Data on the Distribution and Abundance of Submersed Aquatic Vegetation in the Tidal Potomac River and Transition Zone of the Potomac Estuary, Maryland, Virginia, and the District of Columbia, 1988

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ABSTRACT

This report documents the distribution of submersed aquatic vegetation in the tidal Potomac River and transition zone of the Potomac Estuary during 1988. Maps illustrate the distribution of submersed aquatic plants, including *Hydrilla verticillata* in the tidal Potomac River. Species of submersed aquatic plants found on vegetated transects in the transition zone of the Potomac Estuary are listed for each transect location. Data on the distance from shore and greatest depth of water in which aquatic plants grew on four transects and on Secchi depths throughout the study reach are reported. These data can be used to quantify changes in water clarity and plant distribution.

INTRODUCTION

Carter and Rybicki (1986) reported that submersed aquatic plants, absent from the fresh tidal river for decades, returned in 1983. Submersed aquatic plants are a valuable living resource, and their return indicates an improvement in water quality. By 1984, there were 240 hectares of aquatic vegetation, and in 1985 and 1986, 1,460 hectares were reported between Washington, D. C. and Indian Head, Maryland (Carter and Rybicki, 1986). *Hydrilla verticillata*, an exotic species from Southeast Asia was among 13 species found in the tidal river. *Hydrilla* grows rapidly and outcompetes other species. By 1986, more than 80 percent of the vegetated area above Marshall Hall, Maryland, was dominated by *Hydrilla* (Rybicki and others, 1987). In 1987, plants continued to spread from Indian Head to Mallows Bay, Maryland. In Virginia, plants were found as far south as Powells Creek, Quantico, and Chopawamsic Creek, but no plants were found in Occoquan Bay or Neabsco Creek, according to areal photographs and shoreline surveys (Rybicki and others, 1988, Orth and others, 1989). In 1987 the U.S. Department of Interifor, U.S. Geological Survey estimated there were 1,583 hectares of aquatic plants in the fresh tidal Potomac River.

The U.S. Army Corps of Engineers (COE) began a mechanical harvesting program in the reach between Alexandria, Virginia and Marshall Hall, Maryland in 1986. The COE harvested 17 sites in 1988 to allow recreational boaters access to boat slips and ramps. Monitoring efforts are necessary to determine the spread of *Hydrilla* and other aquatic plants, to improve selection of sites for mechanical harvesting, and to investigate the relations between plant distribution and water quality.

Purpose and Scope

This report documents (1) the distribution of the submersed aquatic vegetation in the tidal Potomac River and transition zone as determined by shoreline surveys and sampling of transects; (2) measured Secchi depths to quantify changes in water clarity during 1978-1988; and (3) the distance

from shore and the greatest depth of water in which aquatic plants grew on four transects.

Description of Study Area

The study reach can be divided into two salinity related zones (fig. 1) (Callender and others, 1984). The tidal river from Chain Bridge to Quantico, Virginia, is fresh except during periods of drought or extremely low river discharge (fig. 1). The transition zone of the estuary between Quantico, Virginia, and the U.S. Highway 301 Bridge has fresh to brackish water (0.5 to 18 mg/L (milligrams per liter) ocean-derived salts). The tidal river, and transition zone of the estuary, and their major tributaries have a deep channel that is flanked on either side by wide shallow flats or shoals suitable for the growth of submersed aquatic plants.

Acknowledgments

This work was partially supported by the U.S. Army Corps of Engineers, Baltimore District.

DISTRIBUTION AND ABUNDANCE OF SUBMERSED AQUATIC VEGETATION

Shoreline surveys for submersed aquatic vegetation in the tidal river and tributaries were conducted in spring and fall of 1988. The spring survey included the tidal river and tributaries from Washington D.C. to Quantico. The fall shoreline survey extended below Quantico to Chopawamsic Creek, Virginia and Mallows Bay, Maryland. Surveys were done by boat, at low tide, using rakes to gather samples and to check whether vegetation was rooted or floating. The vegetated areas were outlined and the proportion of each species in vegetated areas was estimated and referenced on U.S. Geological Survey 7 1/2-minute topographic/bathymetric maps. These data (not shown) were supplied to the U.S. Environmental Protection Agency for use in their Chesapeake Bay-wide status report on submersed aquatic vegetation (Orth and others, 1989). The distribution information was transferred to a small-scale map for publication in this report. Figure 2 shows the percent cover by *Hydrilla verticillata* in vegetated areas, and figure 3 shows percent cover of total submersed aquatic vegetation (all species are included). The total vegetated area from Washington D.C. to Quantico was estimated to be 1,504 hectares. Estimates were made by overlying a grid of known area over the 7-1/2 minute topographic maps and totaling the vegetated squares.

A survey was also conducted in the transition zone of the estuary in late August and September. This survey included sampling (raking) for vegetation at previously established vegetation transects (Carter and others, 1985a,b; Rybicki and others, 1988) and spot-checking between transects and in small tributaries (fig. 4). Codes for the transects in figures 4 and 5 provide information on location and the river or tributary mile for each location. For example, in MN-01T-02, MN is Mattawoman Creek, 01T is 1 nmi (nautical mile) up the tributary from the mouth, and 02 is the second transect for that tributary mile. In MN-01R, MN is Mattawoman Creek, R refers to a transect on the main river, and 01R is the first transect on the edge of the main river. Transects were perpendicular to the shoreline and terminated just

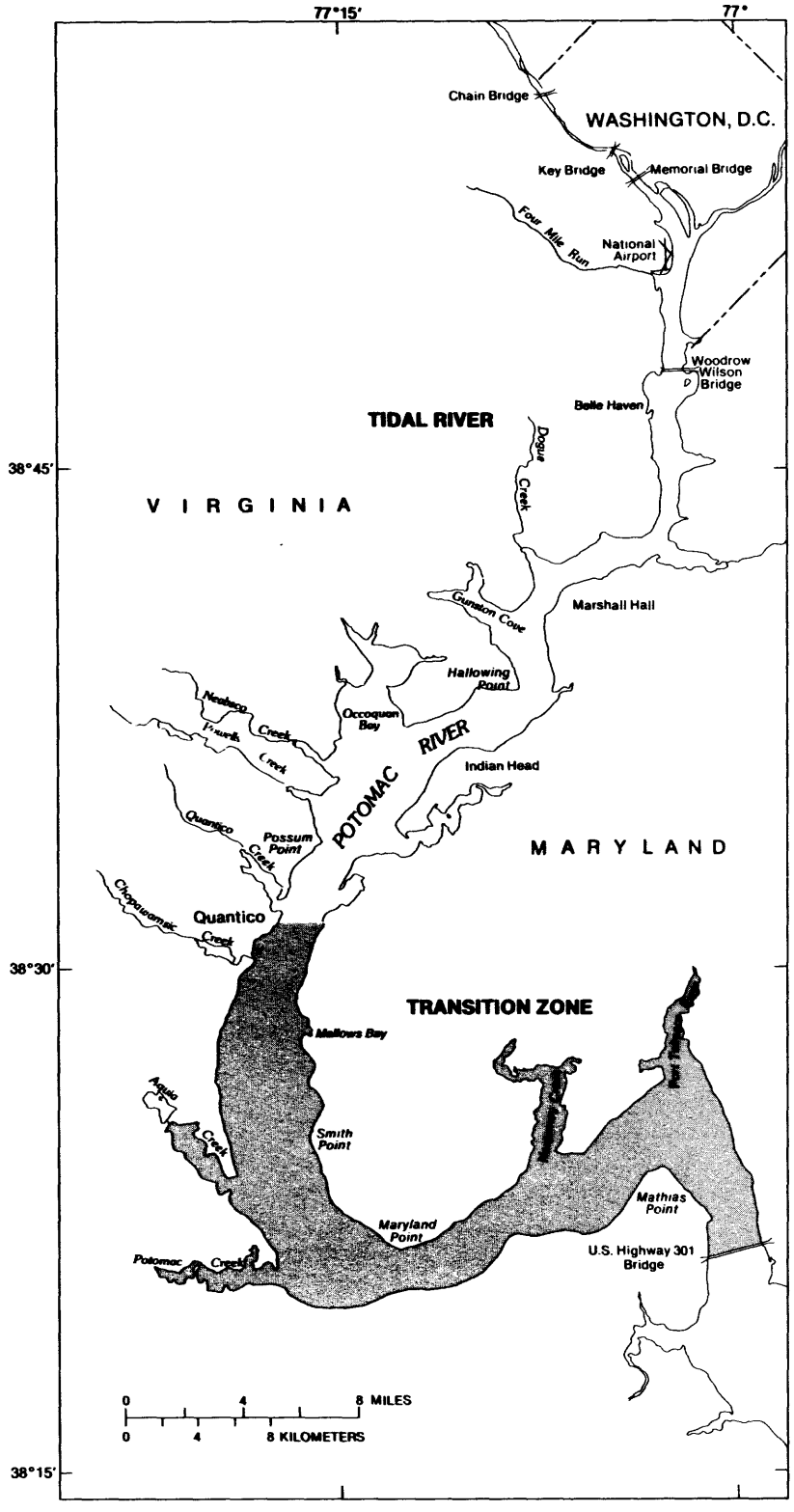

Figure 1. Map showing the tidal Potomac River and transition.

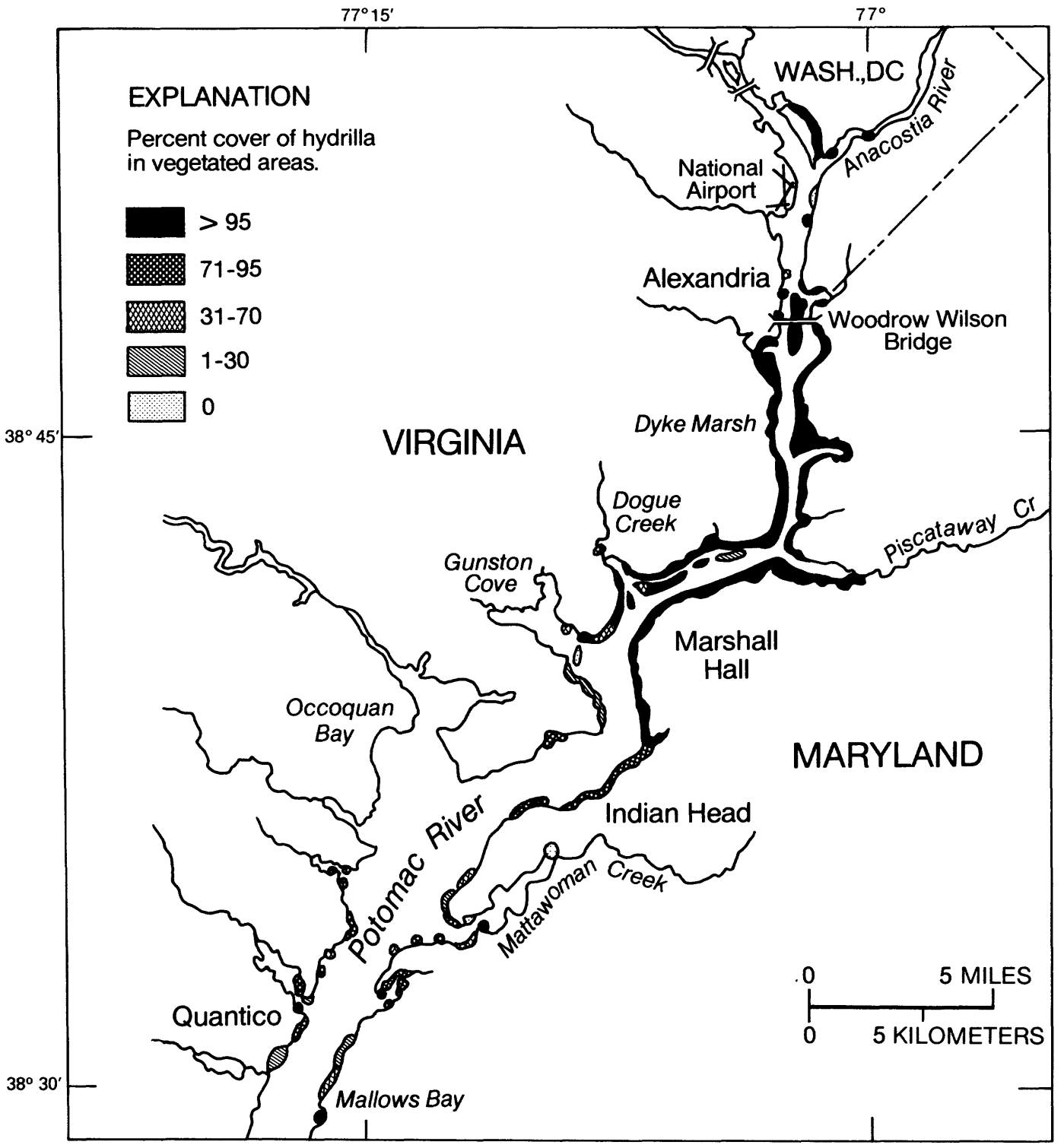

Figure 2. Map showing the percent cover of *Hydrilla verticillata* in vegetated areas of the tidal Potomac River, 1988.

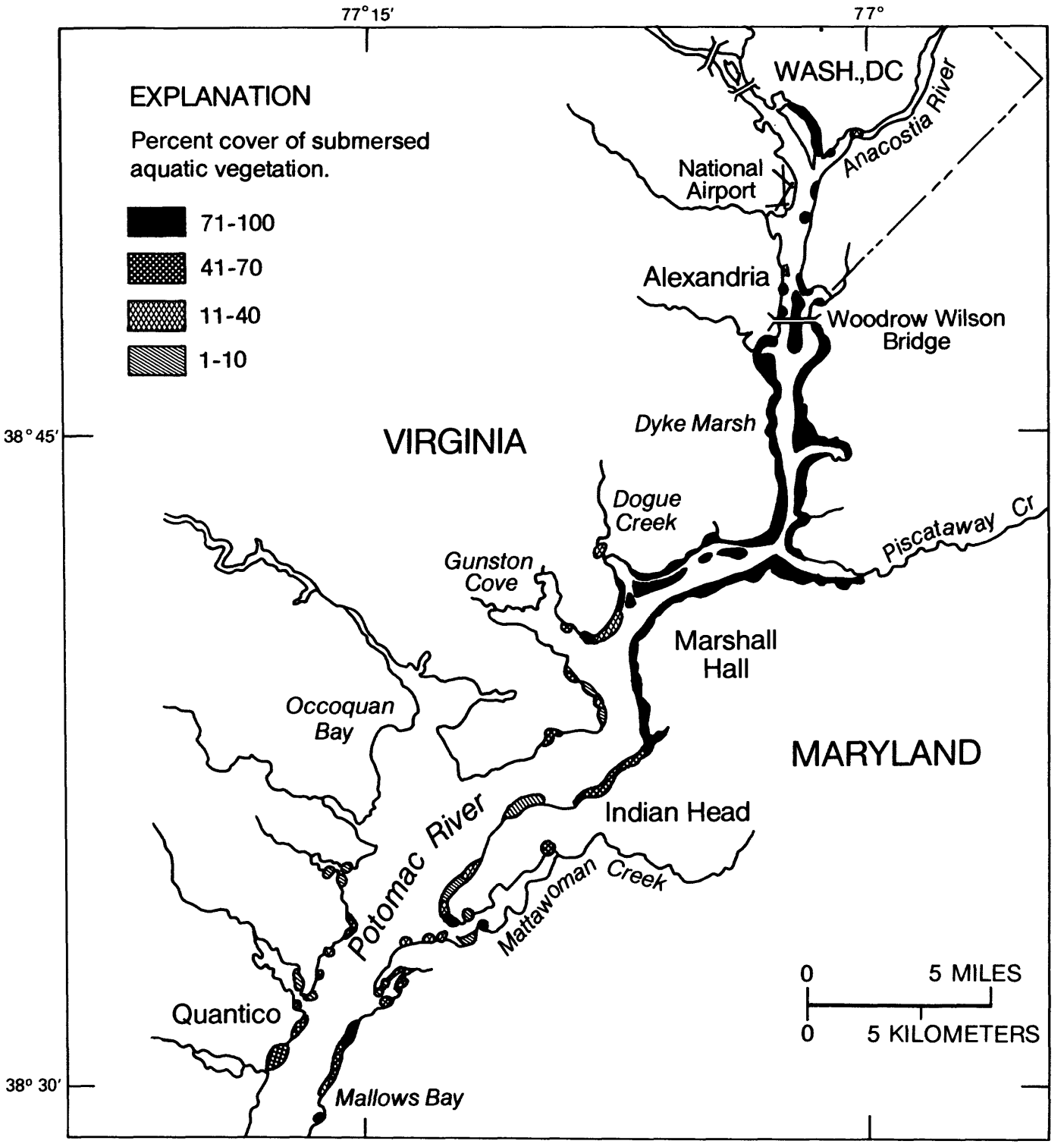

Figure 3. Map showing the percent cover of submersed aquatic plants in the tidal Potomac River, 1988.

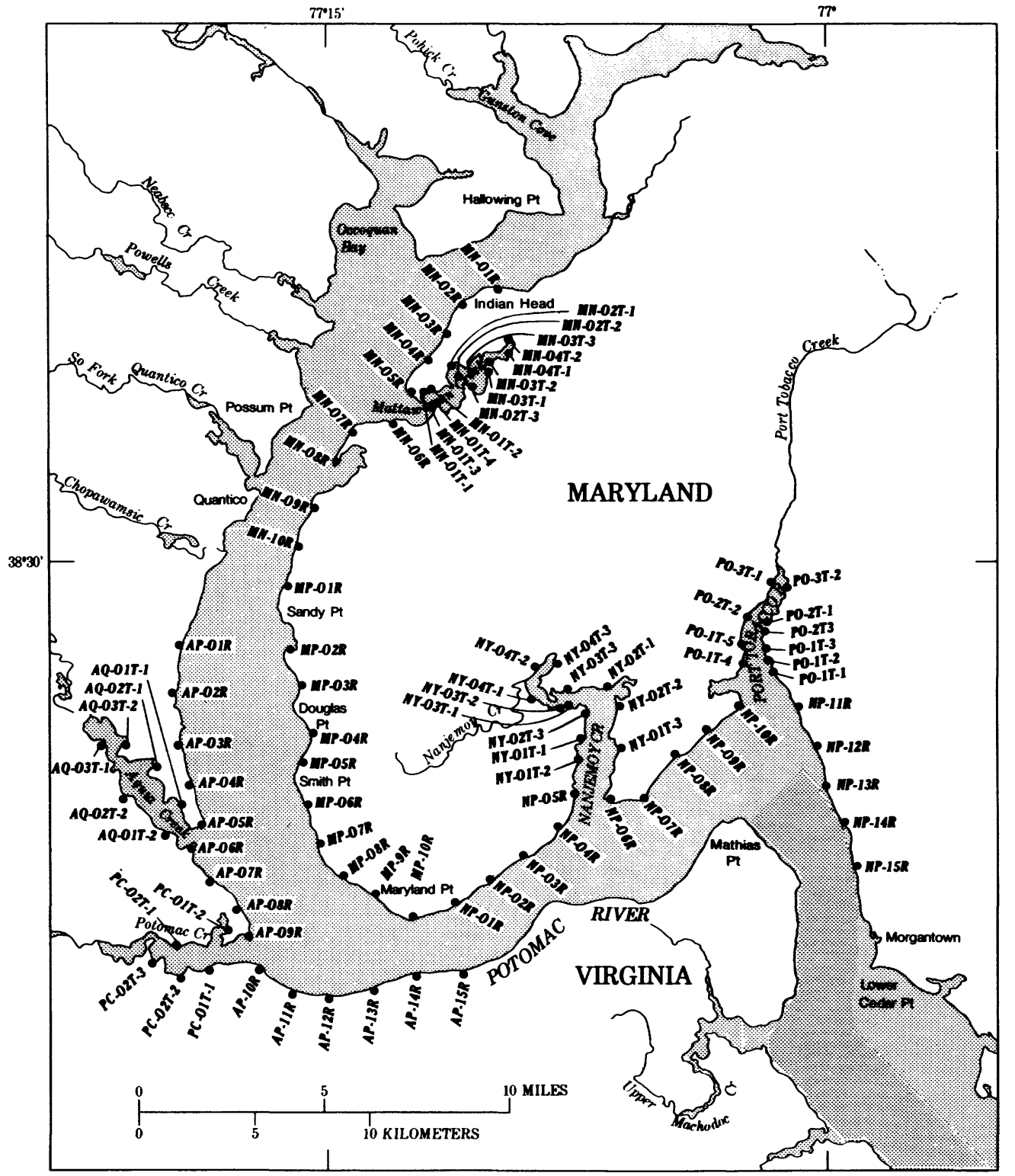

Figure 4.--Location of vegetation transects from Mattawoman Creek to Port Tobacco River. Codes for transects give location and tributary or river mile for each location. MN is Mattawoman Creek, MP is Maryland Point, NP is Nanjemoy Creek-Port Tobacco River, PO is Port Tobacco River, AQ is Aquia Creek, PC is Potomac Creek, AP is Aquia Creek-Potomac Creek.

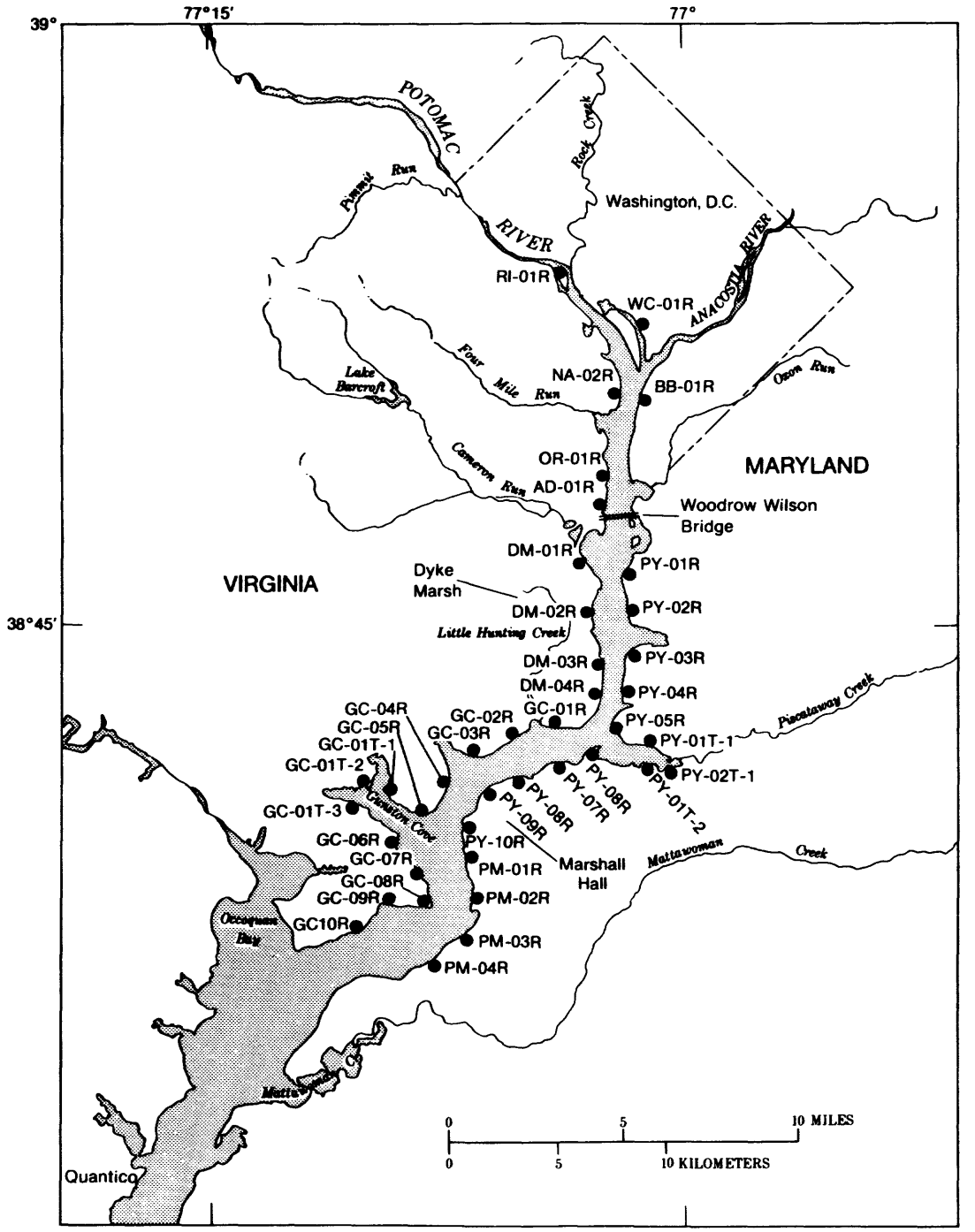

Figure 5.--Location of vegetation sampling-transects in the tidal Potomac River above Mattawoman Creek. Codes for transects give location and tributary or river-mile for each location. RI is Roosevelt Island, NA is National Airport, OR is Oronoco Bay, AD is Alexandria Dock, DM is Dyke Marsh, GC is Gunston Cove, BB is Bolling Air Force Base, PY is Piscataway Creek, and PM is Pomonkey Creek.

beyond vegetation or at 60 meters, when no vegetation was present. All species were identified.

A list of submersed aquatic plants found in the tidal Potomac River or transition zone of the estuary is shown in table 1. Taxonomic nomenclature is according to Hotchkiss (1950,1967), Radford and others (1974), and, Godfrey and Wooten (1979). Species of submersed aquatic vegetation found on or near vegetated transects in the transition zone of the Potomac River Estuary are listed by transect location (table 2).

The distance from shore and the greatest depth of water (at mean low water) in which aquatic plants grew was measured on four vegetation transects; DM-02R, DM-04R, GC-01R, and PY-02R (previously sampled in Carter and others, 1985a,b; and Rybicki and others, 1985, 1986, 1987, and 1988) (fig 5). *Hydrilla* was the dominant plant on all transects. Transects had sampling stations at 10-meter intervals from shore on a line perpendicular to the shoreline. Depth and plant density was measured at each station. The depth was converted to depth at mean low water (according to method in U.S. Department of Commerce, 1987 p. 239.) Transects were terminated if no plants were found at two consecutive stations. Density was determined visually; dense is defined as greater than or equal to 40-percent cover, and sparse is defined as less than 40-percent cover. Where no vegetation was visible, modified oyster tongs were used to determine presence and density of plants. Greatest water depth and distance from shore of submersed aquatic plants on the four transects are shown on table 3.

WATER QUALITY

Measurements of water transparency were made using a Secchi disk (table 4) (readings were made outside the vegetated area if present). Specific conductance, pH, temperature, and dissolved-oxygen concentration was measured with a Hydrolab[1] 4041 4-parameter field meter and sonde at a depth of 0.5 meter from the surface in water generally less than 3 meters deep (table 5). The measurements are listed by nearest transect. (For transect locations see figures 4 and 5.)

[1]Use of brand or trade names in this report is for identification purpose only and does not constitute endorsement by the U.S. Geological Survey.

Table 1.--List of submersed aquatic plants found in the tidal Potomac River and transition zone of the Estuary, 1988
[Taxonomy follows Hotchkiss (1950, 1967) unless otherwise noted.]

Family	Species	Common name
Najadaceae (pondweed family)	*Potamogeton perfoliatus*	Redhead-grass
	Potamogeton pectinatus L.	Sago pondweed
	Ruppia maritima L.	Widgeongrass
	Zannichellia palustris L.	Horned pondweed
	Najas guadalupensis (Sprengel) Morong	Southern naiad
	Najas minor All	
Hydrocharitacae (frogbit family)	*Vallisneria americana* Michaux	Wild celery
	Hydrilla verticillata (L.f.) Caspary.[1]	Hydrilla
Ceratophyllaceae (coontail family)	*Ceratophyllum demersum* L.	Coontail
Haloragidaceae (watermilfoil family)	*Myriophyllum spicatum* L.	Eurasian watermilfoil
Pontedariaceae (pickerelweed family)	*Heteranthera dubia* (Jacquin) MacMillan[2]	Water-stargrass

[1]Keyed from Godfrey and Wooten (1979).
[2]Keyed from Radford and others (1974).

Table 2--Species of submersed aquatic plants found at vegetated transects in the transition zone of the Potomac River Estuary, August-September, 1988

[Cer = *Ceratophyllum demersum*, Het = *Heteranthera dubia*, Hydr = *Hydrilla verticillata*, Myrio = *Myriophyllum spicatum*, N. guad = *Najas guadalupensis*, N. min =*Najas minor*, Rup = *Ruppia maritima*, P. perf = *Potamogeton perfoliatus*, Val = *Vallisneria americana*]

Nearest transect	Species
AP-01R	Het, Myrio, N. min, Val
AP-02R	Cer, Het, Myrio, Val
AP-05R	Myrio
AP-13R	Cer
Mallows Bay (south cove)	Hydr
MP-03R	Cer, Myrio, Val
MP-04R	Cer, Myrio, Val
MP-05R	Val
MP-09R	Val
Between MP-09R & MP-10R	Val
MP-10R	Val
NP-01R	Val
NP-02R	Val
NP-03R	Myrio, Val
NP-04R	Val
Upstream of NP-05R	Val
NP-05R	P. perf
NP-06R	Val
NP-07R	Val
NP-08R	Val
NP-09R	P. perf, Rup, Val
NP-10R	Myrio, P. perf, Rup, Val
NP-11R	P. perf, Rup, Val
NY-1T-03	Val
NY-2T-01	Myrio
Upstream of NY-2T-02	Myrio, Val
NY-2T-02	P. perf, Val
NY-3T-01	Myrio, Val
NY-3T-02	Myrio, Val
NY-3T-03	Cer, Myrio, Val
NY-4T-01	Myrio
Between NY-4T-01 and NY-4T-02	Myrio, Val
NY-4T-02	Myrio, Val
NY-4T-03	Cer, Myrio, Val

Table 2--Species of submersed aquatic plants found at vegetated transects in the transition zone of the Potomac River Estuary, August-September, 1988, continued

[Cer = *Ceratophyllum demersum*, Het = *Heteranthera dubia*, Hydr = *Hydrilla verticillata*, Myrio = *Myriophyllum spicatum*, N. guad = *Najas guadalupensis*, N. min = *Najas minor*, Rup = *Ruppia maritima*, P. perf = *Potamogeton perfoliatus*, Val = *Vallisneria americana*]

Nearest transect	Species
Between NY-4T-03 and NY-3T-03	Cer, Myrio, Val
PO-1T-01	P. perf, Val
PO-1T-02	P. perf, Val
PO-1T-03	P. perf, Val
PO-1T-05	Myrio
PO-2T-01	Val
PO-2T-02	P. perf, Rup, Val
PO-2T-03	P. perf, Rup, Val
Upstream of PO-3T-01	Myrio, Val
Upstream of PO-3T-02	Myrio, Val
PO-3T-02	Myrio

Table 3.--Greatest water depth and distance from shore of submersed aquatic plants at four transects in the tidal Potomac River, September, 1988
[Depth in meters at mean low water, distance in meters]

Transect	Distance from shore		Greatest water depth	
	Dense vegetation	Sparse vegetation	Dense vegetation	Sparse vegetation
DM-02R	0-20	20-45	0.9	1.9
DM-04R	0-400	400-470	1.5	1.5
GC-01R	0-320	320-370	1.9	2.0
PY-02R	0-170	170-190	1.5	2.6

Table 4.--Secchi depths in the tidal Potomac River and Estuary, 1988
[cm is centimeter]

Location or nearest transect	Date (month-day)	Secchi depth (cm)
RI-01R	6-28	56
RI-01R	6-28	100
NA-01R	6-28	74
NA-01R	7-21	40
GC-01R	8-22	86
GC-03R	8-23	112
GC-05R	8-04	67
GC-06R	8-04	49
GC-06R	7-22	42
GC-08R	6-30	36
GC-09R	6-30	30
GC-01T-1	9-22	49
GC-01T-3	7-23	23
GC-01T-3	7-23	35
GC-01T-3	8-04	25
GC-01T-3	8-04	26
GC-01T-3	8-23	50
Occoquan Bay	6-30	27
Occoquan Bay	6-30	29
Occoquan Bay	6-30	34
Occoquan Bay	8-04	50
Neabsco Creek	6-30	29
Powells Creek	8-2	62
Possum Point	8-2	103
Possum Point	8-2	97
Quantico	8-2	80
AP-03R	8-10	109
AP-04R	8-10	110
AP-06R	8-10	72
AP-07R	8-10	71
AP-08R	8-10	111
AP-09R	8-10	60
AP-10R	8-10	43
AP-11R	8-10	60
AP-12R	8-10	81
AP-13R	8-10	67
AP-14R	8-10	73
AP-15R	8-10	64
AQ-01T-1	8-02	45
AQ-03T-1	8-10	37
AQ-03T-2	8-02	40
PC-01T-2	8-10	55
PC-01T-2	8-10	50
PC-02T-1	8-10	37
PC-02T-3	8-10	30

Table 4--Secchi depths in the tidal Potomac River and Estuary, 1988, continued

[cm is centimeter]

Location or nearest transect	Date (month-day)	Secchi depth (cm)
PC-02T-3	8-10	33
PC-02T-2	8-10	32
Anacostia River	10-06	45
Anacostia River	10-06	40
Anacostia River	10-06	40
Anacostia River	10-04	60
Anacostia River	10-04	110
WC-01R	10-04	125
BB-01R	6-25	68
BB-01R	10-04	68
PY-01R	8-04	67
PY-01R	9-28	120
PY-02R	8-25	120
PY-08R	8-04	56
PY-09R	8-23	55
PY-01T-1	9-08	36
PY-01T-2	9-08	81
MN-02R	7-25	86
MN-04R	7-25	95
MN-05R	7-27	125
MN-08R	7-25	52
MN-08R	7-27	84
MN-10R	9-15	102
MN-01T-1	7-27	44
MN-01T-1	7-27	50
MN-01T-2	7-27	60
MN-02T-1	7-27	36
MN-04T-2	7-27	30
MN-03T-2	7-27	32
MP-01R	9-15	84
Mallows Bay	9-15	83
Mallows Bay	9-15	85
MP-02R	7-25	70
MP-03R	9-15	102
MP-03R	9-15	90
MP-05R	9-15	94
MP-06R	9-15	76
MP-07R	9-15	90
MP-08R	9-15	64
MP-09R	9-15	86
MP-10R	9-15	57
NP-01R	9-15	70
NP-02R	9-15	61

Table 4--Secchi depths in the tidal Potomac River and Estuary, 1988, continued
[cm is centimeter]

Location or nearest transect	Date (month-day)	Secchi depth (cm)
NP-03R	9-15	56
NP-04R	9-15	45
NP-06R	9-14	41
NP-07R	9-14	46
NP-08R	9-14	77
NP-09R	9-14	53
NP-10R	9-14	89
NP-11R	9-14	66
NP-11R	9-14	52
NP-11R	9-14	60
NY-01T-3	9-14	33
NY-02T-1	9-14	33
NY-02T-2	9-14	30
NY-03T-3	9-14	32
NY-04T-2	9-14	42
NY-04T-3	9-14	44
PO-01T-1	9-14	53
PO-01T-3	9-14	46
PO-01T-4	9-14	45
PO-01T-5	9-14	50
PO-02T-1	9-14	45
PO-02T-2	9-14	40
PO-02T-2	9-14	51
PO-03T-1	9-14	39
PO-03T-2	9-14	45

Table 5.--Specific conductance, pH, temperature, and dissolved-oxygen concentration in the tidal Potomac River and Estuary, August-September 1988

[Cond is specific conductance in microsiemens per centimeter at 25 degrees celsius; Temp is temperature in degrees Celsius; DO is dissolved-oxygen concentration, in milligrams per liter; n.d. is no data available]

Location	Date	Cond	pH	Temp	DO
Powells Creek	8- 2	350	7.5	30.8	7.7
Quantico Creek	8- 2	1040	7.7	30.9	6.4
Quantico	8- 2	1200	7.9	31.6	7.0
Chopawamsic Creek	8- 2	1690	7.9	32.2	8.0
AP-01R	8- 2	1676	8.0	33.2	8.3
AP-03R	8-10	1908	6.8	30.3	5.8
AP-04R	8- 2	1820	8.4	32.7	9.1
AP-06R	8-10	1931	7.6	30.4	5.8
AP-08R	8-10	1947	6.9	30.2	6.3
AP-10R	8-10	1885	8.6	31.8	8.7
AP-11R	8-10	1900	7.5	31.6	7.5
AP-12R	8-10	1910	7.5	31.3	7.8
AP-14R	8-10	1931	7.2	30.9	7.1
AQ-02T-1	8- 2	1839	9.5	32.7	10.2
AQ-03T-2	8-10	803	8.8	33.0	9.0
PC-01T-2	8-10	1919	8.4	30.8	7.5
PC-02T-1	8-10	1908	8.7	31.1	7.6
PC-02T-2	8-10	1895	9.1	31.2	8.5
PC-02T-3	8-10	1890	9.3	31.3	8.6
MP-01R	9-15	3000	7.4	23.0	6.8
Chicamuxen Creek	7-25	837	n.d.	n.d.	n.d.
Mallows Bay	7-25	548	n.d.	n.d.	n.d.
Mallows Bay	9-15	3280	7.4	23.6	7.1
MP-03R	9-15	4210	7.6	23.7	7.4
MP-05R	9-15	4570	7.4	23.6	7.2
MP-06R	9-15	5860	7.4	23.5	6.6
MP-07R	9-15	7600	7.8	23.9	8.3
MP-08R	9-15	7620	7.4	23.9	6.7
MP-09R	9-15	8600	7.4	24.5	6.6
MP-10R	9-15	8730	7.4	24.7	6.5
NP-01R	9-15	8330	7.4	24.4	6.8
NP-02R	9-15	11000	7.5	25.0	6.6
NP-03R	9-15	11410	7.5	24.9	6.4
NP-04R	9-15	12720	7.4	24.7	7.9
NP-05R	9-15	10460	7.6	25.0	6.6
NP-06R	9-14	11900	8.6	25.4	8.8
NP-07R	9-14	11730	8.2	27.7	9.8
NP-08R	9-14	13590	7.8	27.1	8.2
NP-09R	9-14	13800	7.4	26.5	8.5

Table 5.--Specific conductance, pH, temperature, and dissolved oxygen in the tidal Potomac River and Estuary, August-September 1988, continued [Cond is specific conductance in microsiemens per centimeter at 25 degrees Celsius; Temp is temperature in degrees Celsius; DO is dissolved-oxygen concentration, in milligrams per liter; n.d. is no data available]

Location	Date	Cond	pH	Temp	DO
NP-10R	9-14	13960	7.3	26.0	6.8
NP-11R	9-14	13940	7.5	24.5	7.1
NY-01T-3	9-14	11920	8.7	27.4	10.5
NY-02T-1	9-14	10980	7.2	26.9	9.0
NY-02T-2	9-14	11120	8.4	28.0	8.4
NY-02T-3	9-14	11270	8.4	26.0	8.6
NY-03T-3	9-14	10360	7.4	25.5	7.3
NY-04T-2	9-14	9200	8.0	26.0	7.4
NY-04T-3	9-14	8580	8.2	26.4	8.2
PO-01T-1	9-14	14030	8.3	24.5	8.8
PO-01T-3	9-14	14030	8.4	24.3	8.6
PO-01T-4	9-14	13000	7.4	23.4	6.4
PO-02T-1	9-14	13540	7.5	23.9	6.3
PO-02T-2	9-14	13900	7.5	24.1	6.3
PO-03T-1	9-14	13500	7.6	23.9	7.0
PO-03T-2	9-14	13170	7.8	24.1	7.6

REFERENCES

Callender, Edward, Carter, Virginia, Hahl, D.R., Hitt, Kerie, and Schultz, Barbara, eds., 1984, A water quality study of the tidal Potomac River and Estuary--an overview: U.S. Geological Survey Water-Supply Paper 2233, 46 p.

Carter, Virginia, Paschal, J.E., Jr., and Bartow, Nancy, 1985a, Distribution and abundance of submersed aquatic vegetation in the tidal Potomac River and Estuary, Maryland and Virginia, May 1978 to November 1981: U.S. Geological Survey Water-Supply paper 2234A, 46 p.

Carter, Virginia, and Rybicki, Nancy, 1986, Resurgence of submersed aquatic macrophytes in the tidal Potomac River, Maryland, Virginia, and the District of Columbia: Estuaries, v. 9, no. 4B, p. 368-373.

Carter, Virginia, Rybicki, N.B., Anderson, R.T., Trombley, T.J., and Zynjuk, G.L., 1985b, Data on the distribution and abundance of submersed aquatic vegetation in the tidal Potomac River and transition zone of the Potomac Estuary, Maryland, Virginia and the District of Columbia, 1983, and 1984: U.S. Geological Survey Open-File Report 85-82, 61 p.

Godfrey, R.K., and Wooten, J.W., 1979, Aquatic and wetland plants of southeastern United States: Athens, Georgia, The University of Georgia Press, 712 p.

Hotchkiss, Norman, 1950, Checklist of marsh and aquatic plants of the United States: U.S. Fish and Wildlife Service, Wildlife Leaflet 210, 34 p.

_____ 1967, Underwater and floating-leaved plants of the United States and Canada: U.S. Fish and Wildlife Service Resource Publication 44, Washington, D.C., 124 p.

Orth, Robert, Capelli, J., Frisch, A.A., and Moore, K.A., 1989, Distribution of submerged aquatic vegetation in the Chesapeake Bay and tributaries and Chincoteague Bay--1987: Chesapeake Bay Program EPA Final Report, 247 p.

Radford, A.E., Ahles, H.E., and Bell, C.R., 1974, Manual of vascular flora of the Carolinas: Chapel Hill, North Carolina, University of North Carolina Press: 1,183 p.

Rybicki, N.B., Anderson, R.T., and Carter, Virginia, 1988, Data on the distribution and abundance of submersed aquatic vegetation in the tidal Potomac River and Estuary, Maryland, Virginia, and the District of Columbia, 1987: U.S. Geological Survey Open-File Report 88-307, 31 p.

Rybicki, N.B., Anderson, R.T., Shapiro, J.M., Johnson, K.L., and Schulman, C.L., 1987, Data on the distribution and abundance of submersed aquatic vegetation in the tidal Potomac River and Estuary, Maryland, Virginia, and the District of Columbia, 1986: U.S. Geological Survey Open-File Report 87-575, 82 p.

Rybicki, N.B., Anderson, R.T., Shapiro, J.M., Jones, C.L., and Carter, Virginia, 1986, Data on the distribution and abundance of submersed aquatic vegetation in the tidal Potomac River Maryland, Virginia, and the District of Columbia, 1985: U.S. Geological Survey Open-File Report 86-126, 49 p.

Rybicki, N.B., Carter, Virginia, Anderson, R.T., and Trombley, T.J., 1985, *Hydrilla verticillata* in the tidal Potomac River, Maryland, Virginia, and the District of Columbia, 1983 and 1984: U.S. Geological Survey Open-File Report 85-77, 26 p.

U.S. Dept. of Commerce, NOAA, 1987, Tide tables 1988, east coast of North and South America, including Greenland: Rockville, Md., 289 p.