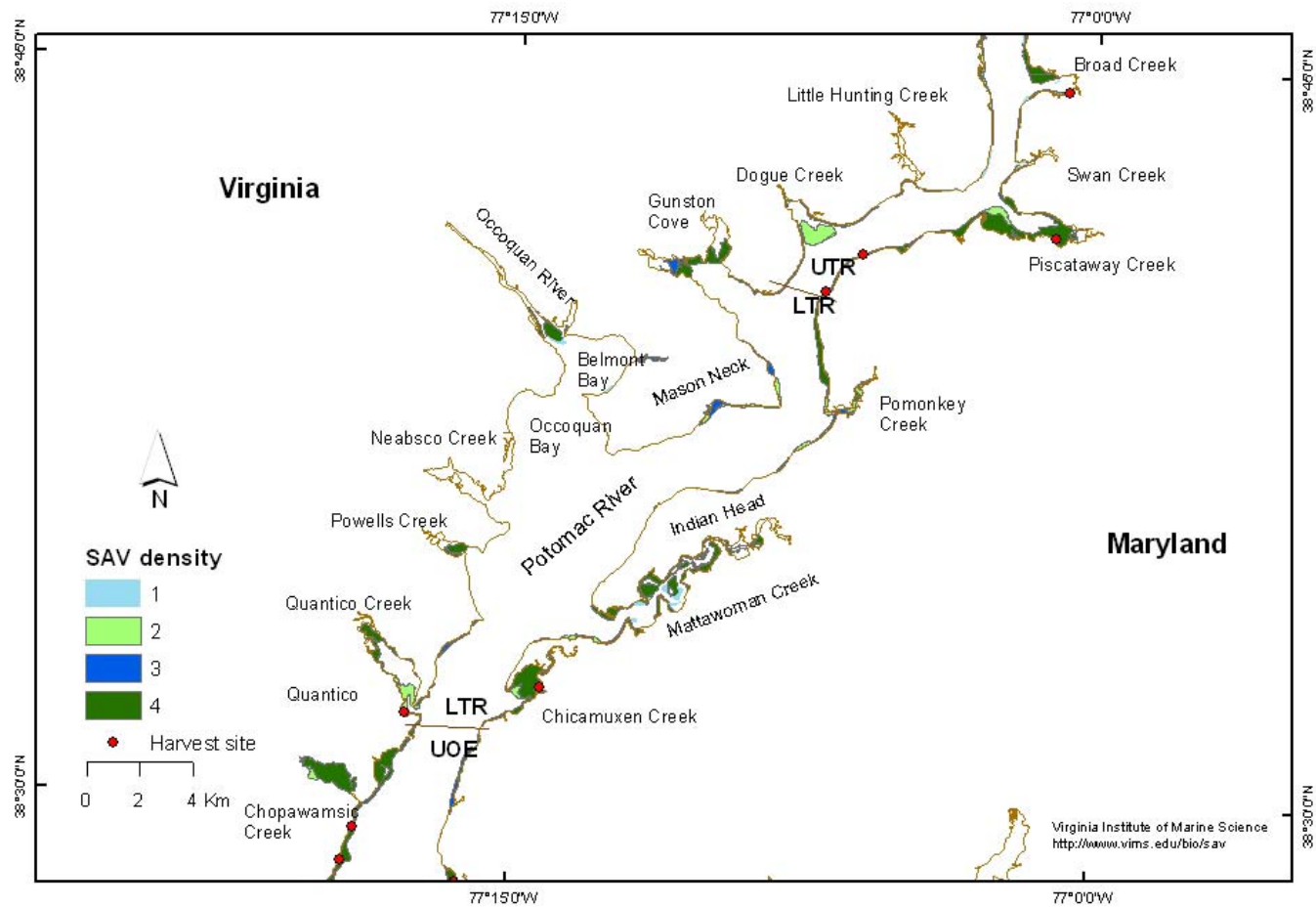


Figure 12 Distribution and density of submersed aquatic vegetation and the locations of the Aquatic Plant Management harvest sites in the tidal Potomac River from Broad Creek, MD to Chopawamsic Creek, VA, 2004. The river segments are the Upper Tidal River (UTR), Lower Tidal River (LTR), and the Upper Oligohaline Estuary (UOE).

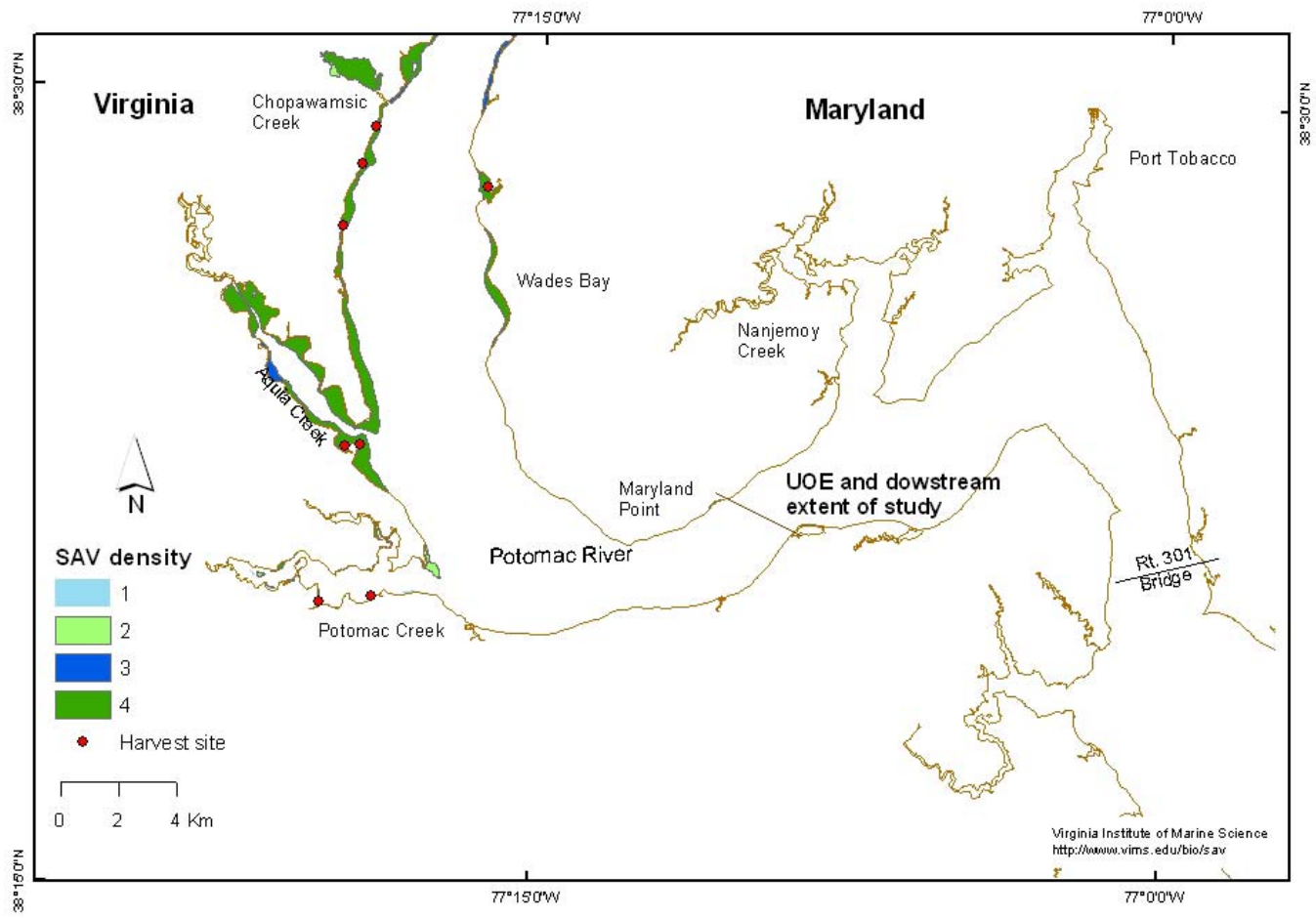


Figure 13 Distribution and density of submersed aquatic vegetation and the locations of the Aquatic Plant Management harvest sites in the tidal Potomac River from Chopawamsic Creek, VA to the downstream extent of the study, 2004. UOE is the Upper Oligohaline Estuary study segment.

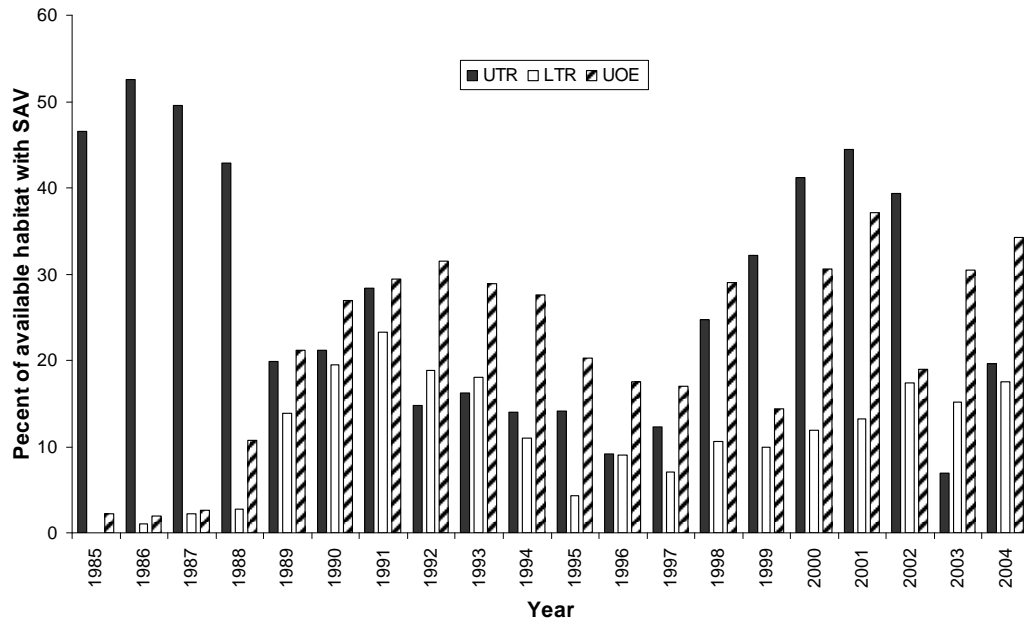


Figure 14 Percent of available habitat (area less than 2m in depth) that was vegetated in each river segment (UTR, LTR, and UOE) from 1985 to 2004. The UTR, LTR, and UOE have 2956, 5173, and 3,355 hectares of available habitat, respectively.

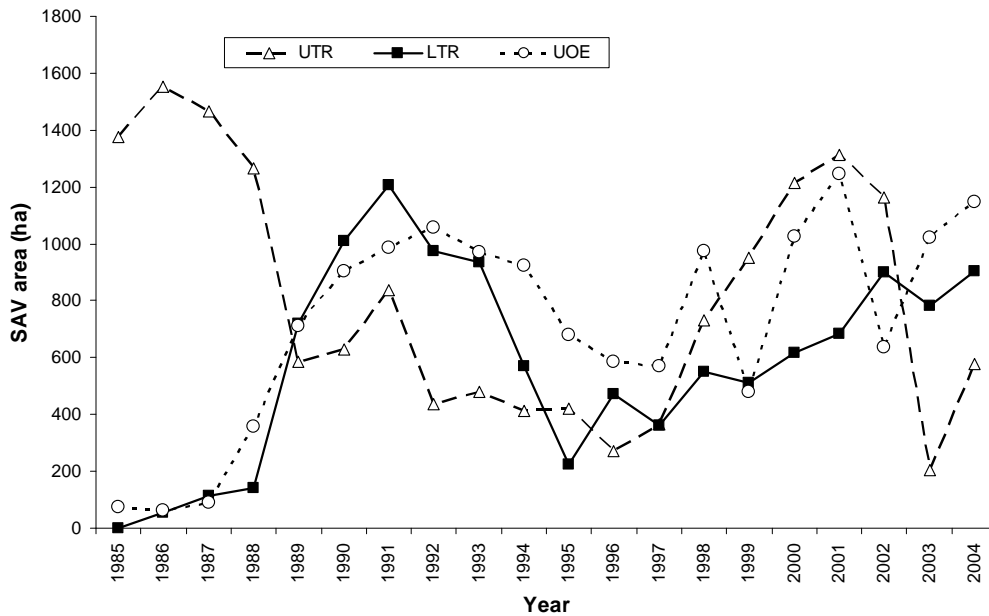


Figure 15 Area occupied by submersed aquatic vegetation (SAV) for each river segment (UTR, LTR, and UOE) from 1985 to 2004. SAV area from Virginia Institute of Marine Science (<http://www.vims.edu/bio/sav/historical.html>) except from US Geological Survey in 1988 (Rybicki and Landwehr, 2007).

Table 1. Percent canopy cover of each species and Shannon diversity index for field beds located continuously along the shoreline in the tidal Potomac River, 2004. Field bed numbers correspond to the numbers in Figs. 4 to 10. Density classes are USGS field data based on a Braun-Blanquet crown cover model where: 1 = 1 to 10 %, 2 = 11 to 40 %, 3 = 41 to 70 %, and 4 = 71 to 100 % cover. Percent cover of each species in a bed is abbreviated as: P_HV (hydrilla), P_MS (milfoil), P_VA (wild celery), P_CD (coontail), P_NM (naiad), P_NGU (southern naiad), P_HD (stargrass), P_EC (common waterweed), and P_CV (muskgrass). USGS is U.S. Geological Survey and DOH is DC Dept. of Health.

Survey date	Field bed number	Data source	USGS quad	Density class	P_HV	P_MS	P_VA	P_CD	P_NM	P_NGU	P_HD	P_EC	P_CV	Div
8/10/2004	1	USGS	Ft. Belvoir	4	100	0	0	0	0	0	0	0	0	0.00
8/10/2004	2	USGS	Ft. Belvoir	3	99	1	0	0	0	0	0	0	0	0.06
8/10/2004	3	USGS	Ft. Belvoir	3	100	0	0	0	0	0	0	0	0	0.00
8/10/2004	4	USGS	Ft. Belvoir	4	99	0	0	1	0	0	0	0	0	0.06
8/10/2004	5	USGS	Ft. Belvoir	3	99	0	0	1	0	0	0	0	0	0.06
8/10/2004	6	USGS	Ft. Belvoir	1	100	0	0	0	0	0	0	0	0	0.00
8/10/2004	7	USGS	Ft. Belvoir	3	45	50	5	0	0	0	0	0	0	0.86
8/10/2004	8	USGS	Ft. Belvoir	1	25	75	0	0	0	0	0	0	0	0.56
8/10/2004	9	USGS	Ft. Belvoir	4	0	0	100	0	0	0	0	0	0	0.00
8/10/2004	10	USGS	Ft. Belvoir	4	5	0	40	10	45	0	0	0	0	1.11
8/10/2004	11	USGS	Ft. Belvoir	4	0	0	75	0	25	0	0	0	0	0.56
8/16/2004	12	USGS	Quantico	3	0	0	95	0	5	0	0	0	0	0.20
8/16/2004	13	USGS	Indian Head	3	40	19	40	0	1	0	0	0	0	1.09
8/16/2004	14	USGS	Indian Head	4	0	100	0	0	0	0	0	0	0	0.00
8/16/2004	15	USGS	Indian Head	4	45	5	5	15	20	5	0	0	5	1.56
8/16/2004	16	USGS	Indian Head	4	3	60	0	35	3	0	0	0	0	0.86
8/16/2004	17	USGS	Indian Head	4	34	5	0	30	31	0	0	0	0	1.24
8/16/2004	18	USGS	Indian Head	3	10	0	90	0	0	0	0	0	0	0.33
8/16/2004	19	USGS	Indian Head	2	0	40	60	0	0	0	0	0	0	0.67
8/16/2004	20	USGS	Indian Head	4	10	20	70	0	0	0	0	0	0	0.80
8/16/2004	21	USGS	Indian Head	1	0	0	100	0	0	0	0	0	0	0.00
8/16/2004	22	USGS	Indian Head	1	0	100	0	0	0	0	0	0	0	0.00
8/16/2004	23	USGS	Indian Head	1	15	75	10	0	0	0	0	0	0	0.73

Table 1 – continued. Percent canopy cover of each species and Shannon diversity index for field beds located continuously along the shoreline in the tidal Potomac River, 2004. Field bed numbers correspond to the numbers in Figs. 4 to 10. Density classes are USGS field data based on a Braun-Blanquet crown cover model where: 1 = 1 to 10 %, 2 = 11 to 40 %, 3 = 41 to 70 %, and 4 = 71 to 100 % cover. Percent cover of each species in a bed is abbreviated as: P_HV (hydrilla), P_MS (milfoil), P_VA (wild celery), P_CD (coontail), P_NM (naiad), P_NGU (southern naiad), P_HD (stargrass), P_EC (common waterweed), and P_CV (muskgrass). USGS is U.S. Geological Survey and DOH is DC Dept. of Health.

Survey date	Field bed number	Data source	USGS quad	Density class	P_HV	P_MS	P_VA	P_CD	P_NM	P_NGU	P_HD	P_EC	P_CV	Div
8/16/2004	24	USGS	Indian Head	2	0	50	50	0	0	0	0	0	0	0.69
9/8/2004	25	USGS	Indian Head	4	99	0	0	1	0	0	0	0	0	0.06
9/8/2004	26	USGS	Indian Head	4	75	0	20	3	3	0	0	0	0	0.72
9/8/2004	27	USGS	Indian Head	4	90	0	0	3	8	0	0	0	0	0.38
9/8/2004	28	USGS	Indian Head	3	95	0	0	5	0	0	0	0	0	0.20
9/8/2004	29	USGS	Indian Head	4	70	3	3	3	23	0	0	0	0	0.86
9/8/2004	30	USGS	Indian Head	4	30	0	0	70	0	0	0	0	0	0.61
9/24/2004	32	USGS	Widewater	4	99	1	0	0	0	0	0	0	0	0.06
9/24/2004	33	USGS	Widewater	3	97	2	0	1	0	0	0	0	0	0.15
9/24/2004	34	USGS	Widewater	3	1	99	0	0	0	0	0	0	0	0.06
9/24/2004	35	USGS	Widewater	4	25	70	5	0	0	0	0	0	0	0.75
9/24/2004	36	USGS	Widewater	4	43	50	1	1	5	0	1	0	0	0.97
9/24/2004	37	USGS	Widewater	4	40	57	0	2	1	0	0	0	0	0.81
9/24/2004	38	USGS	Widewater	4	10	89	1	1	1	0	0	0	0	0.42
9/24/2004	39	USGS	Widewater	4	20	80	0	0	0	0	0	0	0	0.50
9/24/2004	40	USGS	Widewater	4	98	2	0	0	0	0	0	0	0	0.10
9/24/2004	41	USGS	Widewater	4	1	99	0	0	0	0	0	0	0	0.06
9/24/2004	42	USGS	Widewater	3	0	100	0	0	0	0	0	0	0	0.00
10/12/2004	43	USGS	Widewater	2	30	70	0	0	0	0	0	0	0	0.61
10/12/2004	44	USGS	Widewater	2	0	0	40	60	0	0	0	0	0	0.67
10/12/2004	45	USGS	Widewater	2	30	65	0	5	0	0	0	0	0	0.79
10/12/2004	46	USGS	Widewater	3	60	30	0	10	0	0	0	0	0	0.90

Table 1 – continued. Percent canopy cover of each species and Shannon diversity index for field beds located continuously along the shoreline in the tidal Potomac River, 2004. Field bed numbers correspond to the numbers in Figs. 4 to 10. Density classes are USGS field data based on a Braun-Blanquet crown cover model where: 1 = 1 to 10 %, 2 = 11 to 40 %, 3 = 41 to 70 %, and 4 = 71 to 100 % cover. Percent cover of each species in a bed is abbreviated as: P_HV (hydrilla), P_MS (milfoil), P_VA (wild celery), P_CD (coontail), P_NM (naiad), P_NGU (southern naiad), P_HD (stargrass), P_EC (common waterweed), and P_CV (muskgrass). USGS is U.S. Geological Survey and DOH is DC Dept. of Health.

Survey date	Field bed number	Data source	USGS quad	Density class	P_HV	P_MS	P_VA	P_CD	P_NM	P_NGU	P_HD	P_EC	P_CV	Div
10/12/2004	47	USGS	Widewater	2	0	99	0	0	0	0	0	1	0	0.06
10/12/2004	48	USGS	Widewater	4	0	100	0	0	0	0	0	0	0	0.00
10/12/2004	49	USGS	Widewater	3	0	100	0	0	0	0	0	0	0	0.00
10/12/2004	50	USGS	Widewater	2	0	65	30	0	0	0	0	5	0	0.79
10/12/2004	51	USGS	Widewater	4	0	50	50	0	0	0	0	0	0	0.69
10/12/2004	52	USGS	Widewater	3	0	40	60	0	0	0	0	0	0	0.67
10/12/2004	53	USGS	Widewater	3	0	5	95	0	0	0	0	0	0	0.20
10/14/2004	54	USGS	Indian Head	4	70	1	2	25	2	0	0	0	0	0.80
10/14/2004	55	USGS	Indian Head	3	0	0	95	5	0	0	0	0	0	0.20
10/14/2004	56	USGS	Indian Head	4	25	1	3	70	1	0	0	0	0	0.79
10/14/2004	57	USGS	Indian Head	4	95	5	0	0	0	0	0	0	0	0.20
10/14/2004	58	USGS	Indian Head	2	0	10	90	0	0	0	0	0	0	0.33
10/14/2004	59	USGS	Indian Head	3	0	70	30	0	0	0	0	0	0	0.61
10/14/2004	60	USGS	Indian Head	4	0	100	0	0	0	0	0	0	0	0.00
10/14/2004	61	USGS	Indian Head	2	0	60	40	0	0	0	0	0	0	0.67
10/14/2004	62	USGS	Indian Head	3	0	20	80	0	0	0	0	0	0	0.50
10/14/2004	63	USGS	Indian Head	4	30	40	5	15	10	0	0	0	0	1.39
10/20/2004	64	USGS	Passapatanzy	2	0	100	0	0	0	0	0	0	0	0.00
10/20/2004	65	USGS	Passapatanzy	3	0	100	0	0	0	0	0	0	0	0.00
10/20/2004	66	USGS	Passapatanzy	1	0	95	0	5	0	0	0	0	0	0.20
10/20/2004	67	USGS	Passapatanzy	2	35	0	0	35	30	0	0	0	0	1.10

Table 1 – continued. Percent canopy cover of each species and Shannon diversity index for field beds located continuously along the shoreline in the tidal Potomac River, 2004. Field bed numbers correspond to the numbers in Figs. 4 to 10. Density classes are USGS field data based on a Braun-Blanquet crown cover model where: 1 = 1 to 10 %, 2 = 11 to 40 %, 3 = 41 to 70 %, and 4 = 71 to 100 % cover. Percent cover of each species in a bed is abbreviated as: P_HV (hydrilla), P_MS (milfoil), P_VA (wild celery), P_CD (coontail), P_NM (naiad), P_NGU (southern naiad), P_HD (stargrass), P_EC (common waterweed), and P_CV (muskgrass). USGS is U.S. Geological Survey and DOH is DC Dept. of Health.

Survey date	Field bed number	Data source	USGS quad	Density class	P_HV	P_MS	P_VA	P_CD	P_NM	P_NGU	P_HD	P_EC	P_CV	Div
10/20/2004	68	USGS	Passapatanzy	3	100	0	0	0	0	0	0	0	0	0.00
10/20/2004	69	USGS	Passapatanzy	1	100	0	0	0	0	0	0	0	0	0.00
10/21/2004	70	USGS	Mt. Vernon	4	10	0	80	10	0	0	0	0	0	0.64
10/21/2004	71	USGS	Mt. Vernon	4	40	30	0	30	0	0	0	0	0	1.09
10/21/2004	72	USGS	Mt. Vernon	3	60	0	0	40	0	0	0	0	0	0.67
10/21/2004	73	USGS	Mt. Vernon	4	60	20	0	20	0	0	0	0	0	0.95
10/21/2004	74	USGS	Mt. Vernon	4	95	0	0	5	0	0	0	0	0	0.20
10/21/2004	75	USGS	Mt. Vernon	4	65	0	0	35	0	0	0	0	0	0.65
10/21/2004	76	USGS	Mt. Vernon	4	50	30	0	20	0	0	0	0	0	1.03
10/21/2004	77	USGS	Mt. Vernon	4	5	0	95	0	0	0	0	0	0	0.20
10/21/2004	78	USGS	Mt. Vernon	4	60	30	0	10	0	0	0	0	0	0.90
10/21/2004	79	USGS	Mt. Vernon	3	0	0	100	0	0	0	0	0	0	0.00
10/21/2004	80	USGS	Mt. Vernon	2	50	50	0	0	0	0	0	0	0	0.69
10/21/2004	81	USGS	Mt. Vernon	2	30	40	20	10	0	0	0	0	0	1.28
10/21/2004	82	USGS	Mt. Vernon	3	40	0	60	0	0	0	0	0	0	0.67
10/21/2004	83	USGS	Mt. Vernon	4	25	5	60	10	0	0	0	0	0	1.03
10/21/2004	84	USGS	Mt. Vernon	2	80	0	0	20	0	0	0	0	0	0.50
10/21/2004	85	USGS	Mt. Vernon	3	0	0	100	0	0	0	0	0	0	0.00
10/21/2004	86	USGS	Port Tobacco	3	0	0	100	0	0	0	0	0	0	0.00
10/22/2004	87	USGS	Mt. Vernon	3	0	15	85	0	0	0	0	0	0	0.42
10/22/2004	88	USGS	Mt. Vernon	3	20	60	10	10	0	0	0	0	0	1.09
10/22/2004	89	USGS	Mt. Vernon	4	10	0	0	90	0	0	0	0	0	0.33
10/22/2004	90	USGS	Mt. Vernon	2	5	0	90	5	0	0	0	0	0	0.39

Table 1 – continued. Percent canopy cover of each species and Shannon diversity index for field beds located continuously along the shoreline in the tidal Potomac River, 2004. Field bed numbers correspond to the numbers in Figs. 4 to 10. Density classes are USGS field data based on a Braun-Blanquet crown cover model where: 1 = 1 to 10 %, 2 = 11 to 40 %, 3 = 41 to 70 %, and 4 = 71 to 100 % cover. Percent cover of each species in a bed is abbreviated as: P_HV (hydrilla), P_MS (milfoil), P_VA (wild celery), P_CD (coontail), P_NM (naiad), P_NGU (southern naiad), P_HD (stargrass), P_EC (common waterweed), and P_CV (muskgrass). USGS is U.S. Geological Survey and DOH is DC Dept. of Health.

Survey date	Field bed number	Data source	USGS quad	Density class	P_HV	P_MS	P_VA	P_CD	P_NM	P_NGU	P_HD	P_EC	P_CV	Div
10/22/2004	91	USGS	Mt. Vernon	3	0	15	85	0	0	0	0	0	0	0.42
10/22/2004	92	USGS	Mt. Vernon	2	0	100	0	0	0	0	0	0	0	0.00
10/22/2004	93	USGS	Mt. Vernon	3	0	0	100	0	0	0	0	0	0	0.00
10/22/2004	94	USGS	Mt. Vernon	2	60	0	40	0	0	0	0	0	0	0.67
10/22/2004	95	USGS	Mt. Vernon	4	100	0	0	0	0	0	0	0	0	0.00
10/22/2004	96	USGS	Alexandria	4	100	0	0	0	0	0	0	0	0	0.00
10/25/2004	97	USGS	Quantico	2	100	0	0	0	0	0	0	0	0	0.00
10/25/2004	98	USGS	Quantico	1	100	0	0	0	0	0	0	0	0	0.00
10/25/2004	99	USGS	Quantico	1	0	0	100	0	0	0	0	0	0	0.00
10/25/2004	100	USGS	Quantico	2	100	0	0	0	0	0	0	0	0	0.00
10/25/2004	101	USGS	Quantico	3	95	0	0	5	0	0	0	0	0	0.20
10/25/2004	102	USGS	Quantico	4	16	0	80	2	2	0	0	0	0	0.63
10/25/2004	103	USGS	Quantico	1	0	0	100	0	0	0	0	0	0	0.00
10/25/2004	104	USGS	Quantico	4	92	2	2	2	2	0	0	0	0	0.39
10/25/2004	105	USGS	Quantico	2	0	0	100	0	0	0	0	0	0	0.00
10/25/2004	106	USGS	Quantico	4	85	10	0	3	2	0	0	0	0	0.55
10/25/2004	107	USGS	Quantico	4	0	0	100	0	0	0	0	0	0	0.00
10/25/2004	108	USGS	Quantico	4	96	0	0	2	2	0	0	0	0	0.20
10/25/2004	109	USGS	Quantico	4	70	0	0	2	28	0	0	0	0	0.68
10/25/2004	110	USGS	Quantico	4	98	0	0	1	1	0	0	0	0	0.11
10/25/2004	111	USGS	Quantico	4	60	0	5	30	5	0	0	0	0	0.97
10/25/2004	112	USGS	Quantico	4	80	5	5	10	0	0	0	0	0	0.71

Table 1 – continued. Percent canopy cover of each species and Shannon diversity index for field beds located continuously along the shoreline in the tidal Potomac River, 2004. Field bed numbers correspond to the numbers in Figs. 4 to 10. Density classes are USGS field data based on a Braun-Blanquet crown

cover model where: 1 = 1 to 10 %, 2 = 11 to 40 %, 3 = 41 to 70 %, and 4 = 71 to 100 % cover. Percent cover of each species in a bed is abbreviated as: P_HV (hydrilla), P_MS (milfoil), P_VA (wild celery), P_CD (coontail), P_NM (naiad), P_NGU (southern naiad), P_HD (stargrass), P_EC (common waterweed), and P_CV (muskgrass). USGS is U.S. Geological Survey and DOH is DC Dept. of Health.

Survey date	Field bed number	Data source	USGS quad	Density class	P_HV	P_MS	P_VA	P_CD	P_NM	P_NGU	P_HD	P_EC	P_CV	Div
10/25/2004	113	USGS	Quantico	4	0	0	100	0	0	0	0	0	0	0.61
10/25/2004	114	USGS	Quantico	4	90	5	0	5	0	0	0	0	0	0.61
10/25/2004	115	USGS	Quantico	1	40	29	30	1	0	0	0	0	0	0.63
10/25/2004	116	USGS	Quantico	4	60	10	0	25	5	0	0	0	0	1.03
10/25/2004	117	USGS	Quantico	2	0	100	0	0	0	0	0	0	0	0.64
10/25/2004	118	USGS	Ft. Belvoir	4	99	0	0	0	1	0	0	0	0	0.65
10/26/2004	119	USGS	Ft. Belvoir	3	0	0	100	0	0	0	0	0	0	0.67
10/26/2004	120	USGS	Mt. Vernon	3	0	0	100	0	0	0	0	0	0	0.67
10/26/2004	121	USGS	Mt. Vernon	4	90	0	0	6	2	2	0	0	0	0.67
10/26/2004	122	USGS	Mt. Vernon	1	0	0	100	0	0	0	0	0	0	0.67
10/26/2004	123	USGS	Ft. Belvoir	4	90	0	0	6	2	2	0	0	0	0.67
10/26/2004	124	USGS	Mt. Vernon	4	70	1	20	5	4	0	0	0	0	0.67
10/26/2004	125	USGS	Mt. Vernon	4	5	10	80	5	0	0	0	0	0	0.67
10/26/2004	126	USGS	Mt. Vernon	2	85	10	0	3	0	2	0	0	0	0.67
10/26/2004	127	USGS	Mt. Vernon	1	0	100	0	0	0	0	0	0	0	0.68
10/26/2004	128	USGS	Mt. Vernon	4	5	5	90	0	0	0	0	0	0	0.69
10/26/2004	129	USGS	Mt. Vernon	2	20	60	20	0	0	0	0	0	0	0.69
10/26/2004	130	USGS	Mt. Vernon	3	10	10	75	5	0	0	0	0	0	0.69
10/26/2004	131	USGS	Mt. Vernon	4	25	50	0	25	0	0	0	0	1	0.70
10/26/2004	132	USGS	Mt. Vernon	4	20	0	80	0	0	0	0	0	0	0.71
10/26/2004	133	USGS	Mt. Vernon	4	60	0	0	40	0	0	0	0	1	0.71
10/26/2004	134	USGS	Alexandria	4	75	0	15	10	0	0	0	0	1	0.71
10/26/2004	135	USGS	Alexandria	2	80	0	0	0	20	0	0	0	0	0.72

Table 1 – continued. Percent canopy cover of each species and Shannon diversity index for field beds located continuously along the shoreline in the tidal Potomac River, 2004. Field bed numbers correspond to the numbers in Figs. 4 to 10. Density classes are USGS field data based on a Braun-Blanquet crown cover model where: 1 = 1 to 10 %, 2 = 11 to 40 %, 3 = 41 to 70 %, and 4 = 71 to 100 % cover. Percent cover of each species in a bed is abbreviated as: P_HV

(hydrilla), P_MS (milfoil), P_VA (wild celery), P_CD (coontail), P_NM (naiad), P_NGU (southern naiad), P_HD (stargrass), P_EC (common waterweed), and P_CV (muskgrass). USGS is U.S. Geological Survey and DOH is DC Dept. of Health.

Survey date	Field bed number	Data source	USGS quad	Density class	P_HV	P_MS	P_VA	P_CD	P_NM	P_NGU	P_HD	P_EC	P_CV	Div
10/27/2004	136	USGS	Ft. Belvoir	1	0	100	0	0	0	0	0	0	0	0.00
10/27/2004	137	USGS	Ft. Belvoir	2	0	30	50	20	0	0	0	0	0	1.03
10/27/2004	138	USGS	Ft. Belvoir	2	5	0	95	0	0	0	0	0	0	0.20
10/27/2004	139	USGS	Ft. Belvoir	4	90	5	5	0	0	0	0	0	0	0.39
10/27/2004	140	USGS	Ft. Belvoir	4	0	5	95	0	0	0	0	0	0	0.20
10/27/2004	141	USGS	Ft. Belvoir	4	0	40	60	0	0	0	0	0	0	0.67
10/27/2004	142	USGS	Ft. Belvoir	4	30	0	0	0	70	0	0	0	0	0.61
10/14/2004	143	USGS	Mattawoman Cr.	3	50	0	20	30	0	0	0	0	0	1.03
10/14/2004	144	USGS	Mattawoman Cr.	2	0	0	90	10	0	0	0	0	0	0.33
10/14/2004	145	USGS	Mattawoman Cr.	3	90	0	0	10	0	0	0	0	0	0.33
10/14/2004	146	USGS	Mattawoman Cr.	4	0	0	95	5	0	0	0	0	0	0.20
10/14/2004	147	USGS	Mattawoman Cr.	2	80	0	0	10	5	5	0	0	0	0.71
10/14/2004	148	USGS	Mattawoman Cr.	1	0	0	100	0	0	0	0	0	0	0.00
10/14/2004	149	USGS	Mattawoman Cr.	3	95	5	0	0	0	0	0	0	0	0.20
10/14/2004	150	USGS	Mattawoman Cr.	3	0	100	0	0	0	0	0	0	0	0.00
10/14/2004	151	USGS	Mattawoman Cr.	1	10	0	90	0	0	0	0	0	0	0.33
10/14/2004	152	USGS	Mattawoman Cr.	3	0	10	90	0	0	0	0	0	0	0.33
9/23/2004	153	DOH	Alexandria	1	100	0	0	0	0	0	0	0	0	0.00
9/23/2004	154	DOH	Alexandria	3	99	0	0	1	0	0	0	0	0	0.06
9/23/2004	155	DOH	Washington West	1	100	0	0	0	0	0	0	0	0	0.00
9/23/2004	156	DOH	Washington West	1	100	0	0	0	0	0	0	0	0	0.00
9/23/2004	157	DOH	Washington West	1	100	0	0	0	0	0	0	0	0	0.00
9/24/2004	158	DOH	Alexandria	1	100	0	0	0	0	0	0	0	0	0.00

Table 1 – continued. Percent canopy cover of each species and Shannon diversity index for field beds located continuously along the shoreline in the tidal Potomac River, 2004. Field bed numbers correspond to the numbers in Figs. 4 to 10. Density classes are USGS field data based on a Braun-Blanquet crown cover model where: 1 = 1 to 10 %, 2 = 11 to 40 %, 3 = 41 to 70 %, and 4 = 71 to 100 % cover. Percent cover of each species in a bed is abbreviated as: P_HV

(hydrilla), P_MS (milfoil), P_VA (wild celery), P_CD (coontail), P_NM (naiad), P_NGU (southern naiad), P_HD (stargrass), P_EC (common waterweed), and P_CV (muskgrass). USGS is U.S. Geological Survey and DOH is DC Dept. of Health.

Survey date	Field bed number	Data source	USGS quad	Density class	P_HV	P_MS	P_VA	P_CD	P_NM	P_NGU	P_HD	P_EC	P_CV	Div
9/24/2004	159	DOH	Alexandria	1	0	0	100	0	0	0	0	0	0	0.00
9/24/2004	160	DOH	Alexandria	2	0	0	100	0	0	0	0	0	0	0.00
9/24/2004	161	DOH	Alexandria	2	0	0	100	0	0	0	0	0	0	0.00
9/24/2004	162	DOH	Washington West	2	0	0	100	0	0	0	0	0	0	0.00
9/24/2004	163	DOH	Washington West	3	100	0	0	0	0	0	0	0	0	0.00
9/24/2004	164	DOH	Washington West	1	100	0	0	0	0	0	0	0	0	0.00
9/27/2004	165	DOH	Washington West	2	100	0	0	0	0	0	0	0	0	0.00
9/27/2004	166	DOH	Washington West	1	100	0	0	0	0	0	0	0	0	0.00
9/27/2004	167	DOH	Washington West	2	100	0	0	0	0	0	0	0	0	0.00
9/27/2004	168	DOH	Washington West	1	100	0	0	0	0	0	0	0	0	0.00
9/27/2004	169	DOH	Washington West	1	100	0	0	0	0	0	0	0	0	0.00
10/1/2004	170	DOH	Alexandria	2	0	0	100	0	0	0	0	0	0	0.00