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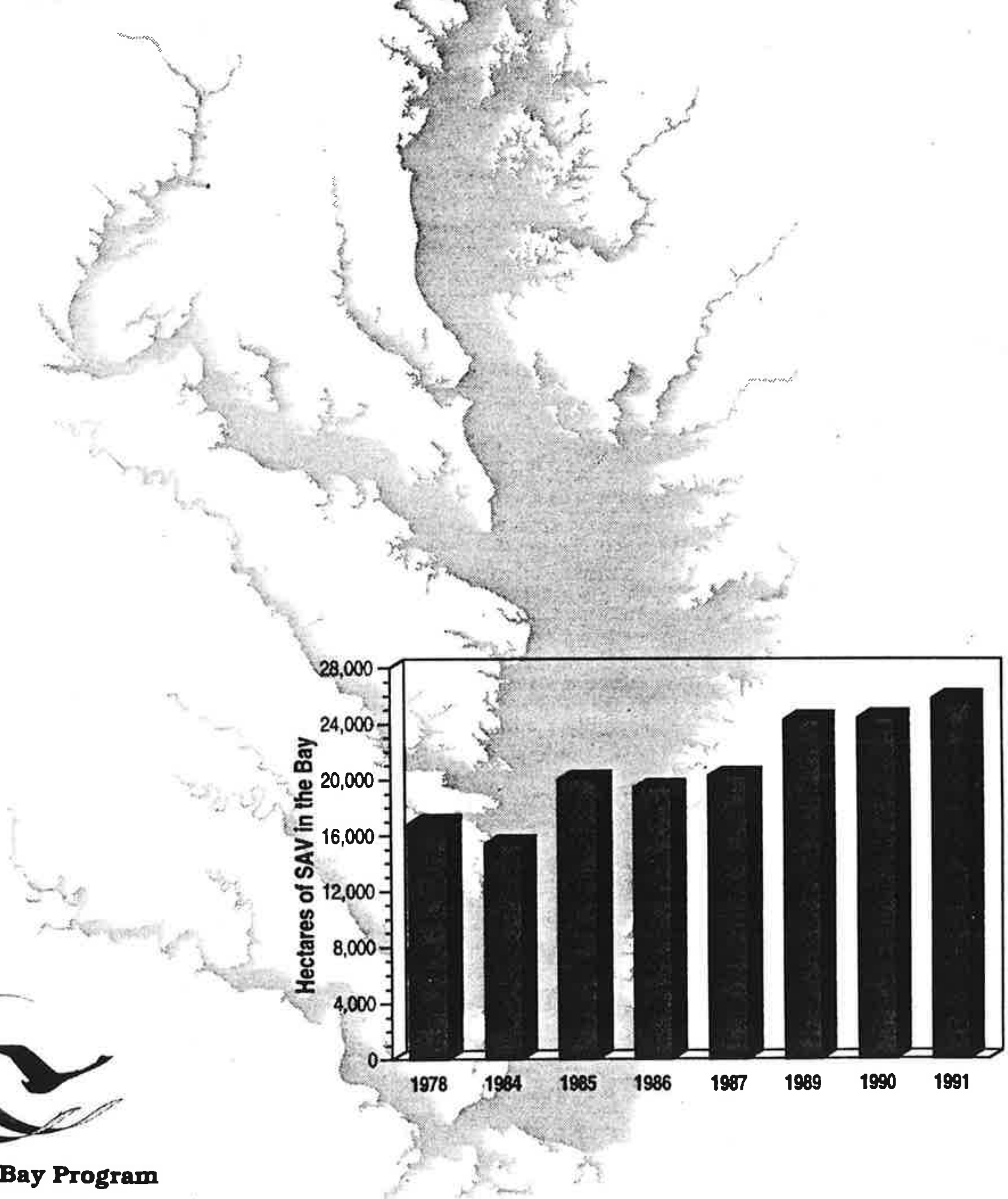

Chesapeake Bay Program

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Trends in the Distribution, Abundance, and Habitat Quality of Submerged Aquatic Vegetation in Chesapeake Bay and its Tidal Tributaries: 1971 to 1991

Robert J. Orth[1]
Richard A. Batiuk[2]
Judith F. Nowak[1]

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1 School of Marine Science; Virginia Institute of Marine Science; College of William and Mary; Gloucester Point, VA 23062
2 U.S. Environmental Protection Agency; Chesapeake Bay Program Office; Annapolis, MD 21403

Executive Summary

Over the last three to four decades, declines of many Chesapeake Bay species from overharvesting, deterioration of water quality, habitat destruction, disease, and meteorological changes have alarmed scientists, managers, politicians, and the public. This concern has prompted scientists to study the magnitude and causes of the declines and managers to develop basinwide agreements to protect, restore, and enhance these living resources.

Submerged aquatic vegetation (SAV) historically contributed to the high primary and secondary productivity of Chesapeake Bay, but in the late 1960s and 1970s it experienced a dramatic baywide decline due to increased nutrient and sediment inputs from development of the surrounding watershed. This decline galvanized diverse groups into formulating the *Submerged Aquatic Vegetation Policy for the Chesapeake Bay and Tidal Tributaries* and the *Implementation Plan for the Submerged Aquatic Vegetation Policy* that would guide managers and scientists in SAV assessment, protection, education, and research to ensure the restoration of these plants.

Living resources monitoring programs are critical in understanding fluctuations in resource abundance. In Chesapeake Bay, monitoring SAV is used to evaluate the success of restoration and protection efforts. The strong link between water quality and the distribution and abundance of SAV makes these plants a good barometer of Chesapeake Bay health.

Significant progress has been made in defining habitat requirements for SAV in Chesapeake Bay. Linked with achievement of these SAV habitat requirements is a tiered set of SAV distribution restoration goals and targets established for Chesapeake Bay, along with restoration targets for SAV bed density and species diversity.

This report builds on two decades of aerial and ground survey SAV distribution data, as well as development of SAV habitat requirements, establishment of SAV restoration goals and targets, compilation of historical water quality data, and implementation of a baywide monitoring program. The objectives of this report are to:

- describe trends in SAV distribution and abundance in Chesapeake Bay and its tidal tributaries from 1971 to 1991;
- relate SAV distribution over time with tiered distribution restoration goals and targets;
- compare trends in SAV distribution with corresponding trends in water quality; and
- correlate SAV distribution with river flow.

Since the first baywide SAV survey in 1978, the total abundance of SAV in Chesapeake Bay and its tidal tributaries has increased by 52 percent from 16,895 hectares in 1978 to 25,623 hectares in 1991 (Figure I, Table I). The 1991 data represent a 56 percent achievement of the Tier I SAV distribution restoration goal (46,025 hectares) and a 10 percent achievement of the Tier III SAV distribution restoration target (247,658 hectares).

Along with the increase in SAV distribution between 1984 and 1991 was a concomitant increase in the overall density of many SAV beds. While 38 percent (5,931 hectares) of mapped SAV was

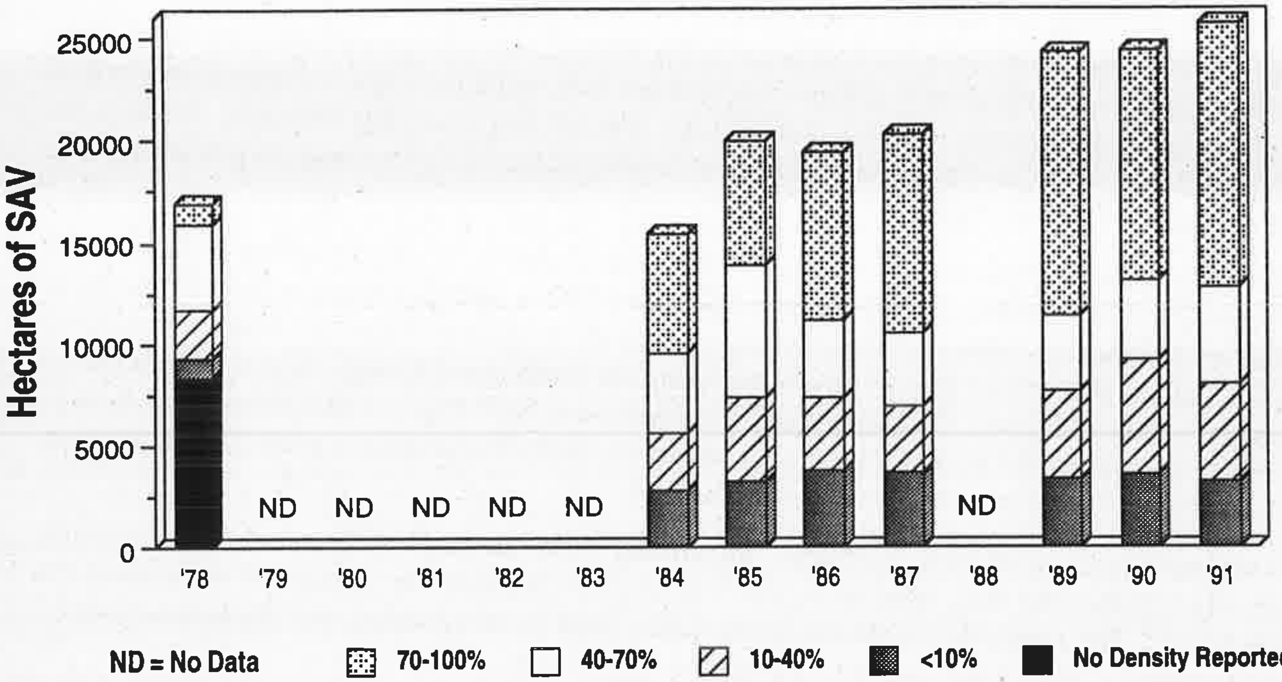

Figure I. Hectares of SAV by density category for all years for which aerial survey data were available baywide. The baywide Tier I SAV restoration goal and Tier III SAV restoration target are 46,025 and 247,658 hectares, respectively. In 1978, density was not recorded for the SAV mapped in the Maryland portion of Chesapeake Bay.
Sources: Anderson and Macomber, 1980; Batiuk et al., 1992; Orth et al., 1979, 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Nowak, 1990.

classified as dense (70-100 percent coverage) in 1984, by 1991 more than twice as many hectares of SAV (12,947 hectares or 50 percent of the total) fit this category (Figure I, Table I).

Patterns of change in SAV populations throughout Chesapeake Bay were complex and varied both in space and time. This complexity most likely reflects the differing characteristics of the Bay's major watersheds, meteorological differences, and differences in the biology of the SAV species. To further describe baywide trends, patterns of SAV distribution from 1984 to 1991 (and from 1971 to 1991 when data were available) in all Chesapeake Bay Program segments were characterized and assigned to one of the following five categories: increasing trend, fluctuating at high levels, fluctuating at low levels, decreasing trend, and little or no SAV (Figure II).

Consistent annual increases in SAV distribution and abundance since 1978 occurred in seven of the 45 Chesapeake Bay Program segments (Lower Chesapeake Bay (CB5); Western Lower Chesapeake Bay (CB6); Eastern Lower Chesapeake Bay (CB7); Tangier Sound (EE3) ; Mobjack Bay (WE4); Middle Potomac River (RET2); and Upper Potomac River (TF2)) (Figure III). Five of the segments are contiguous in the middle to lower portion of the mainstem Bay (Lower Chesapeake Bay, Western Lower Chesapeake Bay, Eastern Lower Chesapeake Bay, Tangier Sound, and Mobjack Bay) and are areas where relatively large, viable populations of SAV still remained after the 1970s decline. Percent increases in SAV distribution from 1978 to 1991 were 56 percent in Mobjack Bay, 64 percent in Eastern Lower Chesapeake Bay, 85 percent in Western Lower Chesapeake Bay, 127 percent in Lower Chesapeake

Table I. Hectares of SAV by Density Category for all Years for which Aerial Survey Data were Available Baywide

Year	No Density Reported	<10%	10-40%	40-70%	70-100%	Baywide Total
1978	8360	911	2,387	4,229	1,011	16,898
1979	ND	ND	ND	ND	ND	ND
1980	ND	ND	ND	ND	ND	ND
1981	ND	ND	ND	ND	ND	ND
1982	ND	ND	ND	ND	ND	ND
1983	ND	ND	ND	ND	ND	ND
1984	—	2,787	2,861	3,854	5,931	15,433
1985	—	3,227	4,111	6,500	6,135	19,974
1986	—	3,785	3,596	3,761	8,283	19,425
1987	—	3,640	3,296	3,585	9,713	20,234
1988	ND	ND	ND	ND	ND	ND
1989	—	3,331	4,350	3,730	12,836	24,247
1990	—	3,561	5,603	3,990	11,240	24,394
1991	—	3,199	4,851	4,731	12,947	25,728

ND = No Data
Sources: Anderson and Macomber, 1980; Batiuk et al., 1992; Orth et al., 1979, 1985, 1986, 1987, 1989, 1990, 1991, and 1992; Orth and Nowak, 1990.

Bay, and 232 percent in Tangier Sound. The larger increases in the Lower Chesapeake Bay and Tangier Sound segments were due primarily to the rapid and sudden growth of *Ruppia maritima* in the Barren Island-Honga River area. These areas had almost no SAV in 1978 but by 1984, SAV beds were reported throughout the area. These beds increased rapidly into large, monospecific, and dense populations of *R. maritima*.

Water quality conditions in the lower mainstem Bay, Tangier Sound, and Mobjack Bay have been suitable for SAV survival and growth consistently since the early 1980s. Up through the late 1970s, the data indicate water quality conditions in these segments fluctuated between unsuitable (not meeting SAV habitat requirements) and suitable (meeting SAV habitat requirements) on an annual basis. The improvements in water quality—relative to the SAV habitat requirements—correspond with documented increases in SAV distribution and abundance.

The upper (TF2) and middle (RET2) segments of the Potomac River were the only other areas showing consistently increasing trends in SAV distribution. These increases resulted, in part, from the 1982 introduction of *Hydrilla verticillata* and its subsequent rapid spread along more than 60 kilometers of shoreline in less than ten years. In the upper and middle reaches of the Potomac River, water quality conditions just met or were slightly above several of the SAV habitat requirements until 1991. Concentrations of the SAV habitat requirement parameters decreased over the water quality data record from 1970 to 1991.

Seven of the Chesapeake Bay Program segments were classified as areas in which SAV occurred in areas greater than 100 hectares but showed no consistent trend of either increasing or decreasing acreage: Northern Chesapeake Bay (CB1); Eastern Bay (EE1); and the Elk/Bohemia (ET2), Lower Choptank (EE2), Manokin (ET8), Big Annemessex (ET9), and the Lower Rappahannock (LE3) river

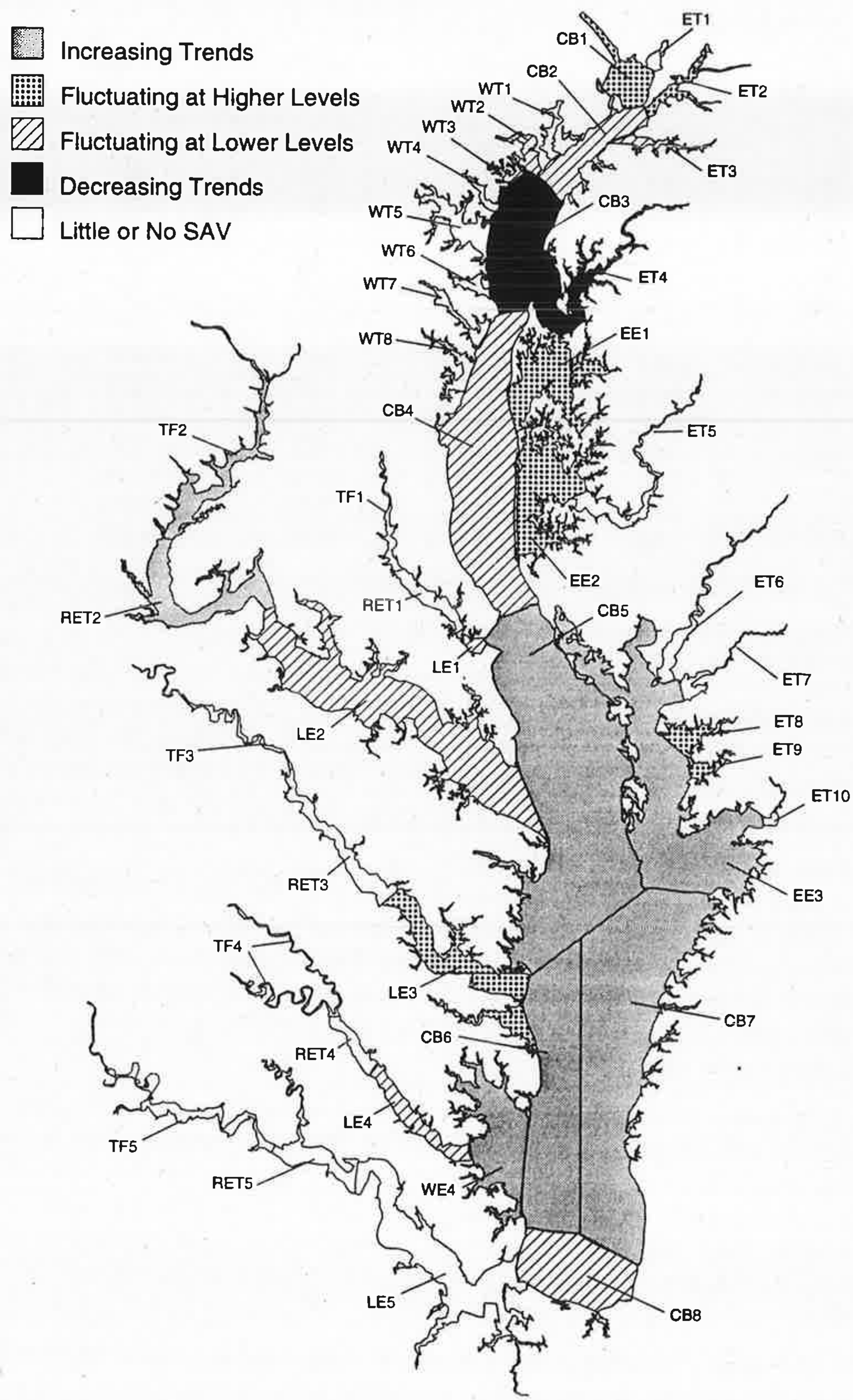

Figure II. Patterns of SAV distributions from 1971-1991 by Chesapeake Bay Program segment.
Sources: Anderson and Macomber, 1980; Chesapeake Bay Program, unpublished data b; Orth et al., 1979, 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Gordon, 1975; Orth and Nowak, 1990.

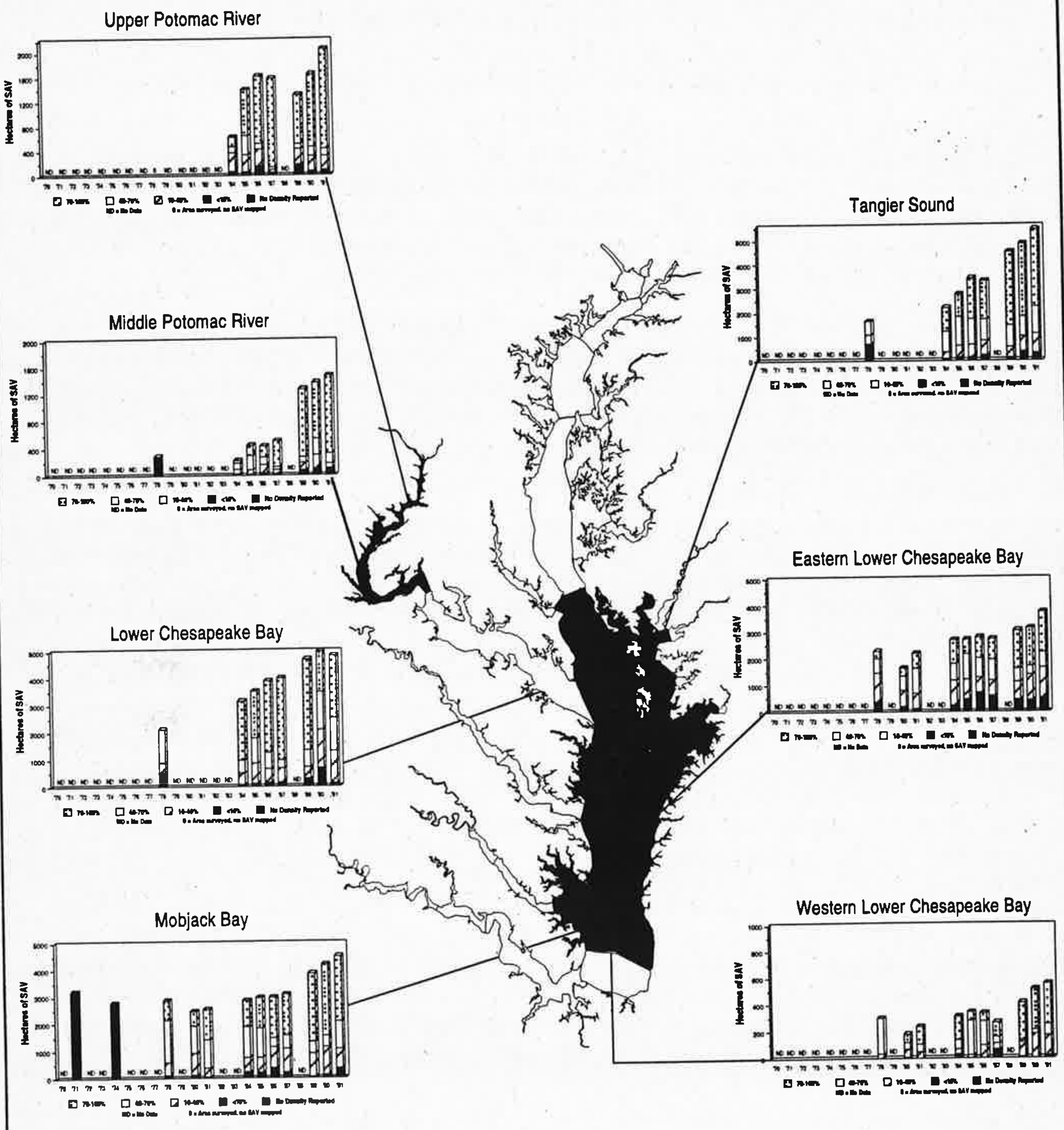

Figure III. Chesapeake Bay segments with increasing trends in SAV.
Sources: Anderson and Macomber, 1980; Chesapeake Bay Program, unpublished data b; Orth et al., 1979, 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Gordon, 1975; Orth and Nowak, 1990.

segments (Figure IV). Three of these segments (the Manokin, Big Annemessex, and Lower Rappahannock rivers) were located near or adjacent to those segments showing consistent increases in SAV distribution. In two segments (Eastern Bay and Lower Choptank River), *R. maritima* rapidly expanded in the mid-1980s but had begun to decline by 1990. By 1991, this species made up only a few scattered beds.

The Susquehanna Flats and tidal Susquehanna River (the northern Chesapeake Bay segment) are included in this category. Interestingly, the flanks of the tidal Susquehanna River below Conowingo Dam are densely vegetated with several SAV species. The very large shallow-water area (Susquehanna Flats), which historically supported one of the Bay's largest SAV communities and contained numerous SAV species, remains sparsely vegetated with only *Myriophyllum spicatum*.

In four segments with SAV distributions fluctuating at higher levels (Northern Chesapeake Bay, Eastern Bay, Lower Choptank River, and Lower Rappahannock River), water quality conditions often just meet SAV habitat requirements. In the three Eastern Shore tributary segments in this category (the Elk/Bohemia, Manokin, and Big Annemessex rivers) both the light attenuation coefficient and total suspended solids habitat requirements have generally not been met from 1970 to 1991.

Nine of the Chesapeake Bay Program segments were classified as areas where SAV occurred in distributions under 100 hectares but showed no consistent trend of either increasing or decreasing SAV distribution (the Upper Chesapeake Bay (CB2); Middle Central Chesapeake Bay (CB4); Mouth of Chesapeake Bay (CB8); and the Sassafras (ET3), Gunpowder (WT2), Middle (WT3), Lower Patuxent (LE1), Lower Potomac (LE2), and Lower York (LE4) river segments) (Figure V). Similar to those segments in which SAV fluctuates at higher levels, most of these segments were either part of the mainstem Bay or were immediately adjacent to it. This group included the Lower York River segment where SAV is present in a very small section near the river mouth; the Lower Potomac River segment where SAV is absent from almost all of the mainstem river; the lower Patuxent River segment; the only two western shore tributaries (the Gunpowder and Middle rivers) that have consistently supported SAV populations throughout the 1980s and 1990s; and three mainstem Bay segments (Upper Chesapeake Bay, Middle Central Chesapeake Bay, and Mouth of the Chesapeake Bay) that contain few areas that could support SAV due to exposed shorelines.

Segments with SAV distributions fluctuating at low levels have had either: water quality conditions suitable for SAV survival and growth but with limited potential habitat (Middle Central Chesapeake Bay and Mouth of Chesapeake Bay); water quality conditions generally suitable for SAV but with limited sources of the propagules necessary for restoration (Lower Patuxent and Lower Potomac rivers); or water quality conditions which ranged from unsuitable to suitable for SAV survival and growth from 1971 to 1991 (the Upper Chesapeake Bay and the Sassafras, Gunpowder, Middle, and Lower York rivers).

Only two of the 45 Chesapeake Bay Program segments were classified as areas with consistently decreasing trends in SAV distribution (Upper Central Chesapeake Bay (CB3) and Chester River (ET4) segments) (Figure VI). These two segments were flanked by segments with little or no SAV (Back, Patapsco, and Magothy rivers) and those with SAV fluctuating at low abundance levels (Upper Chesapeake Bay, Middle Central Chesapeake Bay, Gunpowder River, and Middle River). The Upper Central Chesapeake Bay and Chester River historically supported some of the largest concentrations of SAV beds with high species diversity in the middle Chesapeake Bay region—particularly adjacent to Eastern Neck and Eastern Neck Island.

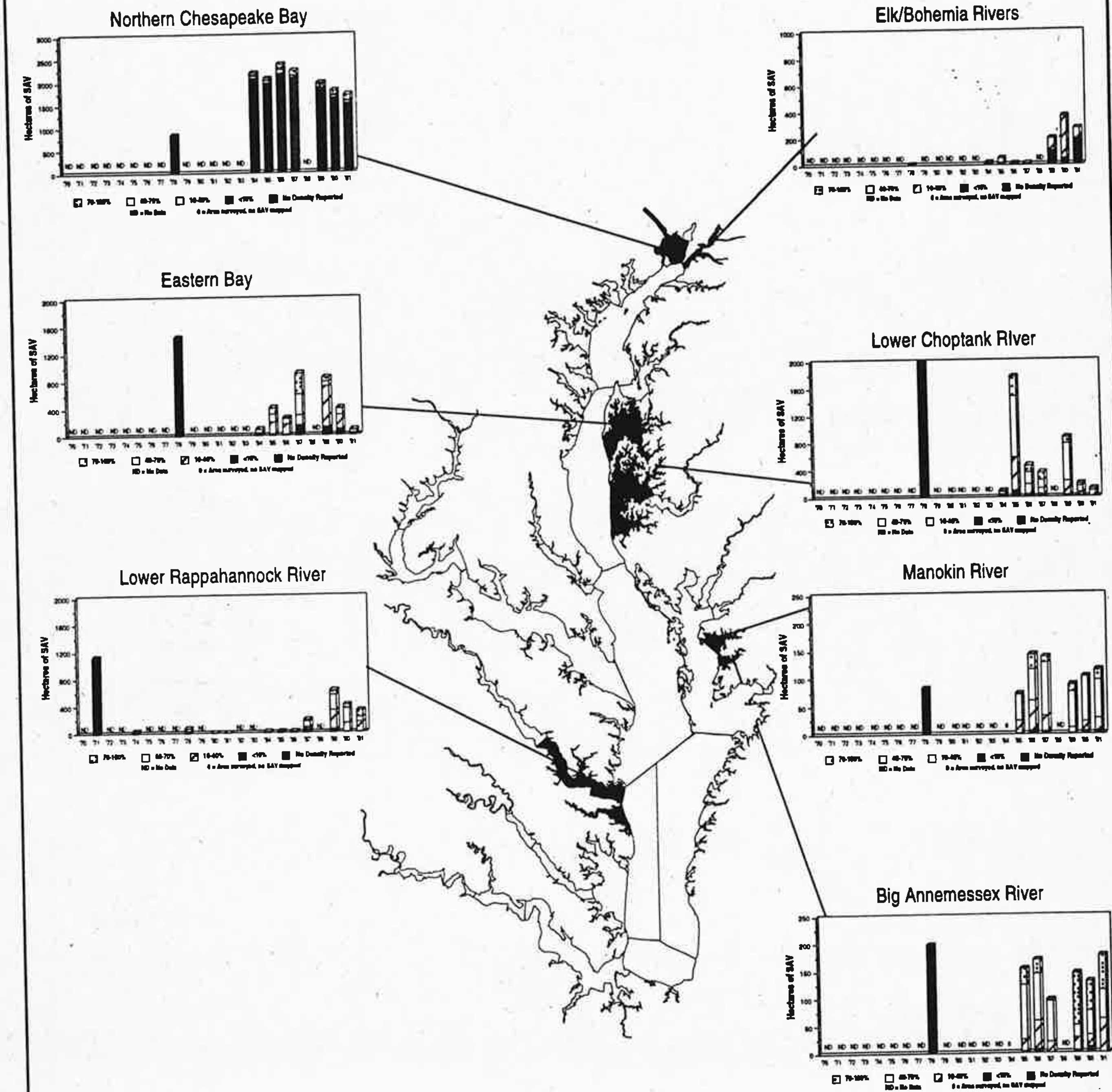

Figure IV. Chesapeake Bay segments with SAV fluctuating at higher levels of abundance.
Sources: Anderson and Macomber, 1980; Chesapeake Bay Program, unpublished data b; Orth et al., 1979, 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Gordon, 1975; Orth and Nowak, 1990.

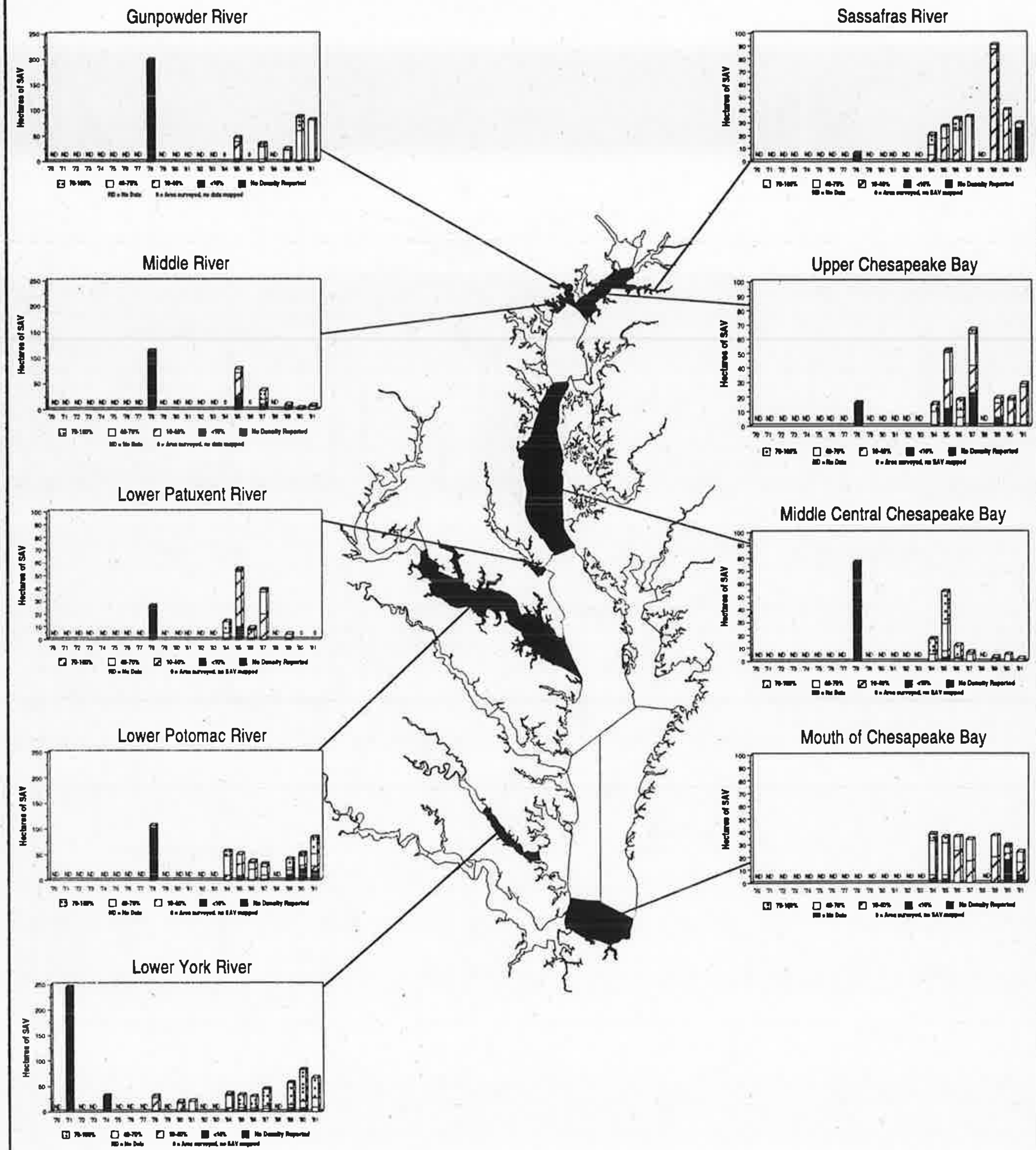

Figure V. Chesapeake Bay segments with SAV fluctuating at lower levels of abundance.
Sources: Anderson and Macomber, 1980; Chesapeake Bay Program, unpublished data b; Orth et al., 1979, 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Gordon, 1975; Orth and Nowak, 1990.

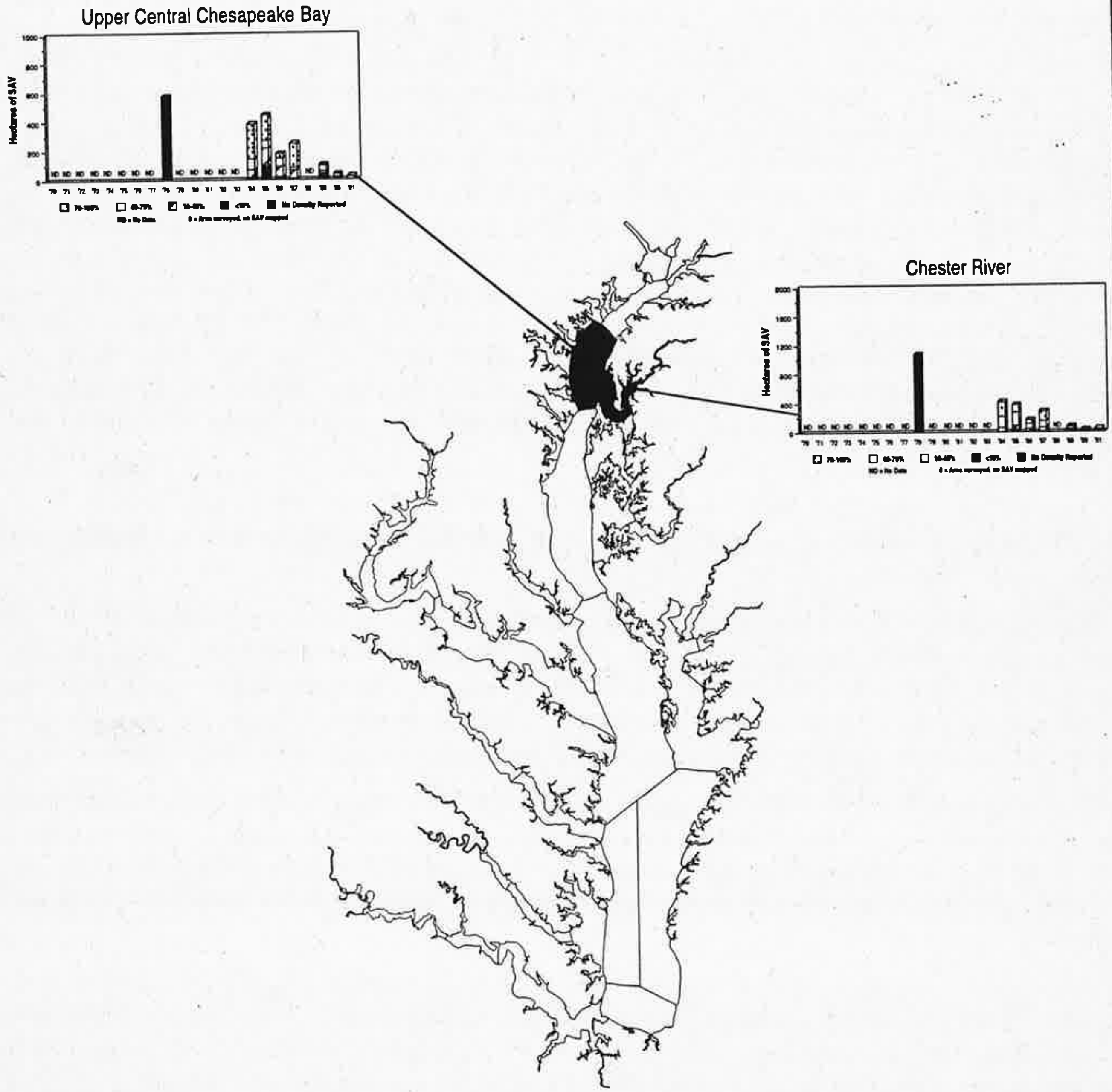

Figure VI. Chesapeake Bay segments with decreasing trends.
Sources: Anderson and Macomber, 1980; Orth et al., 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Nowak, 1990.

Water quality conditions meeting the SAV habitat requirements in the Upper Central Chesapeake Bay fluctuated from year to year over the 1971 to 1991 data record. Water quality in the adjacent Chester River has generally been unsuitable for SAV survival since the mid 1970s.

Twenty of the segments have had little SAV (less than 50 hectares)—Northeast (ET1), (Bush (WT1), Patapsco (WT5), Magothy (WT6), Severn (WT7), South/Rhode/West (WT8), Choptank (ET5), Upper Patuxent (TF1), Middle Patuxent (RET1), Middle James (RET5), and Lower James (LE5) rivers (Figure VII)—or no SAV present since 1978—Back (WT4), Upper Rappahannock (TF3), Middle Rappahannock (RET3), Upper York (TF4), Middle York (RET4), Upper James (TF5), Nanticoke (ET6), Wicomico (ET7), and Pocomoke (ET10) river. All of the major western shore tributaries, except the Potomac River, had two or all three segments in this category. The upper tidal fresh and middle transition segments of these rivers were largely unvegetated. All other segments having little or no SAV are the smaller tributaries along the western or eastern shore. The relatively small drainage basins of these tributaries encompass both highly urbanized and industrialized areas (i.e., the Bush, Back, Patapsco, Magothy, Severn, and South rivers), as well as areas with intensive agriculture (i.e., the Choptank, Nanticoke, and Wicomico rivers) which result in greater nonpoint source inputs of nutrients and sediments.

Ground surveys show that these smaller tidal tributaries had supported SAV beds prior to 1971. Since 1971, however, water quality conditions have been generally unsuitable for SAV survival in these segments where little or no SAV has been mapped.

The river flows of the Susquehanna and Potomac rivers were analyzed to evaluate whether flow is a good indicator of SAV distribution patterns over time. River flow from these two systems accounts for approximately 75 percent of the total freshwater inflow to the Bay. River flow can integrate localized rainfall events minimizing the bias inherent in localized rainfall patterns. The assumption made here is that higher river flow is directly correlated with higher inputs of sediments and nutrients.

The annual river flow pattern in the Susquehanna data (Figure VIII) generally shows average flows in the 1950s, below average flows in the 1960s (the 1962 to 1966 period was one of the lowest flow periods in the 42-year data set), and above average flows in the 1970s. The Potomac River flow data show patterns by decade that resemble those in the Susquehanna although the differences were less pronounced.

These river flow patterns may be a critical driving force in structuring SAV in Chesapeake Bay. In the 1950s, SAV populations generally flourished in most sections of the Bay and its tidal tributaries; river flow during the SAV growing season was normal with a couple of years of above normal runoff punctuated by low runoff years. Submerged aquatic vegetation continued to flourish in the 1960s, a decade characterized by below average river flow. The 1970s were years of major SAV decline baywide and the highest river flow. Submerged aquatic vegetation began to rebound in the 1980s as river flow returned to normal. An interesting comparison shows that the 1980s are punctuated by both high and low flow years. Submerged aquatic vegetation populations could potentially be sustained during high flow years if their growth, distribution, and abundance are maximized during low flow years. Several consecutive high flow years may be most detrimental to SAV populations.

In summary, the largest expansion of SAV between 1978 and 1991 occurred in the lower mainstem Bay segments where SAV populations had not declined as significantly during the 1970s and where water quality consistently met the SAV habitat requirements. The SAV beds remaining in these segments

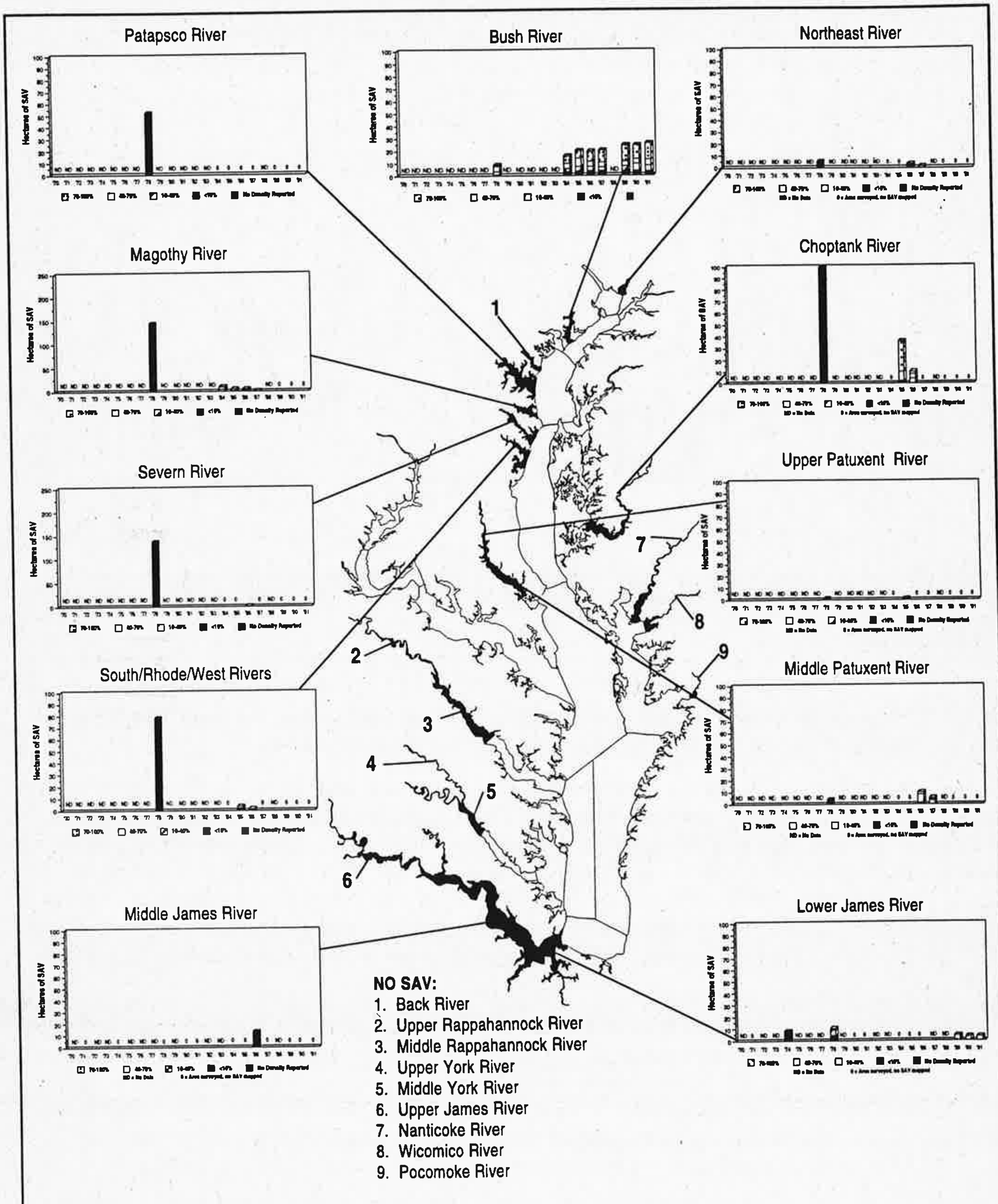

Figure VII. Chesapeake Bay segments with little or no SAV.
Sources: Anderson and Macomber, 1980; Chesapeake Bay Program, unpublished data; Orth et al., 1977, 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Gordon, 1975; Orth and Nowak, 1990.

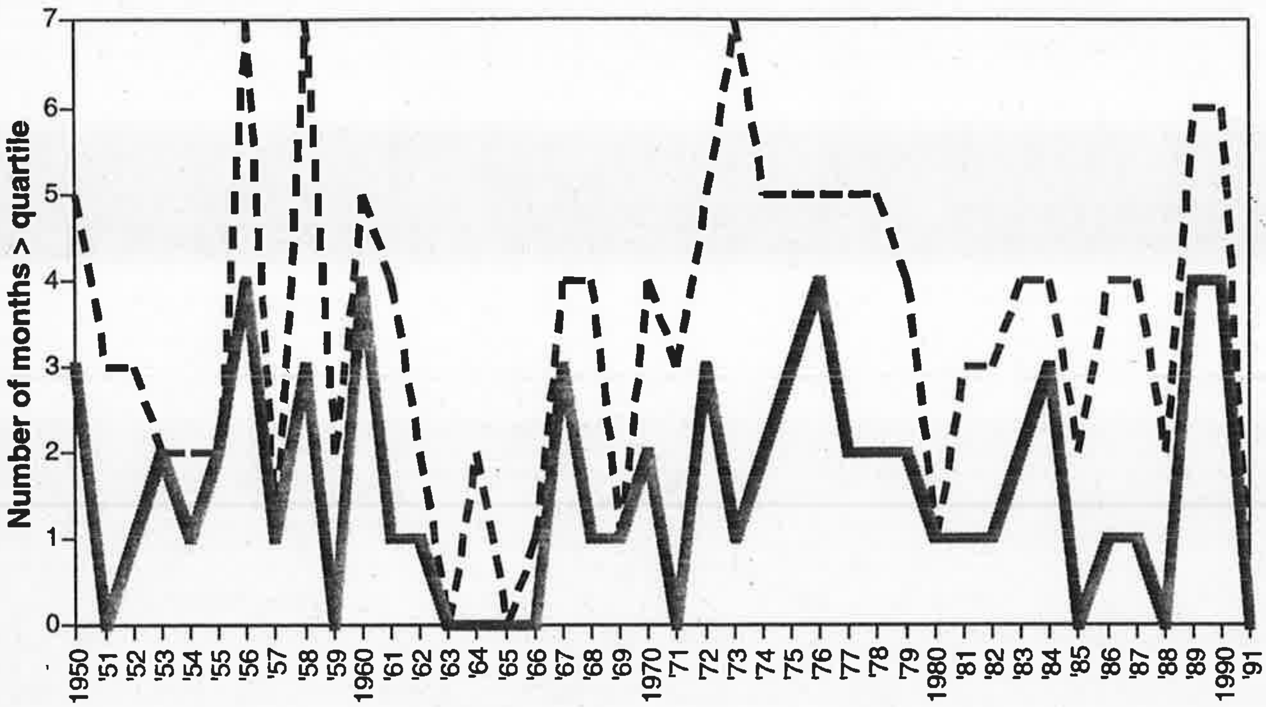

Figure VIII. Susquehanna River flow presented as the number of months between April and October (the SAV growing season) within each year from 1950 to 1991 in which the mean monthly flow is above the 50th percentile (■ ■ ■ ■ ■) and the 75th percentile (▬▬▬) of total river flow.
Source: U.S. Geological Survey.

after the baywide decline may have contributed to a pool of propagules (i.e., seeds or fragments of vegetation capable of forming new plants) that repopulated unvegetated areas.

The rapid spread of SAV in the tidal fresh Potomac River has resulted in the highest levels of abundance of SAV in the river since the early 1900s. Although the exotic, *H. verticillata,* was the dominant species contributing to this rapid spread, numerous other native species co-occur with this species. Some declines in SAV were noted around Washington, DC since 1989, but these losses were offset by the continued rapid downriver expansion of SAV below Quantico to Aquia Creek. In the 1980s, *R. maritima* underwent a sudden and rapid expansion in the middle mainstem Bay, as well as in the lower Patuxent, Chester, Choptank, and Rappahannock rivers, with a subsequent decline in some areas.

Many sections of the Bay and its tidal tributaries remain unvegetated or have very sparse SAV populations—principally the upper western shore and Eastern Shore tributaries and where water quality has not consistently met the SAV habitat requirements. Two major western shore tributaries—the James and Patuxent rivers—have almost no SAV throughout their lengths. The relatively large interannual fluctuations in SAV distribution in many areas of the Bay and its tidal tributaries support the need to monitor SAV annually to understand the factors controlling SAV distribution and abundance.

Submerged aquatic vegetation distributional patterns in the Bay and its tidal tributaries exhibit fairly sharp boundaries between areas with SAV and those without, indicating that relatively small changes in water quality can lead to rapid increases or decreases in SAV populations. Ground surveys have confirmed the presence of remnant SAV populations in small tidal creeks and tributaries (e.g., the Patuxent River), suggesting that the presence of vegetative sources or seed banks could repopulate riverine populations if water quality conditions improve. The recent changes in SAV populations in the Bay suggest that most SAV populations can rebound rapidly if water quality conditions are improved and maintained. Some areas may not become revegetated even after the return of suitable water quality conditions, however, due to a lack of SAV propagules either within or close to these areas.

Acknowledgments

Without the joint support of the following agencies which have supported the Chesapeake Bay submerged aquatic vegetation aerial survey monitoring program over 15 years, the baywide mapping program could not have been accomplished: U.S. Environmental Protection Agency, Grant Numbers X003465-01, -02, -03; U.S. Fish and Wildlife Service, Grant Numbers 14-16-0005-86-028, 87-9005, 90-9031, and 91-9023; Virginia Council on the Environment and Maryland Department of Natural Resources through the Coastal Resources Management Program of the National Oceanographic and Atmospheric Administration, Grant Numbers NA88AA-DCZ-091,092, NA89AA-DCZ-134, NA90AA-H-CZ796, C057-88-031, C188-90-002, C225-91-004; and a private grant from the Allied-Signal Foundation to the College of William and Mary.

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Chapter 1 Introduction

> *"Therefore, to further our commitments made in the 1987 Chesapeake Bay Agreement, we agree...to use the distribution and abundance of submerged aquatic vegetation (SAV) in the Bay and its tidal tributaries, as documented by Baywide and other aerial surveys conducted since 1970, as an initial measure of progress in the restoration of living resources and water quality."*
>
> *– From the 1992 Amendments to the Chesapeake Bay Agreement, signed by Governors Robert Patrick Casey (Pennsylvania), William Donald Schaefer (Maryland), and Lawrence Douglas Wilder (Virginia), Mayor Sharon Pratt Kelly (District of Columbia), Senator Bernie Fowler (Chair, Chesapeake Bay Commission), and Administrator William Reilly (U.S. Environmental Protection Agency).*

Chesapeake Bay has long been renowned for its abundant harvestable resources. No less important, however, is the large and diverse array of non-harvestable plants and animals that contributes to the complexity, balance, and beauty of this dynamic and productive estuary.

Over the last three to four decades, the decline of many species from overharvesting, deterioration of water quality, habitat destruction, disease, and meteorological changes has alarmed scientists, managers, politicians, and the public (Horton and Eichbaum, 1991). This concern triggered scientific studies to document the magnitude and causes of the declines along with basinwide agreements to protect, restore, and enhance these living resources.

Submerged aquatic vegetation (SAV) is a diverse assembly of rooted macrophytes living in the shoal areas of Chesapeake Bay—from its mouth to the headwaters of its tidal tributaries (Stevenson and Confer, 1978; Orth et al., 1992). These plants historically contributed to the high primary and secondary productivity of Chesapeake Bay (Kemp et al., 1984). Scientists correlated the dramatic baywide decline of all SAV species in the late 1960s and 1970s (Orth and Moore, 1983a) with increased nutrients and sediments flowing into the Bay due to development of the surrounding watershed (Kemp et al., 1983). This situation galvanized diverse groups into formulating both a policy and an implementation plan to ensure the restoration of SAV in Chesapeake Bay.

The 1987 Chesapeake Bay Agreement, signed by the governors of Pennsylvania, Maryland, and Virginia, the mayor of the District of Columbia, the chair of the Chesapeake Bay Commission, and the administrator of the U.S. Environmental Protection Agency, set as a major commitment the "need to determine the essential elements of habitat quality and environmental quality necessary to support living resources and to see that these conditions are attained and maintained" (Chesapeake Executive Council, 1987). The *Submerged Aquatic Vegetation Policy for the Chesapeake Bay and Tidal Tributaries* (Chesapeake Executive Council, 1989) and the *Implementation Plan for the Submerged Aquatic Vegetation Policy* (Chesapeake Executive Council, 1990) were developed to guide managers and scientists in SAV assessment, protection, education, and research.

Living resources monitoring programs are critical to understand fluctuations in resource abundance. In Chesapeake Bay, baywide monitoring of SAV is necessary to assess the success of the restoration and protection efforts. The 1992 amendments to the 1987 Chesapeake Bay Agreement state that the distribution and abundance of SAV, documented by baywide and other aerial surveys, will be used as a measure of progress in the restoration of living resources and water quality (Chesapeake Executive Council, 1992). The strong link between water quality and SAV distribution and abundance (Batiuk et al., 1992; Dennison et al., 1993) supports the concept that SAV is a good barometer of Chesapeake Bay health (Orth and Moore, 1988).

Significant progress has been made in defining habitat requirements for Chesapeake Bay's key living resources (Chesapeake Bay Program, 1987; Funderburk et al., 1991) with emphasis on the Bay's SAV community (Batiuk et al., 1992; Dennison et al., 1993). Linked with these SAV habitat require-ments is a tiered set of SAV distribution restoration goals and targets for Chesapeake Bay, along with restoration targets for density and SAV species diversity (Batiuk et al., 1992; Chesapeake Executive Council, 1993; Dennison et al., 1993).

This report builds on two decades of aerial and ground surveys of SAV distribution and abundance data along with development of SAV habitat requirements, establishment of SAV restoration goals and targets, compilation of historical water quality data, and implementation of a coordinated baywide monitoring program. The objectives of this report are to:

- describe trends in SAV distribution and abundance in Chesapeake Bay and its tidal tributaries from 1971 to 1991;
- relate SAV distribution over time with tiered distribution restoration goals and targets;
- compare trends in SAV distribution and abundance with corresponding trends in water quality; and
- correlate SAV distribution with river flow.

Chapter 2: Trend Analysis Approach

Numerous ground and aerial surveys of SAV have been conducted in the past, particularly over the last two decades. This chapter provides a brief description of these surveys and their methodologies. It also includes an explanation of how SAV distribution and abundance data were coupled with water quality monitoring data, the SAV habitat requirements, and the SAV restoration goals and targets.

Chesapeake Bay SAV Species

The term "submerged aquatic vegetation," for the purpose of this analysis, encompasses 25 taxa from ten vascular macrophyte families and three taxa from one freshwater macrophytic algal family (Characeae) but excludes all other algae (Table 1). Eleven species of SAV, exclusive of the algae, are commonly found in Chesapeake Bay and its tidal tributaries.

Table 1. Species of SAV Found in Chesapeake Bay and its Tidal Tributaries

Family	Species	Common Name
Characeae	*Chara braunii* Gm. *Chara zeylanica* Klein ex Willd., em. *Nitella flexilis* (L). Ag., em	Muskgrass
Potamogetonaceae	*Potamogeton perfoliatus*, L. var. *bupleuroides* (Fernald) Farwell *Potamogeton pectinatus* L. *Potamogeton crispus* L. *Potamogeton pusillus* L. *Potamogeton amplifolius* *Potamogeton diversifolius* *Potamogeton epihydrus* *Potamogeton gramineus* *Potamogeton nodosus*	Redhead grass Sago pondweed Curly pondweed Slender pondweed
Ruppiaceae	*Ruppia maritima* L.	Widgeongrass
Zannichelliaceae	*Zannichellia palustris* L.	Horned pondweed
Najadaceae	*Najas guadalupensis* (Sprengel) Magnus *Najas gracillima* (A. Braun) Magnus *Najas minor* Allioni *Najas muenscheri* *Najas flexilis*	Southern naiad Naiad
Hydrocharitaceae	*Vallisneria americana* Michaux *Elodea canadensis* (Michaux) *Egeria densa* Planchon *Hydrilla verticillata* (L.f.) Boyle	Wild celery Common elodea Waterweed Hydrilla
Pontedariaceae	*Heteranthera dubia* (Jacquin) MacMillian	Water stargrass
Ceratophyllaceae	*Ceratophyllum demersum* L.	Coontail
Trapaceae	*Trapa natans* L.	Water chestnut
Haloragaceae	*Myriophyllum spicatum* L.	Eurasian water milfoil
Zosteraceae	*Zostera marina* L.	Eelgrass

Classification and nomenclature derived from: Godfrey and Wooten, 1979 and 1981; Harvill et al., 1977 and 1981; Karteśz and Kartesz, 1980; Radford et al., 1968; Wood and Imahori, 1964 and 1965. Sources: Brush, 1987; Brush and ,1989; Carter et al. ,1985a; Chesapeake Bay Program, unpublished data c; Davis, 1985; Hurley, 1990; Orth and Nowak, 1990; Orth et al., 1979; Paschal et al., 1982; Rybicki et al., 1988, 1987, and 1986; Stevenson and Confer, 1978; R. Younger, Personal Communication.

Zostera marina (eelgrass) is dominant in the lower reaches of the Bay. *Myriophyllum spicatum* (Eurasian watermilfoil), *Potamogeton pectinatus* (sago pondweed), *Potamogeton perfoliatus* (redhead grass), *Zannichellia palustris* (horned pondweed), *Vallisneria americana* (wild celery), *Elodea canadensis* (common elodea), *Heteranthera dubia* (water stargrass), *Ceratophyllum demersum* (coontail), and *Najas guadalupensis* (southern naiad) are less tolerant of high salinities and are found in the middle and upper reaches of the Bay and its tidal tributaries (Stevenson and Confer, 1978; Orth et al., 1979; Orth and Moore, 1981, 1984). *Ruppia maritima* (widgeongrass) tolerates a wide salinity range and is found from the Susquehanna Flats south to the mouth of the Chesapeake Bay.

Approximately seventeen other species occur only occasionally. When present, they populate areas principally in the middle and upper reaches of Chesapeake Bay and in its tidal tributaries (Table 1). *Hydrilla verticillata* (hydrilla), a recently introduced exotic species, dominates SAV beds in the tidal fresh reaches of the Potomac River (Carter and Rybicki, 1986). It has also been reported in the Susquehanna Flats (Orth et al., 1989, 1991, 1992), although its growth there has not been as widespread as in the Potomac River (Kollar, personal communication).

Stevenson and Confer (1978), Carter et al. (1983), Batiuk et al. (1992), Hurley (1992), and Stevenson and Staver (in press) provide more detailed descriptions of the biology and ecology of the above species.

Chesapeake Bay Program Segments

Chesapeake Bay Program segments are used to present the 1971 to 1991 SAV distribution and abundance data and the 1970 to 1991 water quality data described here (Figure 1). In 1983, the Chesapeake Bay Program developed and adopted the Chesapeake Bay segmentation scheme. It was first published in *Chesapeake Bay: Profile for Environmental Change* (U.S. Environmental Protection Agency, 1983). Since then, the segmentation scheme has been used both to design monitoring programs and as the spatial scheme for management, analysis, interpretation, and presentation of monitoring data. The Chesapeake Bay Program (1990) has published a complete listing of the latitude/longitude coordinates for the segmentation scheme. This scheme differs from the organizational provinces used in the annual SAV aerial monitoring program (see references in Table 2).

The segmentation scheme is problematic in those segments with significant changes in SAV distribution and abundance patterns within an individual segment (e.g., SAV is abundant in the lower portion but absent or limited in the upper portion of the lower York and Rappahannock rivers). Although water quality in the lower portions of these segments is apparently adequate to support viable populations of SAV, water quality in the upper portions is not suitable for SAV growth and long-term survival. Median water quality conditions for the delineation of habitat requirements are derived from all monitoring stations within a segment, however, and may show that the water quality for that segment does not meet some or all SAV habitat requirements.

Several Chesapeake Bay Program segments contain tidal fresh, oligohaline, and mesohaline habitats within a single segment (principally the Chester (ET4) and Choptank (ET5) rivers). For this report, the more stringent set of SAV habitat requirements (i.e., mesohaline requirements) was applied to examine water quality data from 1971 to 1991. The preferred approach is to subdivide the Chesapeake Bay Program segment by individual salinity zones, apply the applicable SAV habitat requirements to data collected within the individual salinity zones, and compare these findings with SAV trends for that subsection. As SAV was absent from the tidal fresh and oligohaline areas of these segments, however, these more detailed analyses were not undertaken.

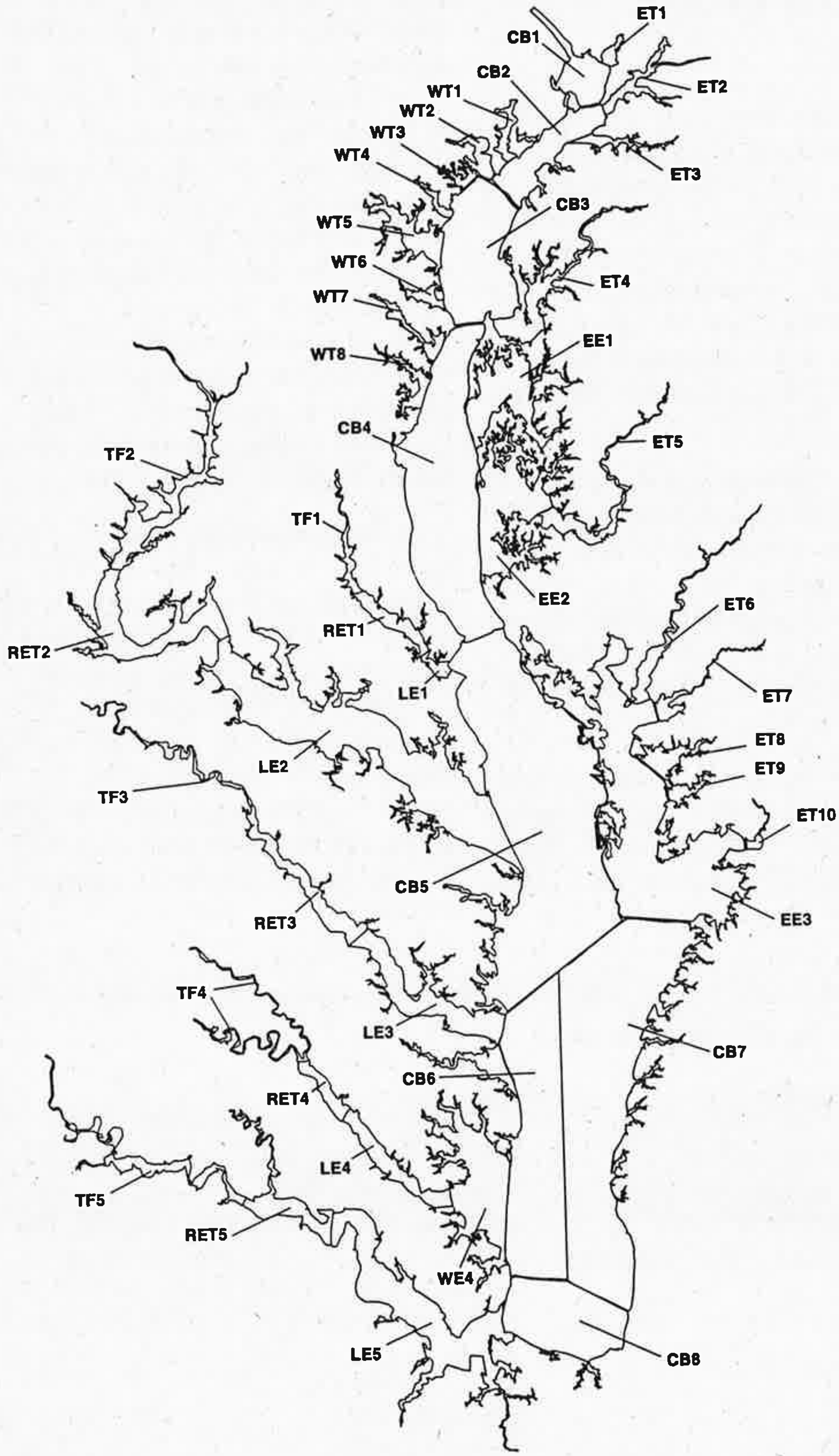


Figure 1. Chesapeake Bay Program segmentation scheme.
Source: Chesapeake Bay Program, 1990.

Baywide and Regional Aerial Surveys

Submerged aquatic vegetation was identified as a critical area of research, along with toxics and nutrients, during the 1976 to 1983 research phase of the Chesapeake Bay Program. Within the SAV research program, three elements were funded: assessing the baywide distribution of SAV; identifying the causes for the recent SAV decline; and determining the role and functional value of the SAV community (U.S. Environmental Protection Agency, 1982).

Low-level aerial photography was used in the first baywide survey in 1978 to assess the distribution and abundance of SAV (Orth et al., 1979; Anderson and Macomber, 1980). Aerial photography acquired under appropriate atmospheric and hydrologic conditions is an effective means of providing a synoptic picture of SAV distribution (Orth and Moore, 1983b).

Regional SAV aerial surveys were conducted in 1980 and 1981 (Virginia only) (Chesapeake Bay Program, unpublished data b). Orth et al. (1985) conducted the next baywide survey in 1984. Using similar methodologies, subsequent baywide surveys were conducted from 1985 to 1987 and from 1989 to 1991 (Orth et al., 1986, 1987, 1989, 1991, and 1992; Orth and Nowak, 1990). Sections of the lower Chesapeake Bay were photographed for SAV in 1974 and were compared with 1971 photographs taken for purposes other than mapping SAV. Both sets of photographs clearly delineated SAV beds (Orth and Gordon, 1975). Although aerial photographs were taken of sections of the Bay in Maryland and Virginia in 1979, and baywide in 1988, SAV beds were not mapped from this photography due to the late date of photoacquisition and the poor quality of the photographs. Table 2 summarizes SAV data available from the aerial surveys conducted between 1971 and 1991.

Vertical aerial photography (1:24,000), black and white or color, was the principal source of information used to assess the distribution and abundance of SAV. Photographs taken under optimal atmospheric, water, and biological conditions (i.e., low sun angle, little or no wind, minimal cloud or haze cover, low tide, and maximum standing biomass of SAV) insured optimal contrast in the imagery for SAV photointerpretation. Submerged aquatic vegetation beds were mapped directly onto USGS 7.5-minute quadrangles of transparent mylar and digitized into a geographic information system.

Table 2. Baywide and Regional SAV Aerial Surveys

Year	Areas Surveyed	Reference
1971	Lower Western Shore	Orth and Gordon, 1975
1974	Lower Western Shore	Orth and Gordon, 1975
1978	Chesapeake Bay	Anderson and Macomber, 1980; Orth et al., 1979
1979	Upper Western Shore–Maryland	Chesapeake Bay Program, unpublished data (a)
1980	Virginia	Chesapeake Bay Program, unpublished data (b)
1981	Virginia	Chesapeake Bay Program, unpublished data (b)
1984	Baywide	Orth et al., 1985
1985	Baywide	Orth et al., 1986
1986	Baywide	Orth et al., 1987
1987	Baywide	Orth et al., 1989
1989	Baywide	Orth and Nowak, 1990
1990	Baywide	Orth et al., 1991
1991	Baywide	Orth et al., 1992

The scale of the photography and that of the 7.5-minute quadrangles were similar, allowing the photointerpreter to overlay the transparent map onto the photograph for SAV bed delineation. Minor differences in scales were adjusted for by shifting the map to assure an adequate number of ground control points and by outlining the SAV over small sections of the photograph at any given point. The reports cited in Table 2 give detailed descriptions of the methodologies for photography (e.g., cameras, film types, and guidelines for the acquisition of photographs), mapping and reporting procedures, and quality control and quality assurance procedures (Orth and Moore, 1983b; Orth et al., 1988).

The aerial survey and mapping program initiated in 1978 provides a baywide perspective of SAV distribution. This program is the foundation for tidal tributary and mainstem Bay segment-specific comparisons of SAV distribution and abundance with water quality data collected through the Chesapeake Bay Water Quality Monitoring Program.

The figures displaying annual SAV distribution and abundance data include all years for which baywide or regional aerial survey data were available for shoreline and shallow water habitats within Chesapeake Bay Program segments, with two exceptions. Data from the 1979 regional aerial survey of Maryland were not included in the analysis of distribution and abundance trends because the mapped portion of the upper Bay was photographed very late in the SAV growing season. Data from the 1980 and 1981 regional (Virginia Bay only) aerial surveys were not included in the analysis of trends for Tangier Sound (EE3) and Lower Chesapeake Bay (CB5) segments because corresponding data for Maryland portions of these segments were not available. Data from these regional surveys were used, however, in the development of the Tier I SAV distribution restoration goal.

To compare the SAV distribution and abundance figures between segments and simultaneously reflect the vast differences in distribution, only four y-axis scales were used: 0-100, 0-250, 0-2000, and 0-5000 hectares. Each figure caption states the Tier I SAV distribution restoration goal for that segment (see the section below on restoration goals and targets). All SAV distribution data, restoration goals, and restoration targets are presented in hectares[1].

Estimates of SAV bed densities (collectively referred to as abundance) are presented within each SAV distribution trend figure. During the SAV bed delineation process, a visual estimate of the percent cover within each bed was made and compared to an enlarged crown density scale (similar to those used for estimating forest tree crown cover from aerial photography) (Orth et al., 1991). The bed density was classified into one of four categories based on a subjective visual comparison with the density scale. These categories were: 1 = very sparse (<10 percent coverage); 2 = sparse (10-40 percent); 3 = moderate (40-70 percent); or 4 = dense (70-100 percent). The number of hectares in each density category for all SAV beds within a segment is illustrated in each SAV distribution trend figure. No density information was reported for the Virginia 1971 and 1974 aerial surveys or the Maryland 1978 SAV aerial survey.

The percent cover value presents a direct visual comparison of the photographic image and the crown density scale. It does not represent a measurement of biomass or standing crop of the SAV community. This crown density scale index is affected by photographic quality. Analysis of change in the percent cover over time in this index requires both consistent conditions and photography from year to year. Differences in the scale of photography or changes in water quality, for example, will yield an inconsistent index. The degree of contrast in the photographs will affect the resolution of features within SAV habitats, altering visual estimates of heterogeneity. Overestimation of percent cover may result if adjacent patches of plants appear to blend into one another. Underestimation of percent cover may result if small plants, spaced between dense patches of larger plants, cannot be distin-

1. To convert to acres, multiply hectares by 2.47.

guished and are interpreted as background sediment. Classification errors will be greatest when the SAV percent cover is close to either the upper or lower limit of another density category. Consistent reporting of this index requires that photographic missions and subsequent products be carefully scrutinized immediately after acquisition to allow for another overflight of those areas not meeting the predescribed conditions.

All data presented in each SAV distribution trend figure are also presented in tabular format for each Chesapeake Bay Program segment. Hectares have been rounded to the nearest whole number. When less than one hectare was reported, the number was treated as a one both in calculating the segment total and in determining the percent achievement of the Tier I SAV distribution restoration goal and the Tier III SAV distribution restoration target. Yearly SAV distribution data are also presented as percentages of these goals and targets for each Chesapeake Bay Program segment. Each table caption provides the segment-specific numerical Tier I distribution restoration goals and Tier III distribution restoration targets.

Submerged aquatic vegetation distribution data are also provided in tables summarizing coverages for the entire Bay, the upper, middle, and lower regions of the Bay, and the states of Maryland, Virginia, and Delaware, and the District of Columbia (Appendix C).

Delineation of SAV beds from aerial photography usually results in an underestimation of the bed area. Only SAV represented by an identifiable and verified habitat signature in the photographs is delineated. The degree of underestimation of the bed area depends upon atmospheric and hydrologic conditions at the time of photoacquisition as well as the nature of the subject area. Guidelines established for the baywide SAV aerial survey minimize these errors (Orth and Moore, 1983b; Orth et al., 1988; Dobson, et al., in press). Edges of SAV beds, particularly those along the outer deeper portions of the beds, are often most difficult to delineate. The plants along these outer edges tend to be patchy and may be obscured by turbid water. Areas with SAV under a minimum detection limit (usually patches of one square meter or less (Dobson et al., in press)) are generally not mapped because they are too small to be detected at the altitude of the aerial overflights. Generally, SAV beds that are considered very sparse in the baywide aerial surveys have many small patches that are at or just above the minimum detection limit. These areas are easily overlooked because they are not clearly visible on photographs taken under sub-optimal conditions. Such areas may be mapped in subsequent years if patches have grown or coalesced to a size greater than the minimum detection unit. In addition, small patches of SAV in some tidal creeks are impossible to map and digitize. These creeks are usually represented by a single line on the 7.5-minute USGS quadrangles; the SAV beds are smaller than the creek itself.

Errors may be introduced throughout the process of photoacquisition, photointerpretation, and digitization. Errors from the photoacquisition and photointerpretation phases have not been fully quantified in either the baywide SAV aerial survey or in other aerial surveys (Dobson et al., in press), resulting in an incomplete statistical understanding of these types of data. Error analysis might require replicate flights to produce multiple images of the same SAV bed and photointerpretation of each set of photographs. Such an analysis would also necessitate an intensive ground survey to delineate the boundaries of the bed in situ.

Digitization errors are easier to quantify. The quality assurance/quality control guidelines established for the baywide aerial survey state that data are unacceptable if the digitizing error rate exceeds 5 percent of the mean of the iterations (Orth et al., 1988). The digitizing error rate of the baywide aerial survey for most SAV polygons is 1 percent or less, but is somewhat higher for very small beds (generally those less than one hectare). The width of a one millimeter line on a 1:24,000 scale, 7.5-minute quadrangle equals 24 meters on the ground. The pencil line defining the SAV polygon can vary from approximately 0.2 to 0.5 millimeters in width, equivalent to a distance of 4.8 to 12.0 meters on the map. Even a slight repositioning of the line from the true edge of a SAV bed, coupled with digitizer error, could yield either a cumulative error if the two are additive or a zero error if they cancel each other.

Similar problems have occurred in delineating historical shoreline changes. Crowell et al. (1991) presented several worst case scenarios in estimating the location of the high water mark. Estimates ranged from 6.1 to 8.9 meters, although the authors state that the magnitude of error is usually much less using post-compilation accuracy assessments.

Despite the potential errors described above, the SAV distribution and abundance data generated through the baywide SAV aerial survey have been gathered using a consistent approach and interpretation for the past two decades. In addition, the questions being addressed through the baywide aerial survey program do not require monitoring of every square meter of SAV in Chesapeake Bay. Many standard statistical tests can not be used on the distribution and abundance data because spatial and temporal statistical comparisons of bed polygons are difficult.

SAV Ground Surveys

Numerous quantitative and qualitative SAV ground surveys have been conducted throughout Chesapeake Bay over the last several decades, several of which have supported the baywide SAV aerial survey program. The latter include surveys by: the Citizens' SAV Hunt Program (baywide: 1985 to 1991); Maryland's Charterboat Captains' Survey (Maryland: 1985 to 1990); U.S. Fish and Wildlife Service (Maryland and Potomac River: 1990 to 1991); Stan Kollar of Harford Community College (upper Chesapeake Bay: 1984 to 1991); Northern Virginia Community College (Potomac River: 1984); U.S. Geological Survey (Potomac River: 1984 to 1989); Essex Community College (Maryland: 1990 to 1991); Metropolitan Washington Council of Governments (Potomac River: 1990 to 1991); Maryland National Capital Planning and Parks Commission (Patuxent River: 1990 to 1991); University of Maryland Horn Point Environmental Laboratory (Maryland: 1984 to 1991); and the Virginia Institute of Marine Science (Virginia: 1984 to 1991). Methodologies for each of these ground surveys can be found in the appropriate SAV distribution and abundance reports for the year of the particular baywide aerial survey (Table 2).

Several SAV ground surveys, independent of the baywide SAV aerial survey, have been conducted over the last two decades. Most notable were surveys conducted by the U.S. Fish and Wildlife Service Migratory Bird and Habitat Research Laboratory/Maryland Department of Natural Resources SAV ground survey which recorded the presence, absence, and species diversity of SAV at over 600 stations annually in the Maryland portion of Chesapeake Bay from 1971 to 1991 (Chesapeake Bay Program, unpublished data c) and the U.S. Geological Survey intensive SAV survey in the Potomac River from 1978 to 1981 (Haramis and Carter, 1983) and subsequent surveys documenting SAV recovery in the Potomac River (Carter et al., 1985b; Carter and Rybicki, 1986; Rybicki and Schening, 1990; Rybicki et al., 1985, 1986, 1987, and 1988). Other surveys between 1971 and 1991 included: the Rhode River from 1966 to 1973 (Southwick and Pine, 1975); Eastern Bay (Stevenson and Confer, 1978); the Milfoil Survey from 1957 to 1977 (Bayley et al., 1978); and a 1990 U.S. Fish and Wildlife Service survey of clams in upper and middle Chesapeake Bay (Jorde et al., 1991).

The Maryland Department of Natural Resources SAV ground survey data (1971 to 1991) are presented by Chesapeake Bay Program segment as the percentage of the total number of stations visited at which rooted SAV was observed. Each figure caption lists the individual years for which data were not available. Appendix D provides a complete listing of Maryland Department of Natural Resources ground survey data. Because of methodological differences, the baywide aerial survey reported SAV in many locations where the Maryland Department of Natural Resources ground survey reported no SAV. This discrepancy has caused problems in areas where vegetation is sparse. In these areas, the baywide aerial survey may report a bed in density class 1 (<10 percent coverage) or

2 (10-40 percent coverage), while the Maryland Department of Natural Resources ground survey may not even sample the vegetation if the sampling station is in the unvegetated portion of the bed and would report no SAV present. The other major methodological difference between these two surveys is that many of Maryland Department of Natural Resources ground survey sampling stations are in water depths of more than one meter below mean low water. The baywide aerial survey has shown that most SAV beds are in water depths less than one meter. The 1985 and 1986 SAV distribution reports positioned Maryland Department of Natural Resources ground survey sampling stations on the same maps with the SAV polygons mapped from the baywide aerial survey. The Maryland Department of Natural Resources ground survey stations were located in deeper waters than the SAV beds that were photographed and mapped in those years (Orth et al., 1986 and 1987).

Submerged aquatic vegetation ground surveys prior to 1971 include a 1,000-transect survey of the upper Chesapeake Bay between 1967 and 1969 (Stotts, 1970) and a benthic survey of the upper Chesapeake Bay from 1959 to 1960 (Stotts, 1960).

Stevenson and Confer (1978) and Stevenson and Staver (in press) describe the methodologies and results for the SAV ground surveys listed above. More detailed information can be obtained from the cited reports and papers. All the above described ground surveys, when coupled with the baywide aerial surveys, are extremely important in describing and understanding SAV distribution patterns on a local or regional scale.

SAV Habitat Requirements

For SAV to grow and survive in any area, water quality must be within the environmental tolerances of those species. Each species can live within an envelope of water quality conditions that define its survival and growth requirements. Chronically exceeding the value for one critical parameter can potentially lead to the loss of SAV in an area. The *Chesapeake Bay Submerged Aquatic Vegetation Habitat Requirements and Restoration Targets: A Technical Synthesis* identified the minimum habitat requirements for SAV in different regions of the Chesapeake Bay (Batiuk et al., 1992).

Submerged aquatic vegetation habitat requirements have been defined as the minimal water quality levels necessary for the plants' survival. The water quality parameters used in the delineation of these SAV habitat requirements were chosen because of their relevance to the survival of the vegetation (Figure 2). The principal environmental water quality parameters for submerged aquatic plants are: light attenuation coefficient, total suspended solids, chlorophyll *a*, dissolved inorganic phosphorus, and dissolved inorganic nitrogen.

Submerged aquatic vegetation habitat requirements were formulated by: determining SAV distributions by transplant survival and baywide distributional surveys; measuring water quality characteristics along large-scale transects that spanned vegetated and non-vegetated regions; and combining distribution data and water quality levels to establish the minimum water quality conditions that allow SAV survival. This type of analysis (referred to as correspondence analysis) was strengthened by factors common to each of the case studies. Field data were collected over several years (almost a decade in the Potomac River) under varying meteorologic and hydrologic conditions by different investigators. Distributions of SAV in four case studies (Susquehanna Flats, upper Potomac River, Choptank River, and York River), across all salinity regimes, were responsive to the five water quality parameters used to develop the SAV habitat requirements. In addition, as the water quality changed from year to year, its improvement or degradation was reflected by the resultant spread or decline of the regional SAV populations.

Habitat requirements for SAV survival and growth were developed based on the analysis and interpretation of seasonal medians of water quality data. Median values were used to characterize the water quality conditions to which SAV was exposed over an annual growing season (April to

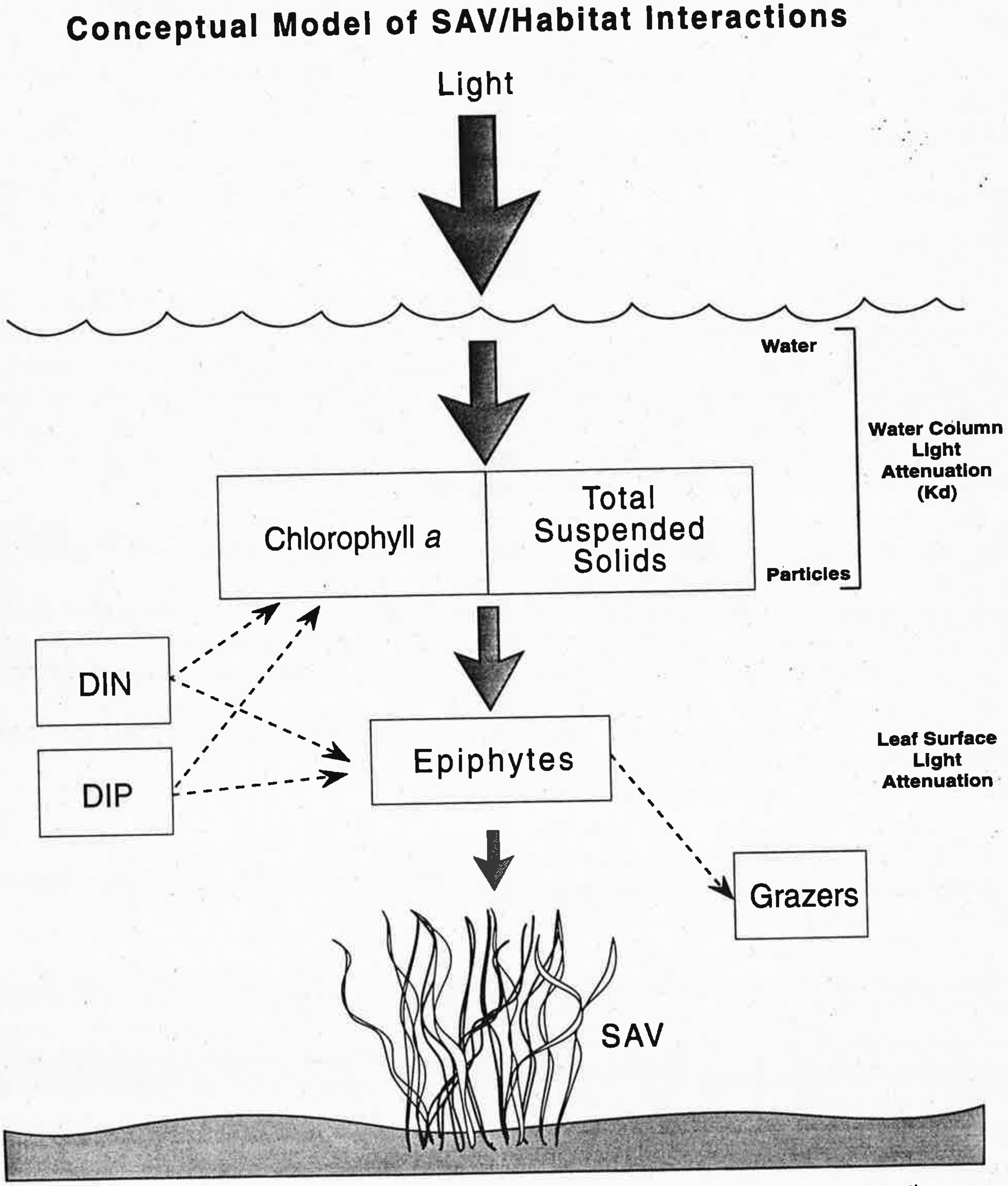


Figure 2. The availability of light for SAV is determined by light attenuation processes. Water column attenuation, measured as light attenuation coefficient (Kd), results from absorption and scatter of light by particles in the water (phytoplankton measured as chlorophyll *a*; total organic and inorganic particles measured as total suspended solids) and by absorption of light by water itself. Algal epiphytes growing on SAV leaf surfaces also contribute to light attenuation. Dissolved inorganic nutrients (DIN = dissolved inorganic nitrogen; DIP = dissolved inorganic phosphorus) contribute to the phytoplankton and epiphyte components of overall light attenuation. Epiphyte grazers control the accumulation of epiphytes. Source: Batiuk et al., 1992.

October for mesohaline, oligohaline, and tidal fresh areas; March to November for polyhaline regions). Median values were chosen because they are more accurate estimators of "average" or "typical" values than mean values when data have a skewed and/ or censored distribution (refer to page 15 in Batiuk et al. (1992) for additional information on these determinations).

The diversity of SAV communities throughout Chesapeake Bay, along with the Bay's wide salinity range, demanded that separate habitat requirements be used for different regions based on salinity. The minimum water quality conditions required to support the survival, growth, and reproduction of SAV to water depths of one meter were used as the set of SAV habitat requirements referenced in this report (Table 3). For SAV to survive to one meter, light attenuation coefficients <2 m^{-1} for tidal fresh and oligohaline regions and <1.5 m^{-1} for mesohaline and polyhaline regions are necessary. Total suspended solids concentrations of <15 mg/L and chlorophyll *a* concentrations of <15 ug/L are consistent requirements for all regions. The habitat requirements for dissolved inorganic nitrogen and dissolved inorganic phosphorus, however, varied substantially among the salinity regimes. In tidal fresh and oligohaline regions, SAV can survive episodic and chronic high dissolved inorganic nitrogen. Consequently, habitat requirements for dissolved inorganic nitrogen were not determined for these regions. In contrast, maximum dissolved inorganic nitrogen concentrations of <0.15 mg/L were established for mesohaline and polyhaline regions. The SAV habitat requirement for dissolved inorganic phosphorus was concentrations <0.02 mg/L for all regions except in mesohaline areas where it was <0.01 mg/L. Differences in the nutrient habitat requirements in different regions of the Chesapeake Bay are consistent with observations from a variety of estuaries where shifts occur in the relative importance of phosphorus versus nitrogen as the limiting nutrient (e.g., Valiela, 1984).

The SAV habitat requirement for two-meter restoration for light attenuation was derived using an exponential light attenuation equation which quantitatively defines the interrelationships among light attenuation, minimum light requirements, and depth penetration (Batiuk et al., 1992). The resultant habitat requirement was a light attenuation coefficient <0.8 m^{-1}, based on 20 percent surface irradiance as the minimum light requirement. Habitat requirements for two-meter restoration could not be determined for the four other water quality parameters.

The SAV habitat requirements represent the absolute minimum level of water quality necessary to sustain plants in shallow water. As such, exceeding any of the five characteristics will seriously compromise the chance of SAV survival. Improvements in water clarity to promote greater depth penetration of SAV would also increase SAV density and biomass. In addition, improving water quality beyond the habitat requirements could lead to the maintenance or re-establishment of a diverse population of native SAV species. Submerged aquatic vegetation habitat requirements also provide a guideline for mitigation efforts using transplants. If SAV habitat requirements are not met, re-establishment of SAV communities via transplants would be futile.

Water quality data that meet the particular SAV habitat requirements for those years that data were available are presented for each segment. Years for which there were no data available to calculate growing season medians are indicated with "ND." Those years in which data were available to calculate a growing season median for at least one SAV habitat requirement (but the applicable SAV habitat requirements were not met) are indicated with a "0." Each figure caption lists the individual years, by SAV habitat requirement parameter, for which data were not available to calculate growing season medians. The numbers of SAV habitat requirements for which growing season medians could be calculated are labeled above the histogram bars when data were not available for all applicable habitat requirements.

Table 3. Chesapeake Bay SAV Habitat Requirements

	SAV Habitat Requirements For One-Meter Restoration[1]						SAV Habitat Requirements For Two-Meter Restoration[1]	
	Habitat Requirements Which Affect Water Column/Leaf Surface Light Attenuation							
Salinity Regime[2]	**Light Attenuation Coefficient (m^{-1})[3]**	**Total Suspended Solids (mg/L)**	**Chlorophyll *a* (µg/L)**	**Dissolved Inorganic Nitrogen (mg/L)**	**Dissolved Inorganic Phosphorus (mg/L)**	**Critical Life Period**	**Light Attenuation Coefficient (m^{-1})[3]**	**Critical Life Period**
Tidal Fresh	<2	<15	<15	—	<0.02	April-October	<0.8	April-October
Oligohaline	<2	<15	<15	—	<0.02	April-October	<0.8	April-October
Mesohaline	<1.5	<15	<15	<0.15	<0.01	April-October	<0.8	April-October
Polyhaline	<1.5	<15	<15	<0.15	<0.02	March-November	<0.8	March-November

1. The SAV habitat requirements are applied as median values over the April to October critical life period for tidal fresh, oligohaline, and mesohaline salinity regimes. For polyhaline salinity regimes, the SAV habitat requirements are applied as median values from combined March to May and September to November data. Light attenuation coefficient should be applied as the primary habitat requirement; the remaining habitat requirements should be applied to help explain regional or site-specific causes of water column and leaf surface light attenuation which can be directly managed.

2. Tidal fresh = <0.5 ppt; oligohaline = 0.5-5 ppt; mesohaline = >5-18 ppt; and polyhaline = >18 ppt.

3. For determination of Secchi depth habitat requirements, apply the conversion factor: Secchi depth = 1.45/light attenuation coefficient.

Source: Batiuk et al., 1992.

SAV Restoration Targets

To evaluate the success of Chesapeake Bay restoration and protection strategies, SAV distribution will continue to be used as a measure of the effectiveness of the different water quality and resource management strategies (Chesapeake Executive Council, 1992). To provide management agencies with a stepwise measure of progress, a tiered set of three SAV distribution restoration targets has been established (Batiuk et al., 1992) (Tables 4 and 5).

Each SAV distribution restoration goal (Tier I) and target (Tiers II and III) represents the increase in SAV acreage expected over time in response to achievement of the habitat requirements for one and two-meter restoration. Distribution restoration targets were developed by mapping potential SAV habitat on U.S. Geological Survey quadrangles and comparing these areas with the historical survey data and more recent distribution data (Batiuk et al., 1992) (Figure 3). For the Tier III SAV restoration target, potential habitat was defined as all shoal areas of the Bay under two meters. Historically, SAV in Chesapeake Bay may have grown in areas with depths to three meters. The two-meter depth contour was chosen, however, because it represented a reasonable estimate considering the anticipated maximum depth penetration of most SAV species given suitable water quality (Table 3). Certain areas were excluded since they were unlikely to support SAV (even with significantly improved water quality) based on long-term historical observation and recent survey information. The Chesapeake Executive Council has since adopted the Tier I SAV restoration target as a living resource restoration goal for the Chesapeake Bay Program (Chesapeake Executive Council, 1993).

Chesapeake Bay Water Quality Data

The water quality data used to determine whether SAV habitat requirements were met from 1970 to 1991 were acquired from two sources: the Chesapeake Bay Program's historical water quality data base and the baywide water quality monitoring program data base (Chesapeake Bay Program, 1993a, 1993b).

The 1970 to 1983 water quality data were extracted from 16 data sets stored within the Chesapeake Bay Program's historical water quality data base. Appendix A provides narrative summaries of each of these data sets. In sharp contrast to more recent data (1984 to 1991), the temporal and spatial coverage of the 1970 to 1983 data are highly variable both within and between years. Samples collected prior to 1984 were chemically analyzed using a variety of methods which resulted in widely ranging detection limits. No reasonable way of accounting for these imbalances was found or attempted in the trend analysis. Within a Chesapeake Bay Program segment, when only one water column surface data point was collected within the defined critical life period, the single observation was used in place of

Table 4. Chesapeake Bay SAV Distribution Restoration Targets

RESTORATION TARGET	DESCRIPTION	AREA (hectares)
Tier I – Composite beds	Restoration of SAV to areas currently or previously inhabited by SAV as mapped through regional and baywide aerial surveys from 1971 to 1990.	46,025
Tier II – One-meter	Restoration of SAV to all shallow water areas defined as existing or potential SAV habitat down to a depth of one meter, excluding areas identified as unlikely to support SAV based on historical observations, recent survey information, and exposure.	In progress
Tier III – Two-meter	Restoration of SAV to all shallow water areas defined as existing or potential SAV habitat down to the two-meter contour, excluding areas identified under the Tier II target as unlikely to support SAV as well as several other areas between one and two meters.	247,658

Source: Batiuk et al., 1992.

Table 5. Chesapeake Bay SAV Distribution Restoration Tier I Goal and Tier III Target by Chesapeake Bay Program Segment

CBP Segment		Tier I SAV Restoration Goal (Hectares)	Tier III SAV Restoration Target (Hectares)
CB1	Northern Chesapeake Bay	3,101	6,975
CB2	Upper Chesapeake Bay	139	3,086
CB3	Upper Central Chesapeake Bay	817	3,426
CB4	Middle Central Chesapeake Bay	103	3,496
CB5	Lower Chesapeake Bay	6,309	15,083
CB6	Western Lower Chesapeake Bay	783	2,923
CB7	Eastern Lower Chesapeake Bay	4,624	11,803
CB8	Mouth of Chesapeake Bay	86	1,928
WT1	Bush River	24	1,836
WT2	Gunpowder River	353	3,056
WT3	Middle River	349	839
WT4	Back River	0	1,061
WT5	Patapsco River	53	1,452
WT6	Magothy River	240	838
WT7	Severn River	189	883
WT8	South/Rhode/West Rivers	78	1,970
TF1	Upper Patuxent River	6	890
RET1	Middle Patuxent River	16	959
LE1	Lower Patuxent River	132	2,653
TF2	Upper Potomac River	3,098	8,304
RET2	Middle Potomac River	1,847	7,443
LE2	Lower Potomac River	282	18,012
TF3	Upper Rappahannock River	0	3,293
RET3	Middle Rapahannock River	0	5,928
LE3	Lower Rappahannock River	1,714	9,342
TF4	Upper York River	0	1,614
RET4	Middle York River	0	2,915
LE4	Lower York River	309	4,822
WE4	Mobjack Bay	5,902	12,529
TF5	Upper James River	0	5,780
RET5	Middle James River	13	4,987
LE5	Lower James River	16	13,841
ET1	Northeast River	7	1,207
ET2	Elk/Bohemia Rivers	467	2,967
ET3	Sassafras River	167	1,515
ET4	Chester River	1,506	5,812
ET5	Choptank River	191	3,009
ET6	Nanticoke River	0	4,082
ET7	Wicomico River	0	2,648
ET8	Manokin River	271	3,763
ET9	Big Annemessex River	363	2,044
ET10	Pocomoke River	0	495
EE1	Eastern Bay	2,474	8,815
EE2	Lower Choptank River	3,646	11,648
EE3	Tangier Sound	6,340	35,686
TOTALS		**46,025**	**247,658**

Sources: Batiuk et al., 1992; Chesapeake Bay Program, 1990.

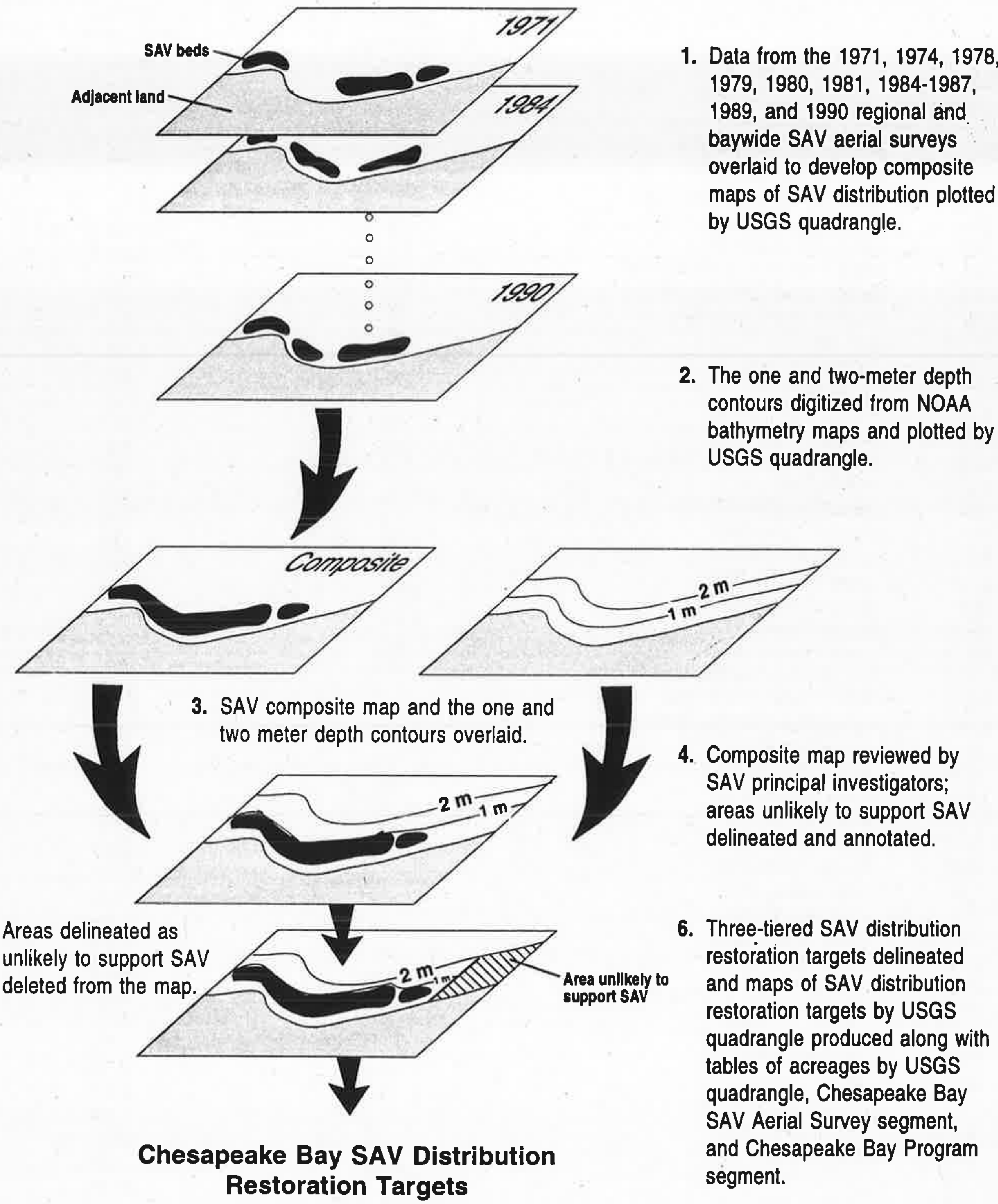


Figure 3. Process for setting Chesapeake Bay SAV distribution restoration targets. Source: Batiuk et al., 1992.

a calculated median value. Appendix B lists the number of data points used to calculate the growing season median.

Recognition of the limited temporal and spatial data coverage within individual segments should guide the interpretation of historical water quality data (pre-1984 or pre-1986 in some tidal tributaries) based on achievement of the SAV habitat requirements. The historical data are useful in assessing overall patterns in meeting the minimum SAV habitat conditions, but do not provide documentation that past conditions were suitable for SAV survival and growth.

The 1984 to 1991 water quality data were extracted from the Chesapeake Bay Water Quality Monitoring Program data base. These baywide data were taken at over 160 stations through the cooperative efforts of Maryland, Virginia, the District of Columbia, and the U.S. Environmental Protection Agency. The *Chesapeake Bay Basin Monitoring Program Atlas* (Chesapeake Bay Program, 1989) summarizes the station locations, sample collection, and analysis methods.

From both the historical and baywide monitoring program data sets, surface (defined as zero to three meters) water quality data were extracted for the following parameters: Secchi depth, total suspended solids, chlorophyll *a*, dissolved inorganic nitrogen (nitrite/nitrate + ammonia), and dissolved inorganic phosphorus (orthophosphate). Secchi depth was converted to the light attenuation coefficient by dividing 1.45 by the Secchi depth.[2]

If more than one measurement was made between zero to three meters at a station during a single sampling, then the mean value was used. The data were then grouped by Chesapeake Bay Program segment, year, and month. Each segment was assigned to one of four salinity regimes. For each salinity regime, applicable SAV habitat requirements and growing season were defined (Table 6). The median value within a growing season was determined for each parameter for each year for each segment using the SAS procedure PROC UNIVARIATE (SAS Institute, 1990).

These median values were then compared directly with the applicable SAV habitat requirement (Table 6). Appendix B provides both a complete listing of median water quality data and comparisons with applicable SAV habitat requirements.

Batiuk et al. (1992) addressed the usefulness of mid-channel monitoring data for describing environmental conditions on shoals where SAV occurs. Results from a comparison of mid-channel and nearshore data from the York, Choptank, and upper Potomac rivers and the upper Chesapeake Bay indicated that mid-channel data may be successfully used to characterize seasonal levels of water quality in adjacent nearshore areas. Individual mid-channel data points do not necessarily have a predictive relationship with nearshore observations, but seasonal aggregations of mid-channel water quality can provide reliable estimates of nearshore water quality conditions for all five SAV habitat requirement parameters. Follow-up comparisons of mid-channel and nearshore water quality data by the Chesapeake Bay Program (1992) yielded similar findings and conclusions.

SAV Trend Analysis Presentation

The figures and tables displaying SAV distribution and abundance, numbers of SAV habitat requirements achieved, and Maryland Department of Natural Resources SAV ground survey data are presented by individual Chesapeake Bay Program segments. Descriptions and interpretations of SAV trends are presented as combined groups of seg-

2. *Although Batiuk et al. (1992) identified a range of conversion factors, the authors point out that there is only a 5 percent discrepancy between light attenuation coefficient values when comparing conversion factors of 1.4 versus 1.7 in water with a Secchi depth of 0.5 meters. Based on the available literature and analysis of data from Chesapeake Bay, therefore, the technical synthesis report adopted the conversion factor of 1.45. Refer to pages 15- through 17 in Batiuk et al., (1992) for a more detailed discussion on this topic.*

Table 6. Applicable SAV Habitat Requirements, Salinity Regime, and Growing Season by Chesapeake Bay Program Segment

CBP SEG	SALINITY REGIME	Kd	TSS	CHL *a*	DIN	DIP	SAV GROWING SEASON
CB1	Tidal Fresh	2.0	15	15	•	0.02	Apr-Oct
CB2	Oligohaline	2.0	15	15	•	0.02	Apr-Oct
CB3	Mesohaline	1.5	15	15	0.15	0.01	Apr-Oct
CB4	Mesohaline	1.5	15	15	0.15	0.01	Apr-Oct
CB5	Mesohaline	1.5	15	15	0.15	0.01	Apr-Oct
CB6	Polyhaline	1.5	15	15	0.15	0.02	March-May, Sept-Nov
CB7	Polyhaline	1.5	15	15	0.15	0.02	March-May, Sept-Nov
CB8	Polyhaline	1.5	15	15	0.15	0.02	March-May, Sept-Nov
WT1	Oligohaline	2.0	15	15	•	0.02	Apr-Oct
WT2	Oligohaline	2.0	15	15	•	0.02	Apr-Oct
WT3	Oligohaline	2.0	15	15	•	0.02	Apr-Oct
WT4	Oligohaline	2.0	15	15	•	0.02	Apr-Oct
WT5	Mesohaline	1.5	15	15	0.15	0.01	Apr-Oct
WT6	Mesohaline	1.5	15	15	0.15	0.01	Apr-Oct
WT7	Mesohaline	1.5	15	15	0.15	0.01	Apr-Oct
WT8	Mesohaline	1.5	15	15	0.15	0.01	Apr-Oct
TF1	Oligohaline	2.0	15	15	•	0.02	Apr-Oct
RET1	Mesohaline	1.5	15	15	0.15	0.01	Apr-Oct
LE1	Mesohaline	1.5	15	15	0.15	0.01	Apr-Oct
TF2	Tidal Fresh	2.0	15	15	•	0.02	Apr-Oct
RET2	Oligohaline	2.0	15	15	•	0.02	Apr-Oct
LE2	Mesohaline	1.5	15	15	0.15	0.01	Apr-Oct
TF3	Oligohaline	2.0	15	15	•	0.02	Apr-Oct
RET3	Mesohaline	1.5	15	15	0.15	0.01	Apr-Oct
LE3	Mesohaline	1.5	15	15	0.15	0.01	Apr-Oct
TF4	Oligohaline	2.0	15	15	•	0.02	Apr-Oct
RET4	Mesohaline	1.5	15	15	0.15	0.01	Apr-Oct
LE4	Polyhaline	1.5	15	15	0.15	0.02	March-May, Sept-Nov
WE4	Polyhaline	1.5	15	15	0.15	0.02	March-May, Sept-Nov
TF5	Tidal Fresh	2.0	15	15	•	0.02	Apr-Oct
RET5	Oligohaline	2.0	15	15	•	0.02	Apr-Oct
LE5	Mesohaline	1.5	15	15	0.15	0.01	Apr-Oct
ET1	Oligohaline	2.0	15	15	•	0.02	Apr-Oct
ET2	Oligohaline	2.0	15	15	•	0.02	Apr-Oct
ET3	Oligohaline	2.0	15	15	•	0.02	Apr-Oct
ET4	Mesohaline	1.5	15	15	0.15	0.01	Apr-Oct
ET5	Mesohaline	1.5	15	15	0.15	0.01	Apr-Oct
ET6	Mesohaline	1.5	15	15	0.15	0.01	Apr-Oct
ET7	Mesohaline	1.5	15	15	0.15	0.01	Apr-Oct
ET8	Mesohaline	1.5	15	15	0.15	0.01	Apr-Oct
ET9	Mesohaline	1.5	15	15	0.15	0.01	Apr-Oct
ET10	Mesohaline	1.5	15	15	0.15	0.01	Apr-Oct
EE1	Mesohaline	1.5	15	15	0.15	0.01	Apr-Oct
EE2	Mesohaline	1.5	15	15	0.15	0.01	Apr-Oct
EE3	Mesohaline	1.5	15	15	0.15	0.01	Apr-Oct

Kd = Light attenuation coefficient (m^{-1})
TSS = Total suspended solids (mg/L)
CHL *a* = Chlorophyll *a* (µg/L)
DIN = Dissolved inorganic nitrogen (mg/L)
DIP = Dissolved inorganic phosphorus (mg/L)
• = No DIN habitat requirement defined for the tidal fresh or oligohaline salinity regime
Sources: Batiuk et al., 1992; Chesapeake Bay Program, 1993b.

ments for the following regions of the mainstem Bay and tidal tributaries:

- Northern Chesapeake Bay (CB1)
- Northeast, Elk, Bohemia, and Sassafras rivers (ET1, ET2, ET3)
- Upper Chesapeake Bay and Upper Central Chesapeake Bay (CB2, CB3)
- Bush, Gunpowder, Middle, Back, and Patapsco rivers (WT1,WT2, WT3, WT4, WT5)
- Chester River (ET4)
- Magothy, Severn, South, Rhode, and West rivers (WT6, WT7, WT8)
- Eastern Bay (EE1)
- Middle Central Chesapeake Bay (CB4)
- Choptank River (EE2, ET5)
- Patuxent River (LE1, RET1, TF1)
- Nanticoke, Wicomico, Manokin, Big Annemessex, and Pocomoke rivers (ET6, ET7, ET8, ET9, ET10)
- Tangier Sound (EE3)
- Potomac River (LE2, RET2, TF2)
- Lower Chesapeake Bay (CB5)
- Rappahannock River (LE3, RET3, TF3)
- Western Lower Chesapeake Bay (CB6)
- Eastern Lower Chesapeake Bay (CB7)
- Mobjack Bay (WE4)
- York River (LE4, RET4, TF4)
- James River (LE5, RET5, TF5)
- Mouth of Chesapeake Bay (CB8)

Chapter 3: Baywide SAV, Habitat Quality, and River Flow Trends

Baywide SAV Trends

Since the first baywide SAV survey in 1978, the total distribution of SAV in Chesapeake Bay and its tributaries has increased by 52 percent from 16,898 hectares to 25,728 hectares in 1991 (Figure 4, Table 7). The 1991 data represent a 56 percent achievement of the Tier I SAV distribution restoration goal (46,025 hectares) and a 10 percent achievement of the Tier III distribution restoration target (247,658 hectares). Submerged aquatic vegetation distribution actually decreased after 1978, dropping to 15,433 hectares in 1984. Decreases from 1978 to 1984 occurred predominantly in the upper Bay segments (Upper Central Chesapeake Bay, Middle Central Chesapeake Bay, Eastern Bay, and the Gunpowder, Middle, Patapsco, Magothy, Severn, Chester, Choptank, Lower Choptank, Lower Patuxent, and Lower Potomac rivers). These declines suggest that water quality conditions in these portions of the Bay continued to worsen and affected the remaining SAV populations. Some of the losses were offset by gains in SAV distribution in other segments during this time period, notably the Lower Chesapeake Bay, Eastern Lower Chesapeake Bay, Tangier Sound, and the Upper Potomac River.

Along with the increase in SAV distribution between 1984 and 1991 was a concomitant increase in the overall density of many SAV beds. While 38 percent (5,931 hectares) of mapped SAV was classified as dense (70 to 100 percent coverage) in 1984, by 1991 more than twice as many hectares of SAV (12,947 hectares or 50 percent of the total) fit this category (Figure 4, Table 7).

Several significant changes between 1978 and 1991, broadly illustrated in Figure 5 and Table 8 and described in detail in Chapter 4, are summarized as follows:

- Although SAV increased in distribution baywide during this period, relatively large interannual fluctuations in SAV distribution occurred in many areas throughout the Bay and its tidal tributaries.
- The largest expansion of SAV occurred in the lower mainstem Bay segments where SAV populations had not declined as dramatically during the 1970s as the upper mainstem Bay or up-tributary areas. The SAV beds remaining in these segments (Western Lower Chesapeake Bay and Eastern Lower Chesapeake Bay) after the period of baywide declines may have contributed to a pool of propagules (i.e., seeds or fragments of vegetation able to form new plants) which supported repopulation of unvegetated areas.
- The rapid spread of SAV in the tidal fresh portion of the Potomac River has resulted in the highest levels of SAV abundance in that river since the early 1900s. Although the exotic *H. verticillata* was the dominant species contributing to this rapid spread, numerous other native species also occur with this exotic. Although some declines in SAV were noted around Washington, DC since 1989, these losses were offset by the continued, rapid downriver expansion below Quantico to Aquia Creek.
- In the 1980s, *R. maritima* underwent a sudden and rapid expansion in the middle mainstem Bay, as well as in the lower Patuxent, Chester, Choptank, and Rappahannock rivers. Subsequent declines occurred in some of these areas.
- Many sections of the Bay and its tidal tributaries remain unvegetated or have very sparse

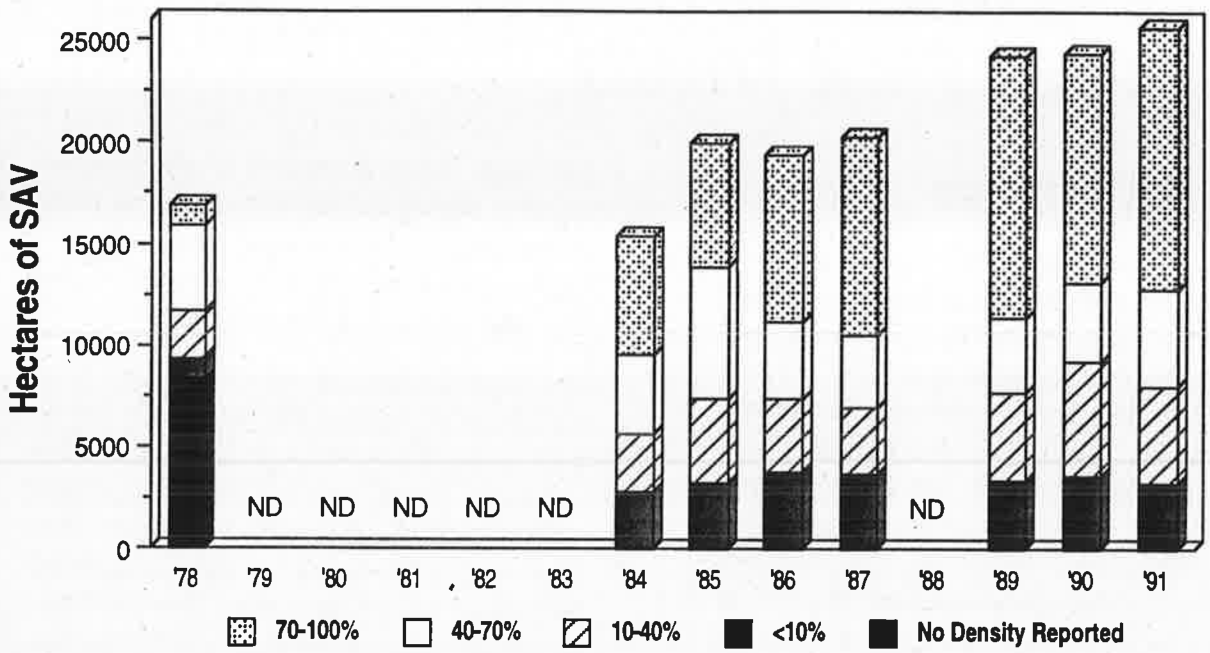


Figure 4. Hectares of SAV by density category for all years for which aerial survey data were available baywide. The baywide Tier I SAV restoration goal and Tier III SAV restoration target are 46,025 and 247,658 hectares, respectively. In 1978, density was not recorded for the SAV mapped in the Maryland portion of Chesapeake Bay. ND=No data. Sources: Anderson and Macomber, 1980; Batiuk et al., 1992; Orth et al., 1979, 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Nowak, 1990.

Table 7. Hectares of SAV by Density Category for all Years for which Aerial Survey Data were Available Baywide

Year	No Density Reported	<10%	10-40%	40-70%	70-100%	Baywide Total
1978	8,360	911	2,387	4,229	1,011	16,898
1979	ND	ND	ND	ND	ND	ND
1980	ND	ND	ND	ND	ND	ND
1981	ND	ND	ND	ND	ND	ND
1982	ND	ND	ND	ND	ND	ND
1983	ND	ND	ND	ND	ND	ND
1984	—	2,787	2,861	3,854	5,931	15,433
1985	—	3,227	4,111	6,500	6,135	19,974
1986	—	3,785	3,596	3,761	8,283	19,425
1987	—	3,640	3,296	3,585	9,713	20,234
1988	ND	ND	ND	ND	ND	ND
1989	—	3,331	4,350	3,730	12,836	24,247
1990	—	3,561	5,603	3,990	11,240	24,394
1991	—	3,199	4,851	4,731	12,947	25,728

ND=No data

Sources: Anderson and Macomber, 1980; Orth et al., 1979, 1985, 1986, 1987, 1989, 1990, 1991, and 1992; Orth and Nowak, 1990.

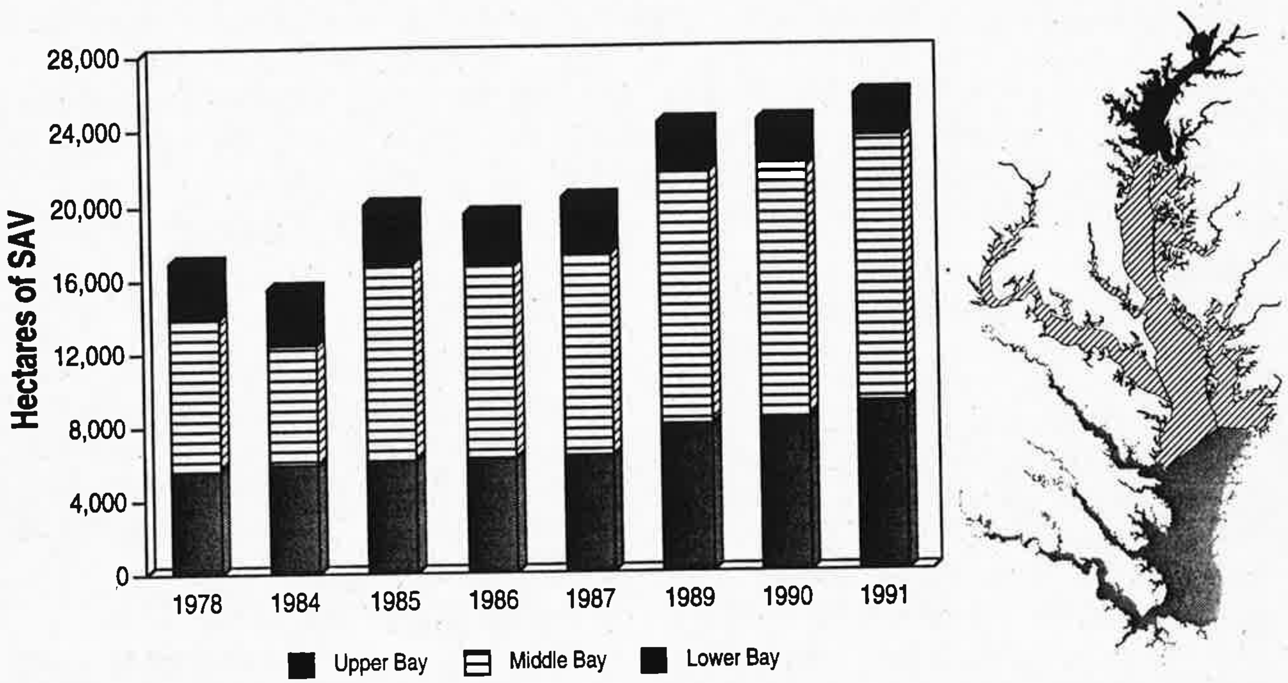


Figure 5. Hectares of SAV by upper, middle, and lower regions of Chesapeake Bay and its tributaries for all years for which aerial survey data were available baywide.
Sources: Anderson and Macomber, 1980; Orth et al., 1979, 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Nowak, 1990.

Table 8. Hectares of SAV by Upper, Middle, and Lower Regions of Chesapeake Bay and its Tidal Tributaries for all Years for which Aerial Survey Data were Available Baywide

Year	Lower Bay	Middle Bay	Upper Bay	Baywide Total
1978	5,576	8,291	3,031	16,898
1984	5,943	6,444	3,046	15,433
1985	6,129	10,710	3,135	19,974
1986	6,198	10,454	2,773	19,425
1987	6,323	10,947	2,964	20,234
1989	8,019	13,759	2,469	20,247
1990	8,326	13,706	2,362	24,394
1991	9,212	14,348	2,168	25,728

Sources: Anderson and Macomber, 1980; Orth et al., 1979, 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Nowak, 1990.

populations—principally the upper western shore and Eastern Shore tributaries. Two major western shore tributaries, the James and Patuxent rivers, have almost no SAV throughout their entire length (although an increase in one species for several years was observed in the Patuxent River (see above)).

- Ground survey reports indicated increasing amounts of *Zannichellia palustris* in many areas of the upper Bay, in particular, the upper western shore tributaries (e.g., the Severn and South rivers). This species is an annual which grows and reproduces in spring and dies by mid summer. The aerial overflights are timed with the peak growth of most SAV species in these areas, after the *Z. palustris* plants have died for the season. Beds of this species, therefore, are not mapped through the aerial survey.

- Ground surveys have confirmed the presence of remnant SAV populations in small tidal creeks and tributaries (e.g., the Patuxent River), suggesting the presence of vegetative sources or seed banks that could repopulate riverine populations if water quality conditions improve.

- The recent changes in SAV populations in the Chesapeake Bay suggest that most SAV populations can rebound very rapidly if water quality conditions improve and are consistently maintained. These observations also suggest that even relatively small changes in water quality can lead to rapid increases or decreases in SAV populations. Some areas may not become revegetated, even after suitable water quality conditions return, due to a lack of SAV propagules either within or close to these areas.

Patterns of change in SAV populations throughout Chesapeake Bay are complex, varying both in space and time. This complexity is most likely a reflection of the different characteristics of the Bay's major watersheds, meteorological differences, and differences in the biology of the species present.

To describe baywide trends further, patterns of SAV distribution from 1984 to 1991 (and from 1971 to 1991 when data were available) in all Chesapeake Bay Program segments were characterized and assigned to one of the following five categories:

Increasing trend - consistent year-to-year increases in SAV distribution (with a few exceptions);

Fluctuating at high levels - often order of magnitude year-to-year fluctuations in SAV distribution, with annual changes between 100 and 2000 hectares in total SAV distribution and no consistent increasing or decreasing trend over time;

Fluctuating at low levels - year-to-year fluctuations in SAV distribution with generally less than 100 hectares total and no consistent increasing or decreasing trend over time;

Decreasing trend - generally consistent year-to-year decreases in SAV distribution with order of magnitude total decreases from the 1970s to the early 1990s; or

Little or no SAV - SAV distribution since 1978 consistently less than 50 hectares total, often with no SAV beds mapped.

Segments with Increasing Trends in SAV

Seven of the 45 Chesapeake Bay Program segments showed consistent annual increases in SAV abundance since 1978: (Lower Chesapeake Bay (CB5), Western Lower Chesapeake Bay (CB6), Eastern Lower Chesapeake Bay (CB7), Tangier Sound (EE3), Mobjack Bay (WE4), Middle Potomac River (RET2), and Upper Potomac River (TF2)) (Figures 6 and 7). Five of the segments are contiguous in the middle to lower portion of the mainstem Bay (Lower Chesapeake Bay, Western Lower Chesapeake Bay, Eastern Lower Chesapeake Bay, Tangier Sound, and Mobjack Bay) and generally represent areas where relatively large viable populations of SAV remained after the 1970s decline.

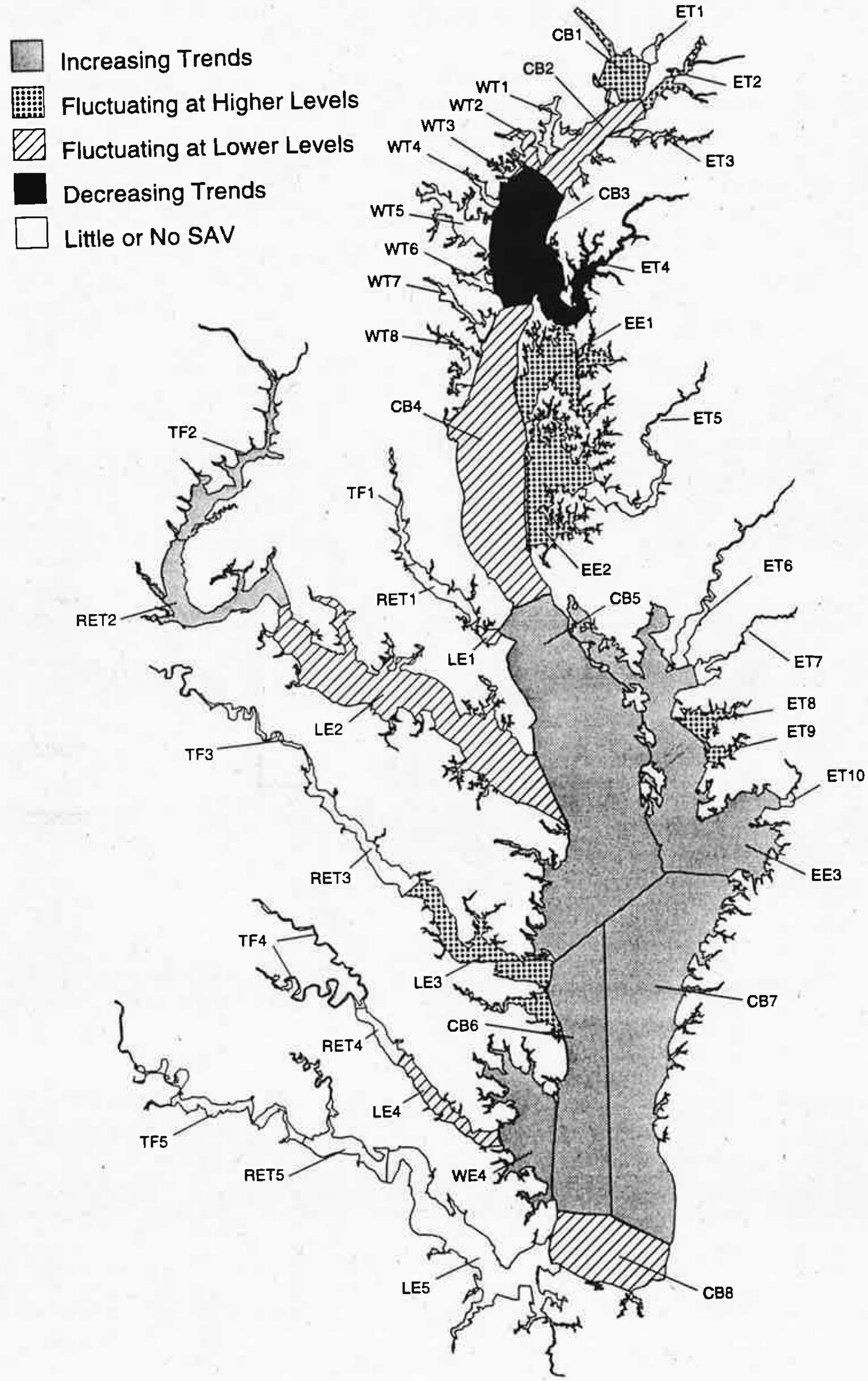


Figure 6. Patterns of SAV distributions from 1971-1991 by Chesapeake Bay Program Segment. Sources: Anderson and Macomber, 1980; Chesapeake Bay Program, unpublished data b; Orth et al., 1979, 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Gordon, 1975; Orth and Nowak, 1990.

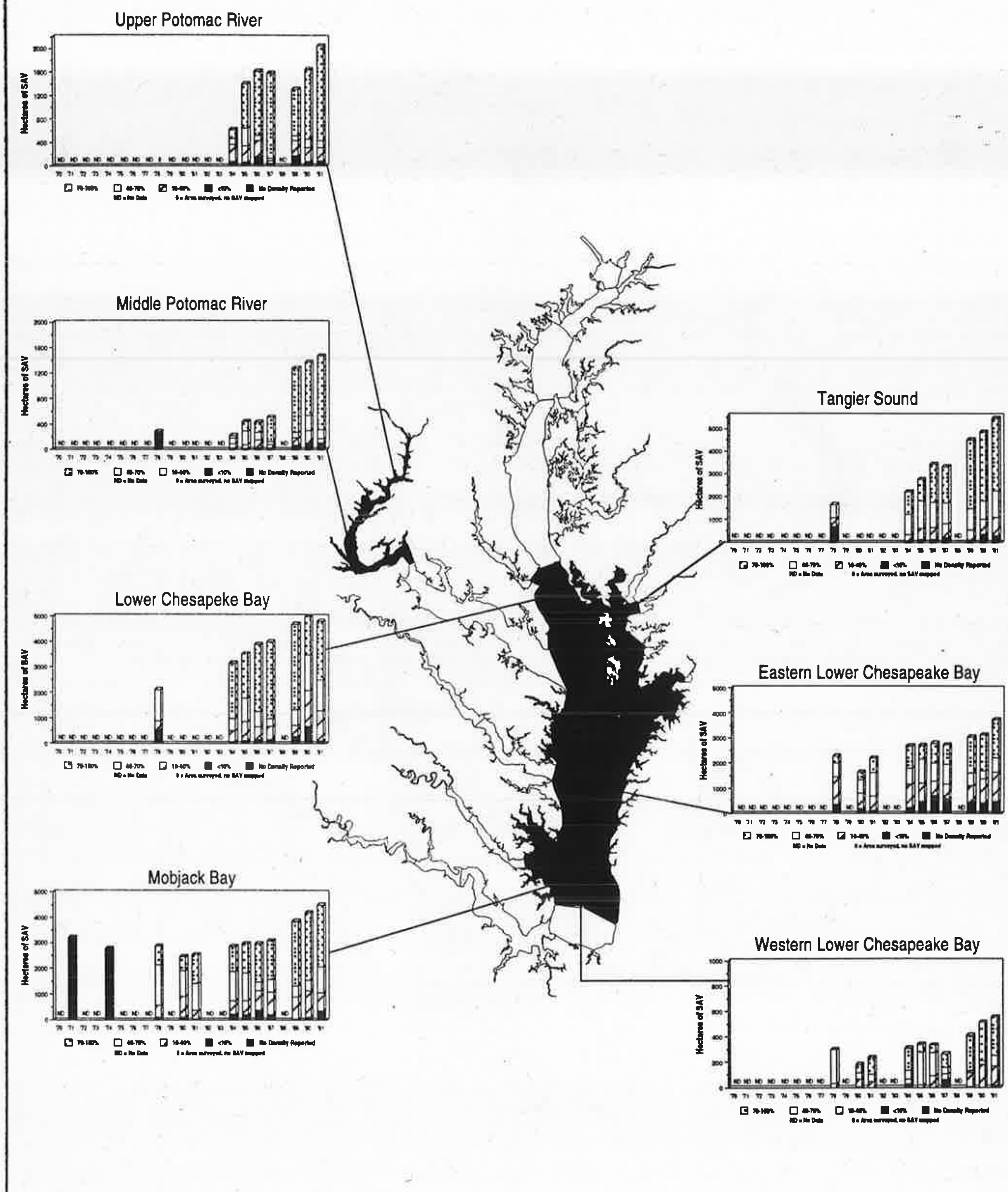


Figure 7. Chesapeake Bay segments with increasing trends in SAV.
Sources: Anderson and Macomber, 1980; Chesapeake Bay Program, unpublished data b; Orth et al., 1979, 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Gordon, 1975; Orth and Nowak, 1990.

Increases in SAV from 1978 to 1991 were 56 percent in Mobjack Bay, 64 percent in the Eastern Lower Chesapeake Bay, 85 percent in the Western Lower Chesapeake Bay, 127 percent in the Lower Chesapeake Bay, and 232 percent in Tangier Sound. The relatively larger increases in Lower Chesapeake Bay and Tangier Sound segments were primarily due to the rapid and sudden growth of *R. maritima* in the Barren Island-Honga River area. These areas had almost no SAV in 1978; by 1984, SAV was reported throughout the area in beds of various sizes and densities. These areas increased rapidly to become large, monospecific, and dense populations of *R. maritima*.

Ruppia maritima was the only species reported from the Barren Island-Honga River section, although *Z. marina* had historically been abundant there. While dense populations of *Z. marina* occur in the Smith-Tangier Island area, ground surveys have only occasionally reported this species in areas north of the Big Annemessex River and Smith Island.

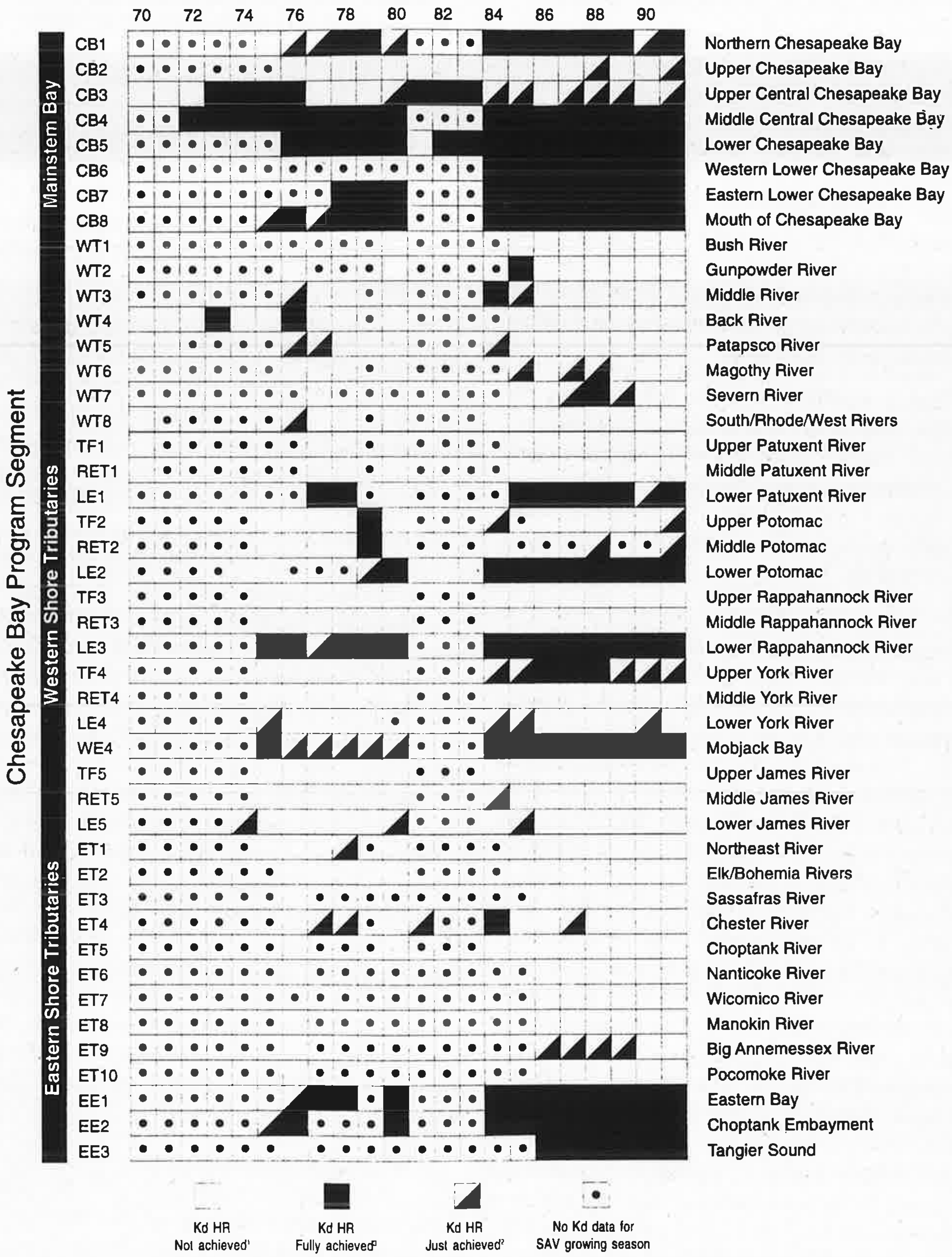
Dispersal mechanisms for *Z. marina* are likely less effective than those for *R. maritima*, leading to a slower spread of this species. *Ruppia maritima* produces more seeds over a longer time period—June through October (Silberhorn, unpublished data)—compared to a three to four-week period from May to early June for *Z. marina* (Silberhorn et al., 1983). In addition, *R. maritima* can spread from detached post-reproductive shoots which remain viable after seed release, then float, and settle to an unvegetated area (Rosenzweig, unpublished data). *Zostera marina* reproductive shoots are terminal and die after seed release although reproductive shoots with viable seeds can break off, float, and be exported from a bed. Neither the distance a shoot can float nor the probability of a viable seed being deposited in an environment conducive to growth are known. Observations of one area where a new *Z. marina* bed apparently developed from seed indicate that reproductive shoots can be transported approximately two kilometers with viable seeds (Orth et al., 1992).

Water quality conditions in the lower mainstem Bay, Tangier Sound, and Mobjack Bay have been suitable for SAV survival and growth consistently since the early 1980s (Figures 8-13). Up through the late 1970s, the data indicate water quality conditions in these segments fluctuated between unsuitable (not meeting the SAV habitat requirements) and suitable (meeting the SAV habitat requirements) on an annual basis. Observed improvements in water quality correspond directly with the documented increases in SAV distribution and abundance.

The only other areas that showed continually increasing trends in SAV distribution were the upper (TF2) and middle (RET2) segments of the Potomac River. These increases resulted, in part, from the 1982 introduction of *H. verticillata* and its subsequent rapid spread over more than 60 kilometers of shoreline in less than ten years. The ability of fragments of *H. verticillata* to root, grow rapidly, and spread allowed this explosive growth in such a short period. Numerous other species were reported in the shallower portions of the SAV beds where they could compete with *H. verticillata*—principally *M. spicatum*, *V. americana*, *H. dubia*, *N. guadalupensis*, *N. gracillima*, *E. canadensis*, *N. minor*, *C. demersum*, *Z. palustris*, *P. pusillus*, and *P. pectinatus*. The timing of the rapid increases was also correlated with improvements made to Blue Plains and other regional wastewater treatment facilities (Carter and Rybicki, 1986). Total suspended solids and phosphorus loadings were significantly reduced and nitrification was introduced. Some SAV declines in 1988 around Washington, DC appeared to be meteorologically controlled, but losses were offset by the larger gains in downriver sections. More species have been reported from this stretch of the Potomac River than any other segment in the entire Chesapeake Bay.

In the upper and middle reaches of the Potomac River, water quality conditions were just met or were slightly above several of the SAV habitat requirements until 1991 (Figures 8-13). There has been a positive trend of decreasing concentrations

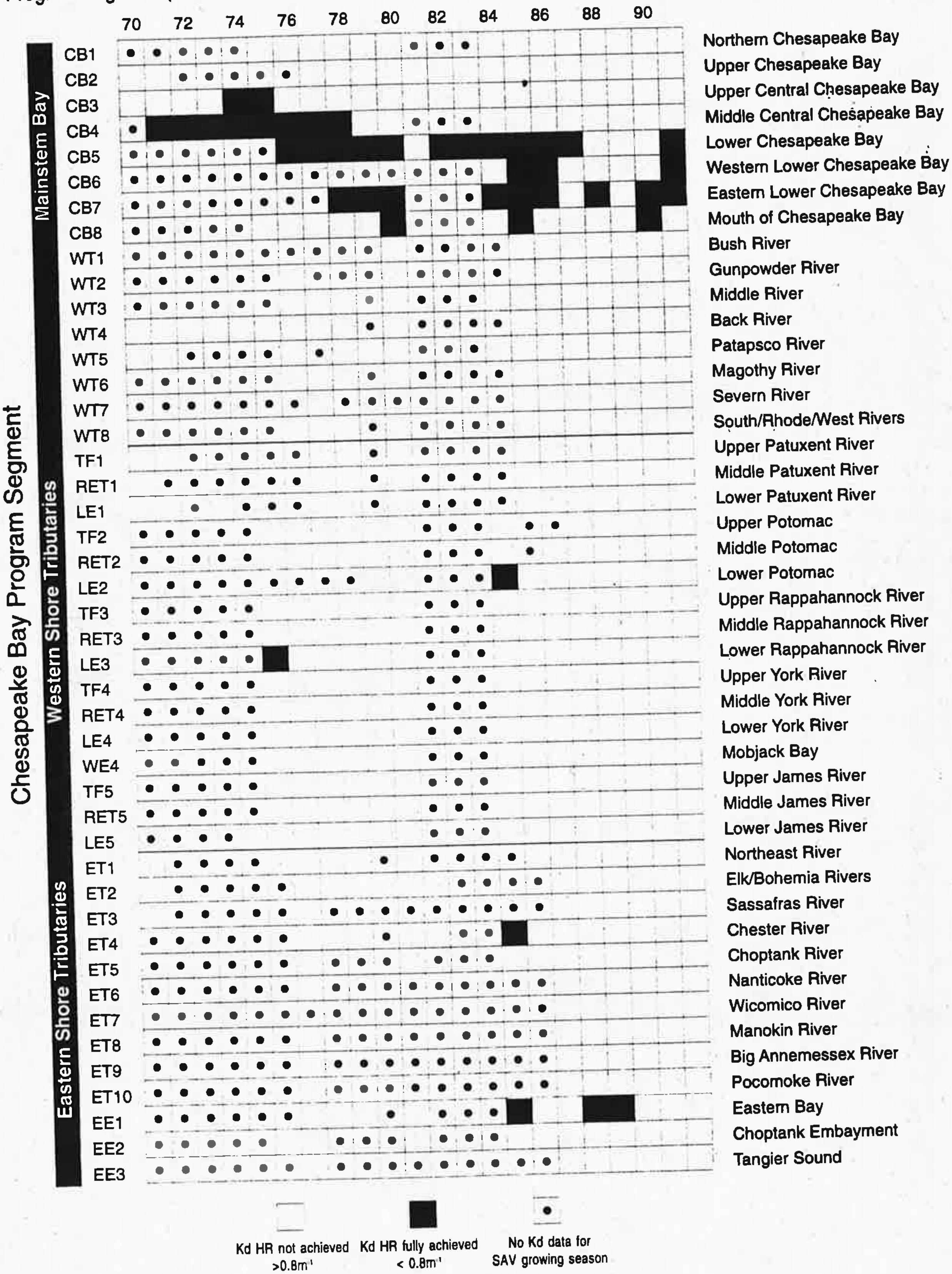
Figure 8. Achievement of the light attenuation coefficient habitat requirements for one-meter restoration by Chesapeake Bay Program segment (1970 to 1991).



1. For tidal fresh and oligohaline segments >2m⁻¹; for mesohaline and polyhaline segments >1.5m⁻¹. 2. For tidal fresh and oligohaline segments 1.75–2m⁻¹; for mesohaline and polyhaline segments 1.25–1.5m⁻¹. 3. For tidal fresh and oligohaline segments <1.75m⁻¹; for mesohaline and polyhaline segments <1.25m⁻¹.

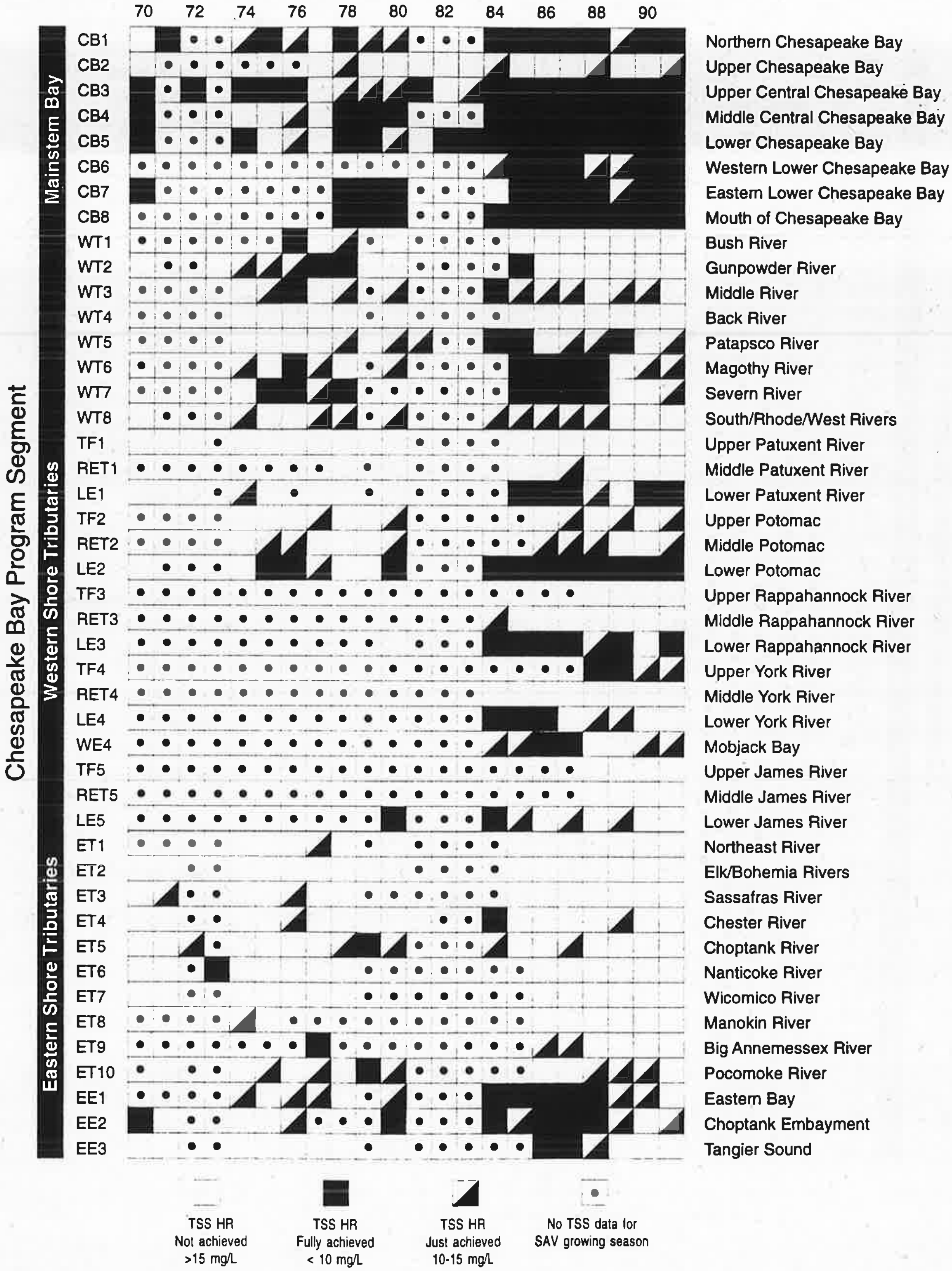
Sources: Batiuk et al., 1992; Chesapeake Bay Program, 1993a and 1993b.

Figure 9. Achievement of the light attenuation coefficient habitat requirements for two-meter restoration by Chesapeake Bay Program segment (1970 to 1991).



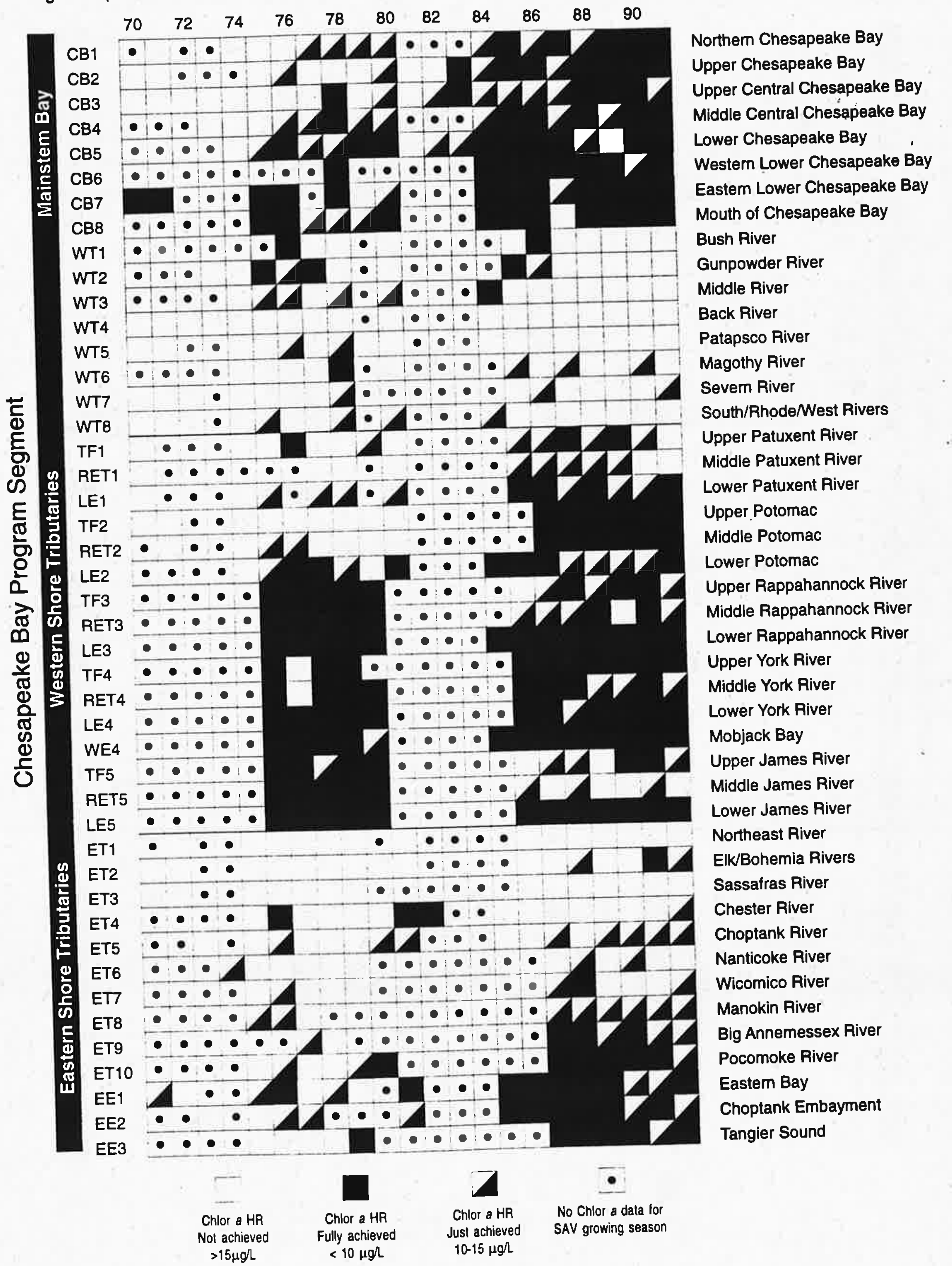
Sources: Chesapeake Bay Program, 1993a and 1993b.

Figure 10. Achievement of the total suspended solids SAV habitat requirements for one-meter restoration by Chesapeake Bay Program segment (1970 to 1991).



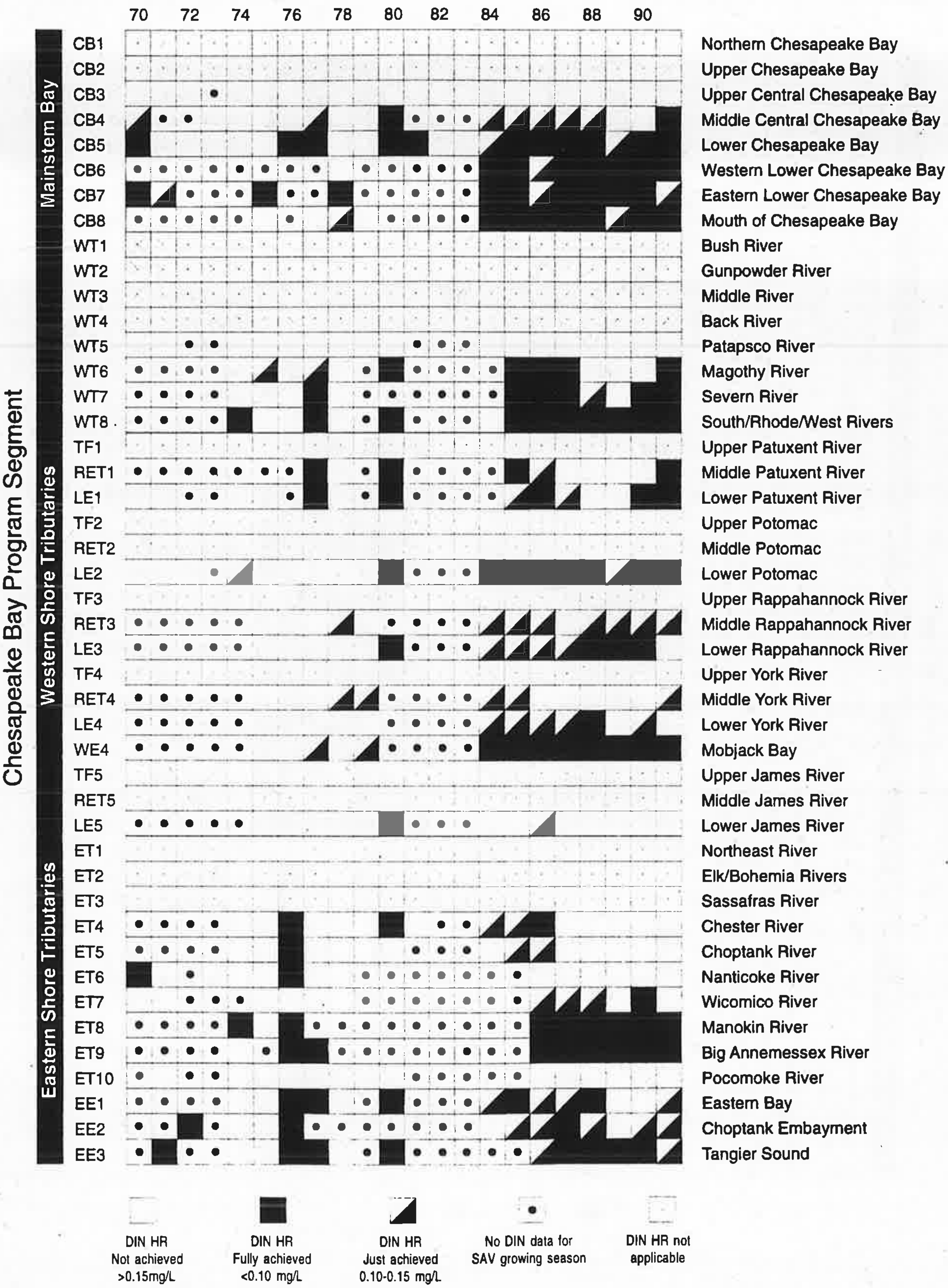
Sources: Batiuk et al., 1992; Chesapeake Bay Program, 1993a and 1993b.

Figure 11. Achievement of the chlorophyll *a* SAV habitat requirements for one-meter restoration by Chesapeake Bay Program segment (1970 to 1991).



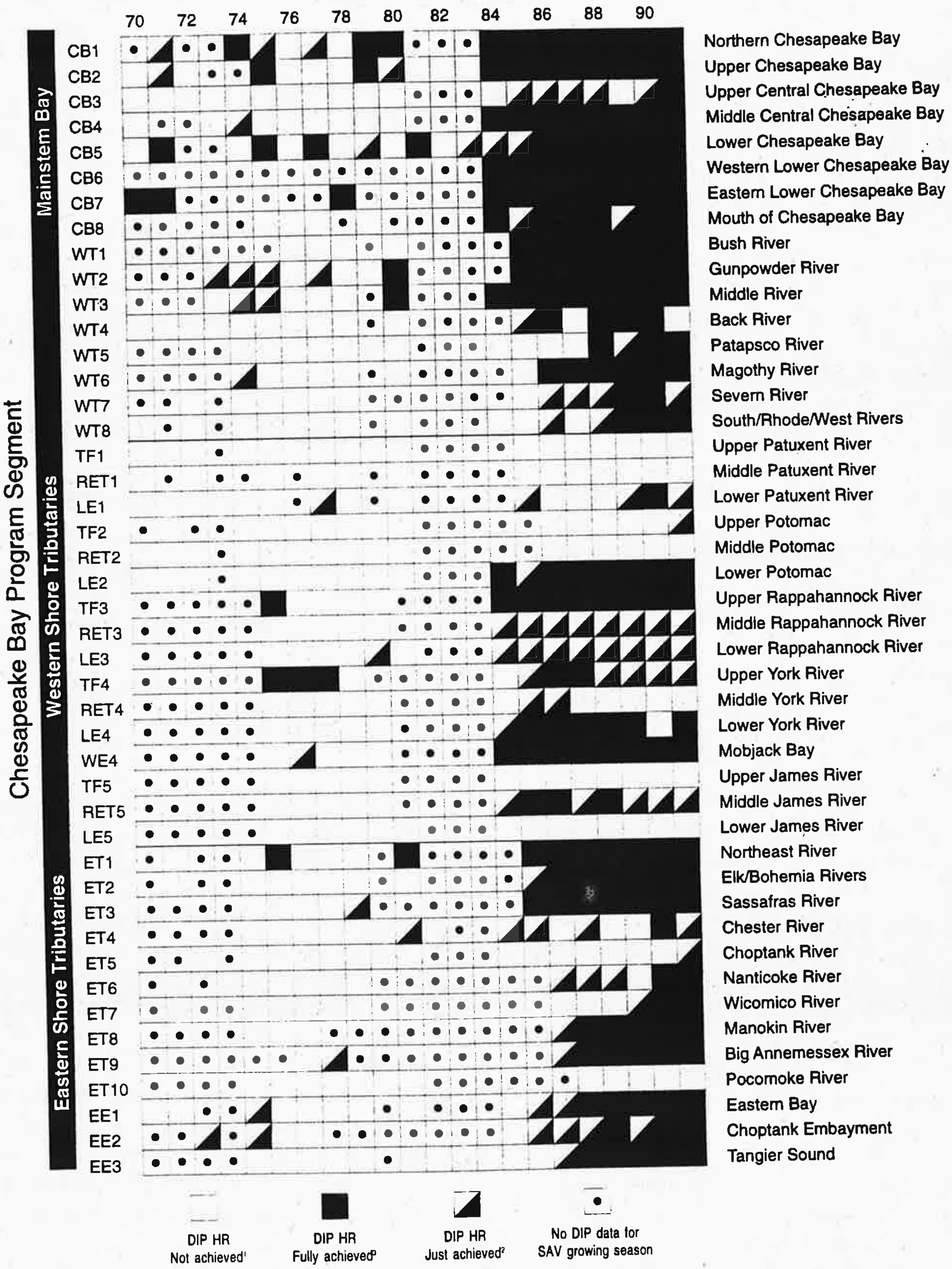
Sources: Batiuk et al., 1992; Chesapeake Bay Program, 1993a and 1993b.

Figure 12. Achievement of the dissolved inorganic nitrogen requirements for one-meter restoration by Chesapeake Bay Program segment (1970 to 1991).



Sources: Batiuk et al., 1992; Chesapeake Bay Program, 1993a and 1993b.

Figure 13. Achievement of the dissolved inorganic phosphorus SAV habitat requirements for one-meter restoration by Chesapeake Bay Program segment (1970 to 1991).



1. For tidal fresh, oligohaline, and polyhaline segments >0.02 mg/L; for mesohaline segments >0.01 mg/L. 2. For tidal fresh, oligohaline, and polyhaline segments 0.015-0.02 mg/L; for mesohaline segments 0.0075-0.01 mg/L. 3. For tidal fresh, oligohaline, and polyhaline segments < 0.015 mg/L; for mesohaline segments <0.0075 mg/L.
Sources: Batiuk et al., 1992; Chesapeake Bay Program, 1993a and 1993b.

of the SAV habitat requirement parameters from 1970 to 1991 (Appendix A).

Segments with SAV Fluctuating at High Levels

Seven of the Chesapeake Bay Program segments were classified as areas in which SAV distributions exceeded 100 hectares but showed no consistent trends of either increasing or decreasing SAV distribution: Northern Chesapeake Bay (CB1), Eastern Bay (EE1), and the Elk/Bohemia (ET2), Lower Choptank (EE2), Manokin (ET8), Big Annemessex (ET9), and Lower Rappahannock (LE3) rivers (Figures 6 and 14). Three of these segments (the Manokin, Big Annemessex, and Lower Rappahannock rivers) were located near or adjacent to those segments that showed consistent increases in SAV distribution. In two segments (Eastern Bay and the Lower Choptank River), *R. maritima* rapidly increased in distribution in the mid 1980s but began to decline by 1990. By 1991, it had been reduced to a few scattered beds. The rapid spread of *R. maritima* could be attributed to its mode of reproduction (high seed production over a long time period) and its ability to produce post-reproductive shoots that contribute to the vegetative population. The rapid vegetative growth of this species was also a factor.

The Susquehanna Flats and tidal Susquehanna River (the Northern Chesapeake Bay segment) are included in this category. Interestingly, the flanks of the tidal Susquehanna River below Conowingo Dam are densely vegetated with a diverse community of SAV species. The very large shallow-water area (Susquehanna Flats) historically supported one of the Bay's largest SAV communities with numerous SAV species (Bayley et al., 1978). This area remains sparsely vegetated with only one species, (*M. spicatum*) recorded, predominantly from ground surveys. Also, *H. verticillata* has not spread rapidly throughout this region as in the Potomac River and remains in scattered beds along the flanks of the river. Its spread may be impeded by the slightly higher salinity water of the Susquehanna Flats compared to the tidal fresh region of the Potomac River.

In four of the segments characterized by SAV distributions fluctuating at high levels (Northern Chesapeake Bay, Eastern Bay, Lower Choptank River, and Lower Rappahannock River), water quality conditions have often just met SAV habitat requirements (Figures 8-13). In the three Eastern Shore tributary segments within this category (Elk/Bohemia, Manokin, and Big Annemessex rivers), the light attenuation coefficient and total suspended solids habitat requirements have generally not been met throughout the 1970 to 1991 data record (Figures 8 and 10).

Segments with SAV Fluctuating at Low Levels

Nine of the segments were classified as areas in which SAV occurred in distributions less than 100 hectares but showed no consistent trends of either increasing or decreasing SAV distribution (Upper Chesapeake Bay (CB2), Middle Central Chesapeake Bay (CB4), Mouth of Chesapeake Bay (CB8), and the Sassafras (ET3), Gunpowder (WT2), Middle (WT3), Lower Patuxent (LE1), Lower Potomac (LE2), and Lower York (LE4) rivers) (Figures 6 and 15). Similar to the segments with SAV fluctuating at higher levels, most of these segments were either mainstem Bay segments or adjacent to the mainstem Bay. This group included the lower York River segment where SAV is present in a very small section of the lower riverine portion; the lower Potomac River segment where SAV is absent from almost all of the mainstem river; the lower Patuxent River segment; the two western shore tributaries (the Gunpowder and Middle rivers) that have consistently supported some SAV throughout the 1980s and 1990s; and three (Upper Chesapeake Bay, Middle Central Chesapeake Bay, and Mouth of the Chesapeake Bay) of the four mainstem Bay segments that contain few areas that could physically support SAV due to exposed shorelines.

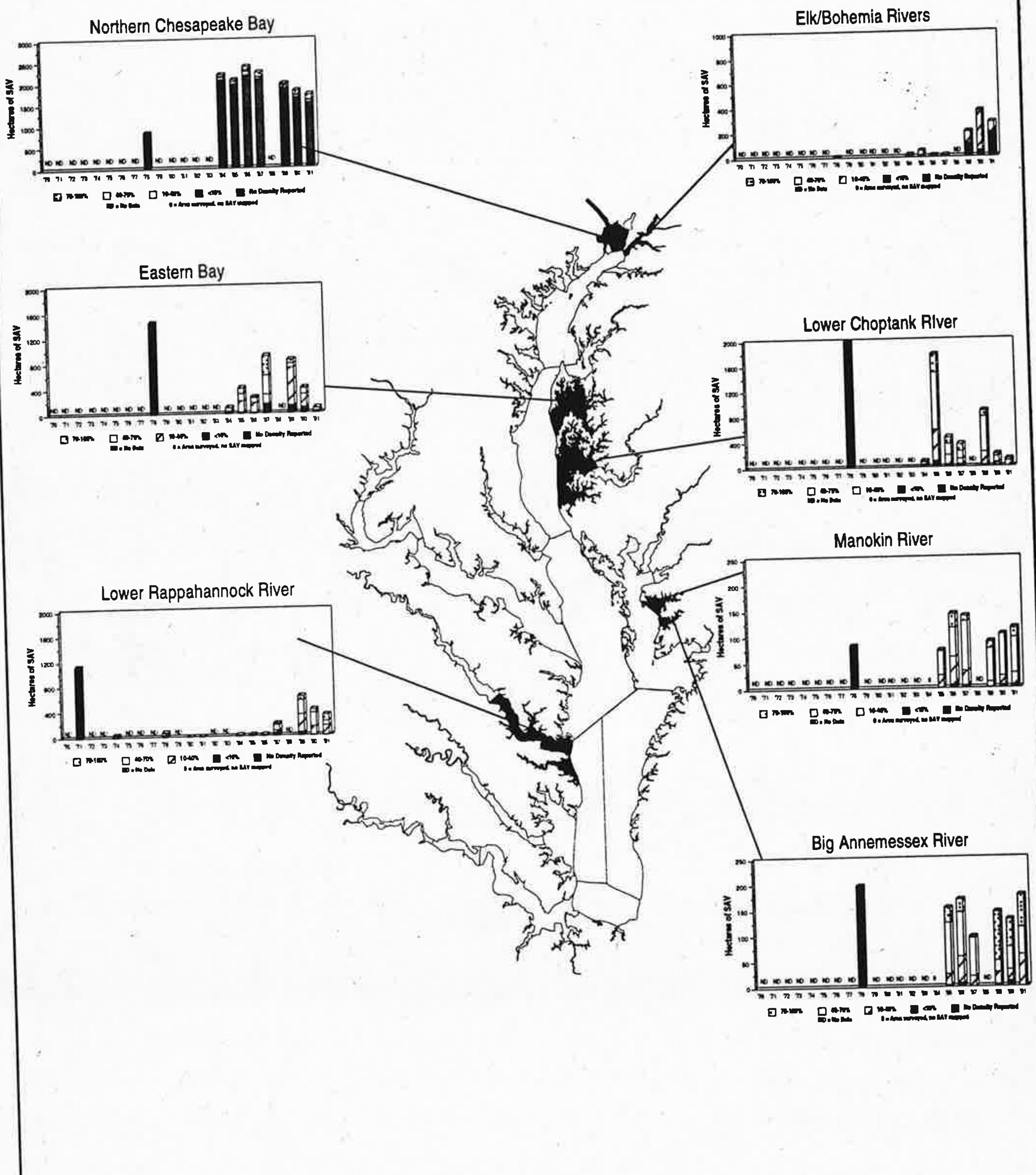


Figure 14. Chesapeake Bay segments with SAV fluctuating at higher levels of abundance.
Sources: Anderson and Macomber, 1980; Chesapeake Bay Program, unpublished data b; Orth et al., 1979, 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Gordon, 1975; Orth and Nowak, 1990.

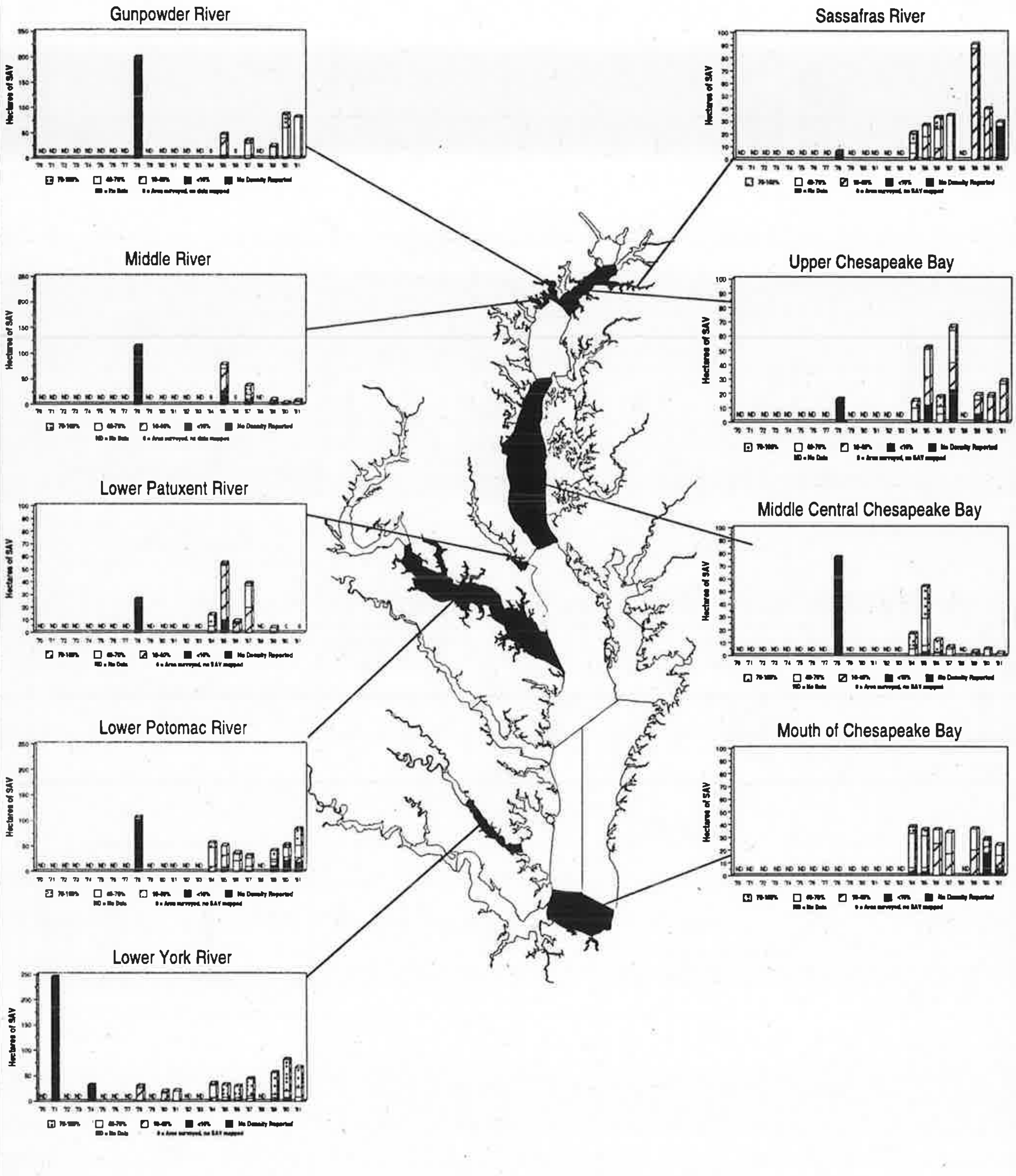


Figure 15. Chesapeake Bay segments with SAV fluctuating at lower levels of abundance.
Sources: Anderson and Macomber, 1980; Chesapeake Bay Program, unpublished data b; Orth et al., 1979, 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Gordon, 1975; Orth and Nowak, 1990.

Segments with SAV distributions fluctuating at low levels have had: water quality suitable for SAV survival and growth but with limited potential habitat (Middle Central Chesapeake Bay and Mouth of Chesapeake Bay); water quality conditions generally suitable for SAV but with limited sources of propagules necessary for restoration (Lower Patuxent and Lower Potomac rivers); or water quality conditions which ranged widely from unsuitable to suitable for SAV survival and growth over the 1971 to 1991 data record (Upper Chesapeake Bay and the Sassafras, Gunpowder, Middle, and Lower York rivers) (Figures 8-13).

Segments with Decreasing Trends

Only two of the 45 Chesapeake Bay Program segments were classified as areas with consistently decreasing trends in SAV distribution: Upper Central Chesapeake Bay (CB3) and Chester River (ET4) (Figures 6 and 16). These segments were flanked by segments with little or no SAV (Back, Patapsco, and Magothy rivers) and those with SAV fluctuating at low levels (Upper Chesapeake Bay, Middle Central Chesapeake Bay, Gunpowder River, and Middle River). The Upper Central Chesapeake Bay and Chester River segments have historically supported some of the largest concentrations of SAV beds with high species diversity in the middle Chesapeake Bay, particularly adjacent to Eastern Neck and Eastern Neck Island. Although six species have been reported from this region in recent years, only *R. maritima* has been commonly reported in ground surveys. Except for one SAV bed in a single cove in the lower Chester River, most beds appeared monospecific.

Water quality conditions meeting the SAV habitat requirements in the Upper Central Chesapeake Bay have fluctuated annually from 1970 to 1991 (Figures 8-13). The water quality in the adjacent Chester River has been generally unsuitable for SAV survival since the mid 1970s (Figures 8-13).

Segments with Little or No SAV

Twenty of the segments have had little SAV (less than 50 hectares): Bush (WT1), Patapsco (WT5), Magothy (WT6), Severn (WT7), South, Rhode, and West (WT8), Choptank (ET5), Upper Patuxent (TF1), Middle Patuxent (RET1), Middle James (RET5), and Lower James (LE5) rivers, or no SAV present since 1978: Back (WT4), Northeast (ET1), Nanticoke (ET6), Wicomico (ET7), Pocomoke (ET10), Upper Rappahannock (TF3), Middle Rappahannock (RET3), Upper York (TF4), Middle York (RET4), and Upper James (TF5) rivers (Figures 6 and 17). Each of the major western shore tributaries, except the Potomac River, had two or all three of its segments in this category, with the upper tidal fresh and middle transition segments principally unvegetated All other segments with little or no SAV are smaller tributaries along the western or eastern shores. Their relatively small drainage basins encompass not only highly urbanized and industrialized areas (i.e., the Bush, Back, Patapsco, Magothy, Severn, and South rivers), but areas with intensive agriculture (i.e., the Choptank, Nanticoke, and Wicomico rivers), activities resulting in greater nonpoint source inputs of nutrients and sediments.

Early ground surveys showed that these smaller tidal tributaries had supported SAV beds prior to 1971. Since 1971, however, segments with little or no mapped SAV have had water quality conditions generally unsuitable for SAV survival (Figures 8-13).

During the late 1980s and 1990s, *Z. palustris* was reported from several locations by the Citizens' SAV Hunt Program, especially in the Severn and South rivers. This species is an annual which grows rapidly in spring from seed[3]. It then reproduces and dies by early summer in these areas. The species is not detected through the baywide aerial survey because these areas are photographed in mid summer, usually after this species has disappeared for the season.

3. The precise germination period in Chesapeake Bay is uncertain but may be during late winter.

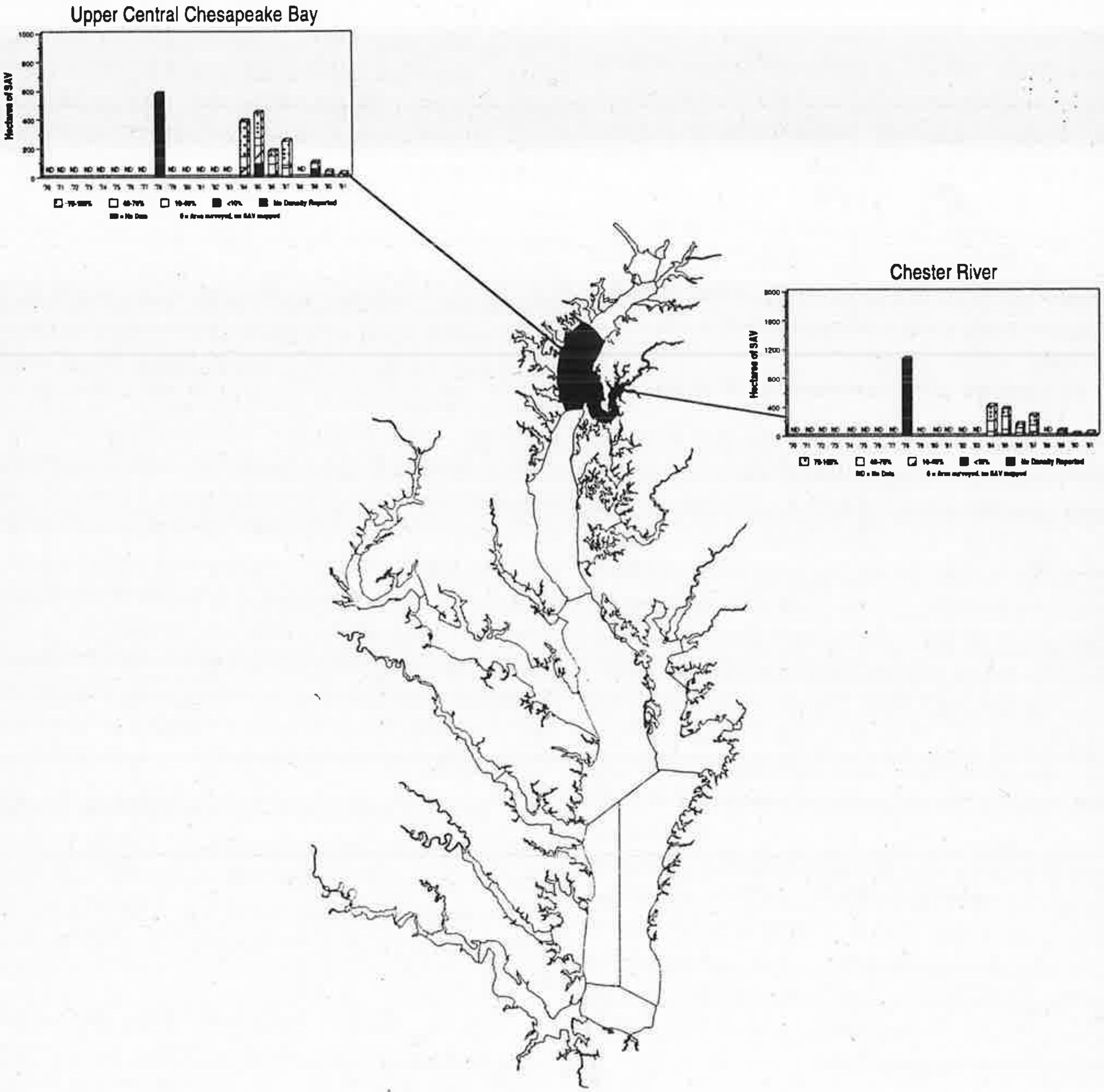


Figure 16. Chesapeake Bay segments with decreasing trends.
Sources: Anderson and Macomber, 1980; Orth et al., 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Nowak, 1990.

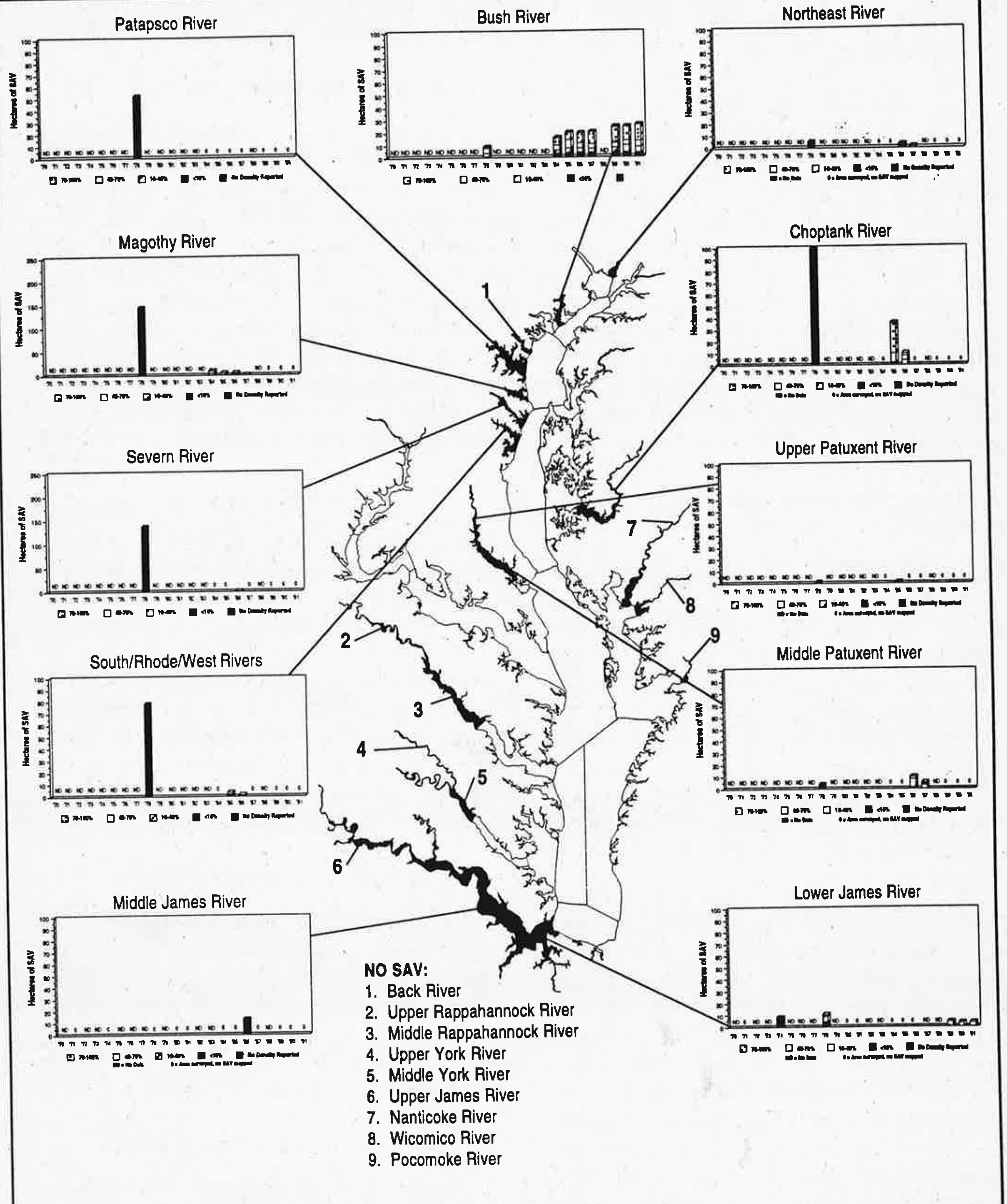


Figure 17. Chesapeake Bay segments with little or no SAV.
Sources: Anderson and Macomber, 1980; Chesapeake Bay Program, unpublished data; Orth et al., 1977, 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Gordon, 1975; Orth and Nowak, 1990.

Baywide Water Quality/SAV Habitat Requirement Patterns

Achievement of the SAV habitat requirements by year and segment are presented in a series of figures to illustrate baywide patterns in water quality (Figures 8-13). Years in which water quality conditions were more than 25 percent lower than the habitat requirements are identified to highlight those segments which had conditions suitable for SAV growth and propagation in addition to survival. Strict application of the SAV habitat requirements on a met/not met basis results in a loss of valuable information contained in the two decades of water quality data. Additional insights into habitat quality factors contributing to SAV trends are gained by examining water quality conditions which either just meet or are well below minimal habitat requirements.

Light Attenuation Coefficient

Consistent year-to-year attainment of the light attenuation coefficient habitat requirement for one-meter restoration was limited to the mainstem Bay (Susquehanna Flats and from the Bay Bridge south to the mouth of the Bay), the lower reaches of several major western shore tributaries (Patuxent, Potomac, and Rappahannock rivers), and large embayments (Mobjack Bay, Eastern Bay, lower Choptank River, and Tangier Sound) (Figure 8).

The light attenuation coefficient habitat requirement for two-meter restoration was met during one or more growing seasons from 1970 to 1991 in the Lower Potomac River, Lower Rappahannock River, Chester River, Eastern Bay, Upper Central Chesapeake Bay, Middle Central Chesapeake Bay, Lower Chesapeake Bay, Western Lower Chesapeake Bay, Eastern Lower Chesapeake Bay, and the Mouth of Chesapeake Bay segments (Figure 9). Even in these segments, this habitat requirement was not met consistently in all years for which data were available. Only in the lower Bay segments do SAV beds extend to the two-meter depth contour with the exception of the upper Potomac River where *H. verticillata*, a canopy-forming species, can reach similar depths (Batiuk et al., 1992).

Total Suspended Solids

The overall pattern of meeting the total suspended solids habitat requirement is generally similar to that of the light attenuation coefficient habitat requirement for one-meter restoration (Figure 10). The pattern of meeting or not meeting both the light attenuation and total suspended solids habitat requirements reflects the influence of total suspended solids concentrations on water column light attenuation. In some segments, however, the light attenuation coefficient habitat requirement for one-meter restoration is met but the total suspended solids habitat requirement is not.

Chlorophyll a

In the mainstem Bay and the major western shore tidal tributaries and embayments, the chlorophyll *a* requirement generally has been met throughout the data record (Figure 11). In all ten upper western shore tributaries (Bush, Gunpowder, Middle, Back, Patapsco, Magothy, Severn, South, Rhode, and West rivers) and several Eastern Shore tributaries (Northeast, Elk, Bohemia, Sassafras, Chester, Nanticoke, and Wicomico rivers), the chlorophyll *a* habitat requirement has not been met over most of the 22-year data record.

Dissolved Inorganic Nitrogen

The only general pattern in the dissolved inorganic nitrogen habitat requirement is that segments have either consistently met or not met this requirement over the data record (Figure 12). Some segments (i.e., the Magothy, Lower York, and Wicomico rivers, and Eastern Bay) show no consistent pattern over the data record.

Dissolved Inorganic Phosphorus

Water quality has shown a trend from not meeting (1974 to 1980) to meeting the dissolved inorganic phosphorus habitat requirement (since 1984) in most areas of Chesapeake Bay and its tidal tributaries (Figure 13). Areas where this trend does not hold include segments of the Patuxent, Potomac, York, James, Choptank, and Pocomoke rivers.

Baywide Trends in SAV and River Flow

Submerged aquatic vegetation distribution patterns have been strongly linked to water quality. Based on empirical evidence, the habitat requirements identify the minimum water quality levels necessary to support SAV in different sections of Chesapeake Bay and its tidal tributaries (Batiuk et al., 1992; Dennison et al., 1993). River flow from the Susquehanna and Potomac rivers was also chosen to test whether it is a good indicator of SAV distribution over time. These two rivers account for approximately 75 percent of the total freshwater inflow to the tidal Bay. River flow can integrate localized rainfall events, minimizing the bias inherent in localized rainfall patterns. It is assumed that higher flow correlates with higher inputs of sediments and nutrients.

Susquehanna River flow was measured at Conowingo, Maryland and Potomac River flow was measured at Little Falls, Virginia. The mean monthly flow was divided into quartiles by comparing each month and year to the overall distribution of flow for that month from 1950 to 1991. For example, the mean monthly flow from October, 1952 was compared to the distribution of October flows from 1950 to 1991. Each monthly flow was classified as first quartile (minimum to 25th percentile), second quartile (>25th percentile to median), third quartile (> median to 75th percentile), fourth quartile (>75th percentile to upper extreme), and upper extreme (>75th percentile + (1.5 x interquartile) to maximum). The interquartile range, which estimates the variability in the data, is the 75th percentile minus the 25th percentile. The quartile data were also summarized by year, counting the number of months from April to October (the SAV growing season (Batiuk et al., 1992)) that were above the median and above the 75th percentile. Years with average flow should have about half of the months (three or four) above the median. These annual summaries were graphed and tested for significant differences ($p < 0.05$) by decade with the Kruskall-Wallis one-way Analysis of Variance (ANOVA) by ranks, using the NPAR1Way procedure in SAS with the Wilcoxon option (SAS Institute, 1990).

Appendix E summarizes the distribution of flow data for each month from 1950 to 1991 for the Susquehanna and Potomac rivers. Figures 18 and 19 show the number of months between April and October that exceeded the median flow (dashed line) and the 75th percentile of flow (solid line) for the Susquehanna and Potomac rivers, respectively.

The annual flow pattern in the Susquehanna data (Figure 18) shows generally average flows in the 1950s, below average flows in the 1960s (the 1962 to 1966 period was one of the lowest flow periods in the 42-year data set), above average flows in the 1970s (the period from 1972 to 1979 was one of the wettest as five of seven months in every year equaled or exceeded the median flow), and average flows in the 1980s. This pattern was statistically significant for the number of months above the median (Kruskall-Wallis $X^2 = 10.4$, $p = 0.016$), but not for the number of months above the 75th percentile (Kruskall-Wallis $X^2 = 4.4$, $p = 0.2$), which showed less pronounced differences by decade. For the number of months above the median, the mean rank by decade was lowest for the 1960s (13.8) and highest for the 1970s (29.9), while the other two decades had mean ranks close to the expected value of 20.5 (19.1 for the 1950s and 19.3 for the 1980s).

The Potomac River flow data show patterns by decade that resemble those in the Susquehanna, however, the differences were less pronounced (Figure 19). The flows in the 1960s were not as consistently low and the flows in the 1970s were not as consistently high (Figure 17). The differences between the rivers were most pronounced in 1976 and 1977, when the Susquehanna River had five months with flows above the median and the Potomac River had only one month with above-the-median flows. There were no significant differences

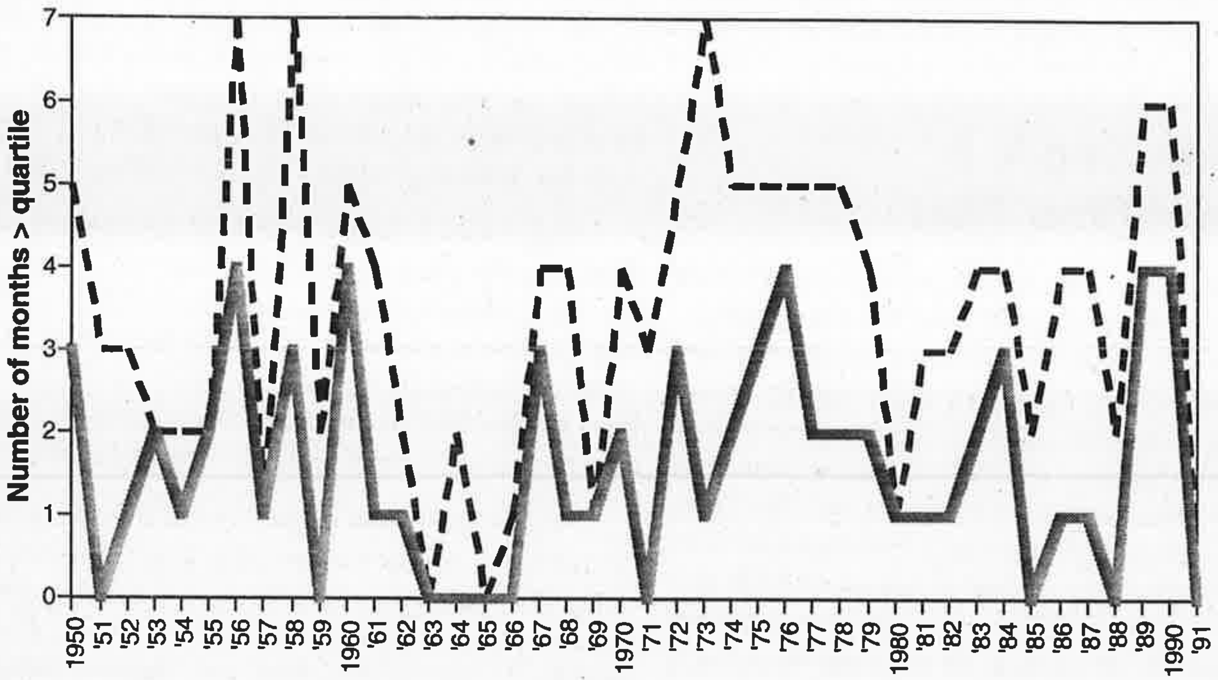


Figure 18. Susquehanna River flow presented as the number of months between April and October (the SAV growing season) within each year from 1950 to 1991 in which the mean monthly flow is above the 50th percentile (■ ■ ■ ■ ■) and the 75th percentile ( ) of total river flow.
Source: U.S. Geological Survey (unpublished data).

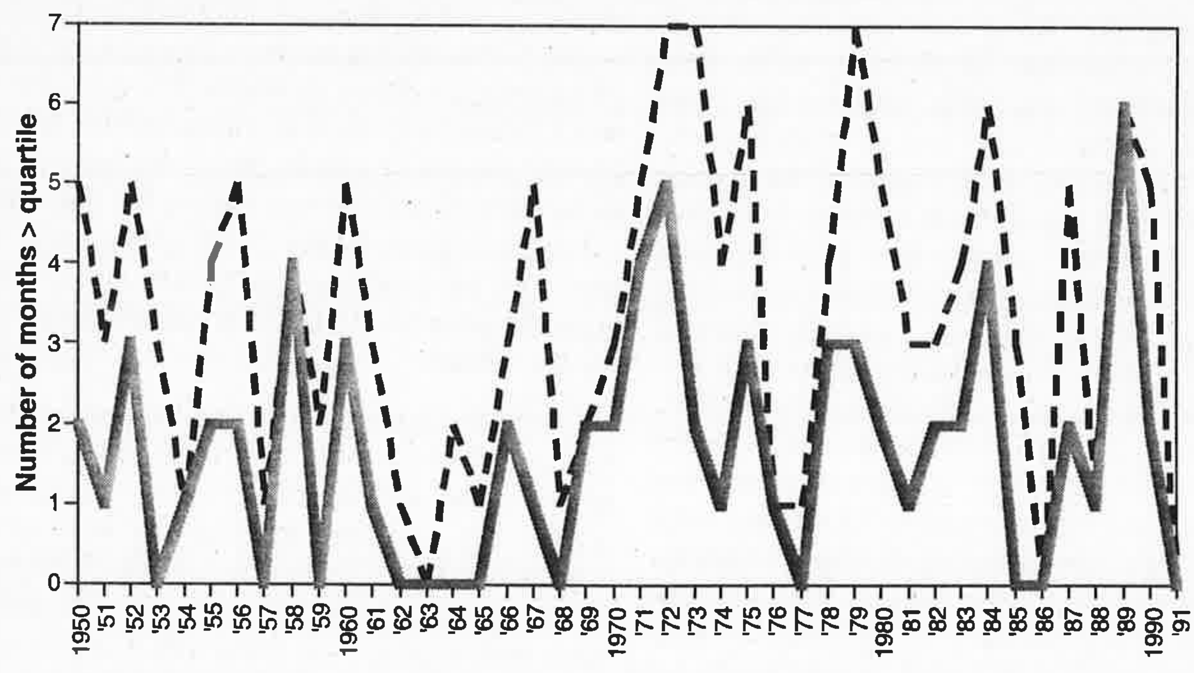


Figure 19. Potomac River flow presented as the number of months between April and October (the SAV growing season) within each year from 1950 to 1991 in which the mean monthly flow is above the 50th percentile (■ ■ ■ ■ ■) and the 75th percentile ( ) of total river flow.
Source: U.S. Geological Survey (unpublished data).

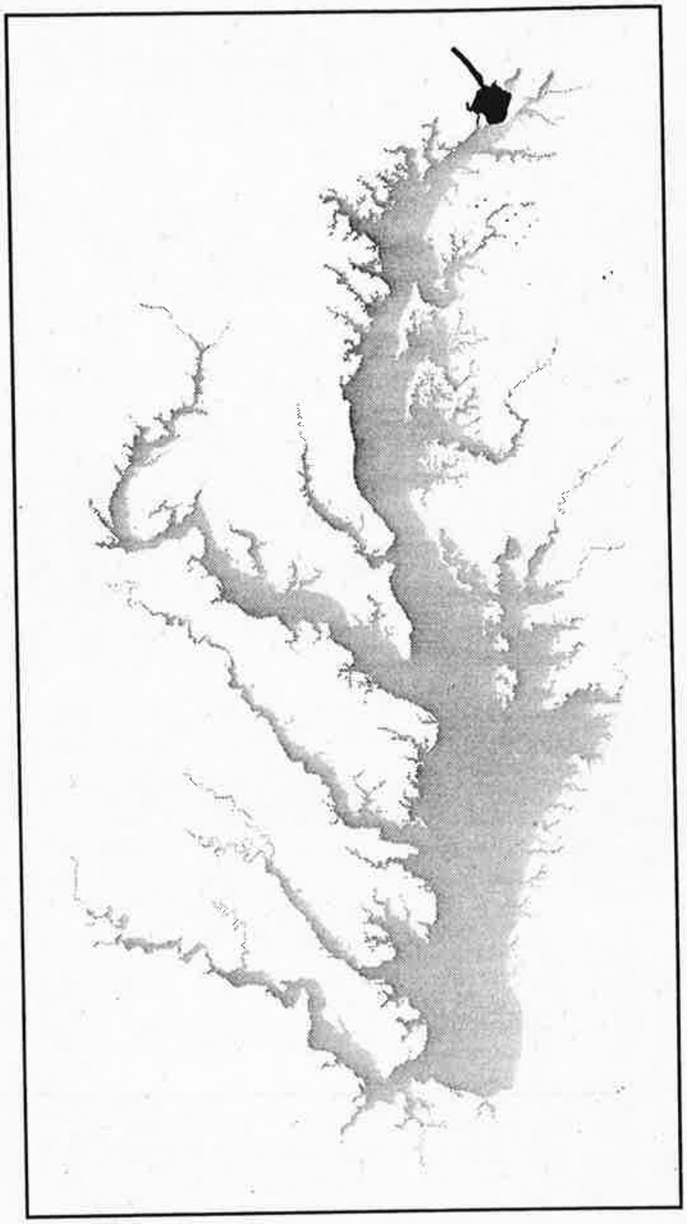
among decades in the Potomac River data for the number of months above the median (Kruskall-Wallis $X^2 = 5.7$, $p = 0.13$) or for the number of months above the 75th percentile (Kruskall-Wallis $X^2 = 5.6$, $p = 0.13$).

The patterns described above suggest that river flow may be a critical driving force in structuring the SAV populations in Chesapeake Bay. In the 1950s, SAV populations were flourishing in most sections of the Bay and its tidal tributaries. River flow from the Susquehanna and Potomac rivers during the SAV growing season was normal with a couple of years of above normal runoff followed by low runoff years. Submerged aquatic vegetation continued to flourish in the 1960s. The 1970s showed a major baywide decline in SAV. This period had the highest river flows and was marked by eight consecutive years (1972 to 1979) for which five of the seven growing season months had flow from the Susquehanna River at or above the 50th percentile and which included one of the most significant storms to affect the Chesapeake Bay—Tropical Storm Agnes. Submerged aquatic vegetation began to rebound in the 1980s as river flow returned to normal. Interestingly, the 1980s flow is punctuated with high and low flow years. Submerged aquatic vegetation populations potentially could be sustained during higher flow years if their growth, distribution, and abundance is maximized during low flow years. Several consecutive high flow years may be most detrimental to SAV populations.

Chapter 4: Regional Trends in SAV Distribution, Abundance, and Habitat Quality

Historically, SAV in Chesapeake Bay has undergone both site-specific and species-specific fluctuations in distribution. Past fluctuations, however, were not of the same magnitude as the 1970s baywide decline which affected all SAV species throughout the Bay (Orth and Moore, 1983a and 1984; Stevenson and Confer, 1978; Stevenson and Staver, in press). The most notable of these historical changes were: 1) the decline of *Zostera marina* in the 1930s (when it also declined worldwide (Rasmussen, 1977)); 2) the loss of SAV in the Potomac River by the 1930s; 3) the rapid expansion and subsequent decline of *M. spicatum* primarily in the upper Bay and Potomac River in the 1950s and 1960s, displacing many native species (Bayley et al., 1978); and 4) the rapid spread of *Hydrilla verticillata* in the tidal fresh portions of the Potomac River in the 1980s (Carter and Rybicki, 1986). Stevenson and Confer (1978), Orth and Moore (1984), Carter and Rybicki (1986), and Stevenson and Staver (in press) offer more detailed accountings of many of these changes.

Northern Chesapeake Bay



The Northern Chesapeake Bay, which includes the Susquehanna River and Susquehanna Flats, historically supported dense[5] and diverse SAV beds (Bayley et al., 1978). Prior to the 1960s, the U.S. Fish and Wildlife Service recognized this area as one of the most important habitats for migrating waterfowl on the East Coast (Stewart 1962). Johns Hopkins University scientists examined long-term historical changes (over the past 1800 years) in SAV populations using seed and pollen analysis in Furnace Bay (Brush et al., 1981; Brush and Hilgartner, 1989; Davis, 1985). These studies showed the presence of SAV throughout this period until 1972; some species experienced declines related to initial European settlement and water use.

Native SAV in this region was affected by rapid expansion of the exotic, *Myriophyllum spicatum*, in the 1950s. This species was first reported in 1881 in the Potomac River near Alexandria, Virginia[6], but remained an inconspicuous member of the Bay ecosystem until the 1950s (Bayley et al., 1978; Stevenson and Confer, 1978).

Beginning in the late 1950s and continuing through the early 1960s, *M. spicatum* displaced much native SAV (Bayley et al., 1968 and 1978). As the *M. spicatum* population began to decline around 1962, however, many native species began to increase in abundance by the late 1960s. Some dominant and some non-dominant native species were less abundant, however, and fewer total species existed compared to the time before the expansion of *M. spicatum*.

Between the late 1960s and 1972, native plants began to decline once more. By the end of 1972, they had almost completely disappeared, principally due to Tropical Storm Agnes in 1972. The first baywide aerial survey in 1978 reported 838 hectares, mostly along the flanks of the Susquehanna River and in a small area in the Susquehanna Flats.

Since 1984, SAV distributions have fluctuated annually between 1,691 hectares (1991) and 2,365 hectares (1986) in the Susquehanna River and Susquehanna Flats region (Figure 20, Table 9). The percent of the Maryland Department of Natural Resources vegetated SAV ground survey stations has fluctuated between 0 and 17 percent in the tidal

5. *The term "dense," as used here, should not be confused with the density classification scheme used in the aerial survey.*

6. *The exact timing of its introduction into the United States is unknown but is likely around the time of its first recorded appearance.*

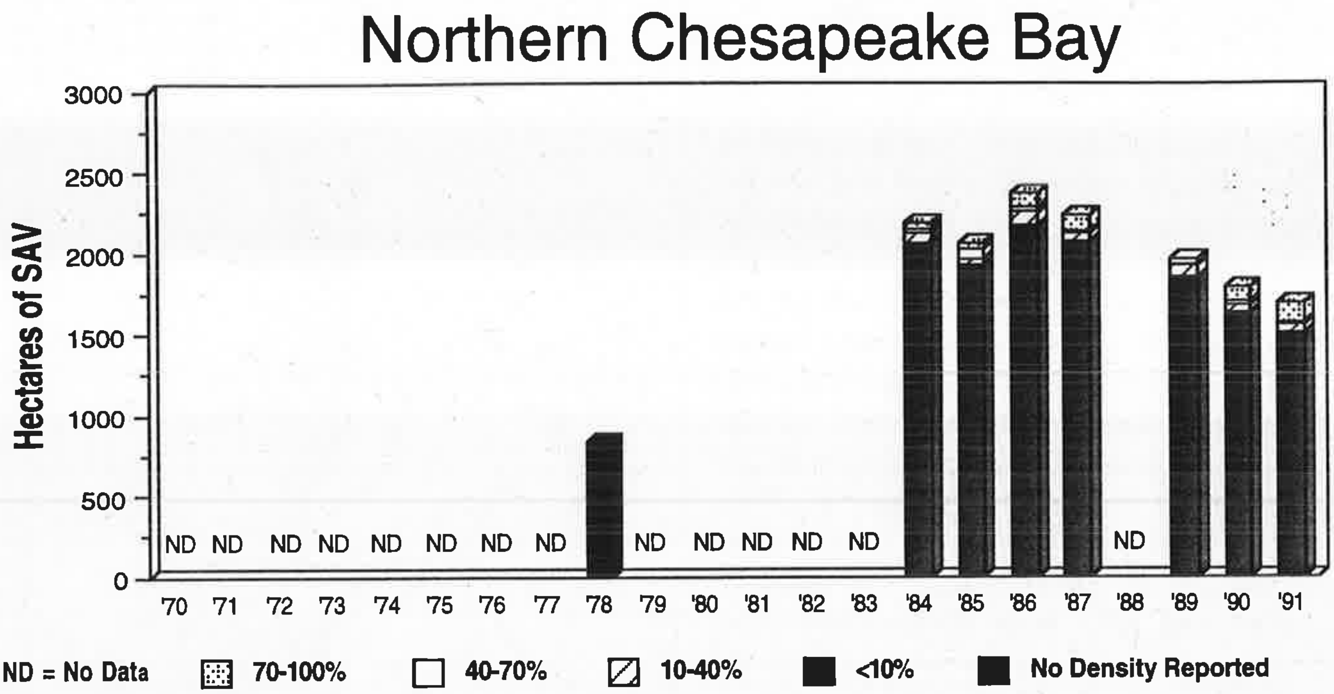


Figure 20. Hectares of SAV by density category for all years for which aerial survey data were available. For CBP Segment CB1 (Northern Chesapeake Bay), the Tier I SAV restoration goal is 3,101 hectares.
Sources: Anderson and Macomber, 1980; Orth et al., 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Nowak, 1990.

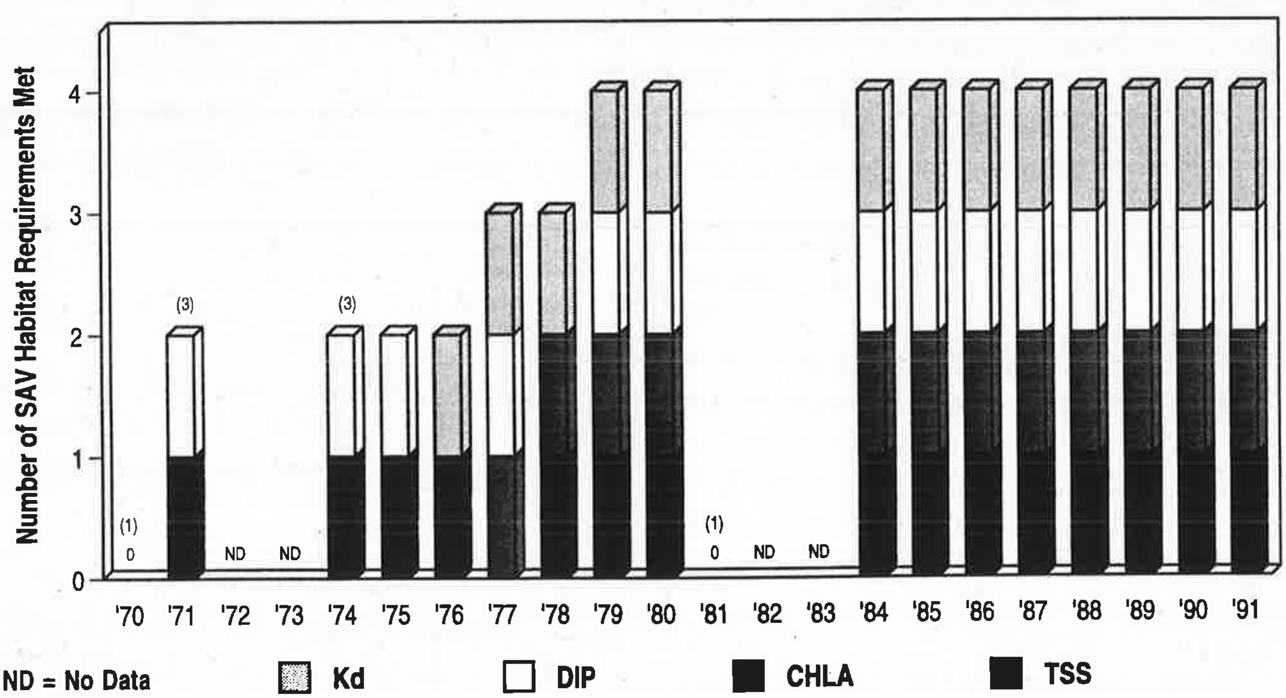


Figure 21. The number of SAV habitat requirements met over the SAV growing season from 1970 to 1991 for CBP Segment CB1 (Northern Chesapeake Bay). No SAV habitat requirements met = 0; no water quality data available = ND. Sufficient data for the following parameters were not available to calculate growing season medians: Kd (1970-1974, 1981-1983); TSS (1972, 1973, 1981-1983); CHLA (1970, 1972, 1973, 1981-1983); and DIP (1970, 1972, 1973, 1982, and 1983). Numbers of SAV habitat requirements with growing season medians are shown above bars when some values were missing.
Sources: Chesapeake Bay Program, 1993a and 1993b.

Susquehanna River and Susquehanna Flats region over the past 21 years with some SAV (3 to 17 percent) reported for most years (Figure 22).

Although the areal extent of SAV includes a significant portion of the Susquehanna Flats, SAV density is very sparse (<10 percent coverage). This very large area presently supports sparse populations of one predominant species, *M. spicatum*. Anecdotal and ground survey information suggest that dense and diverse SAV populations once grew here, but no estimate has been made of the magnitude of this historical bed. The shoreline of this section (from just below Havre de Grace and Mill Creek/Furnace Bay to an area approximately two miles upriver, including the shoreline surrounding some of the islands) has continuously supported small but moderate to dense fringing beds of SAV containing up to six species. Ground surveys by different groups (in particular Stan Kollar, Harford Community College) have reported nine species over the past seven years.

Myriophyllum spicatum has been most frequently found in these fringing beds along with *V. americana*. Other species reported are *H. dubia*, *N. guadalupensis*, *N. minor*, *C. demersum*, *P. perfoliatus*, *P. pectinatus*, and *H. verticillata*. Although *H. verticillata* has been continuously reported in this region since 1984 and has expanded to several beds, it has not developed into the large contiguous beds presently found in the Potomac River (Kollar, personal communication).

Since 1984, Stan Kollar of Harford Community College has transplanted SAV (primarily *V. americana*) into the Susquehanna Flats region (Kollar, 1985, 1986, 1987, and 1988). The most successful sites were at Perry Point and Fishing Battery (the latter was protected by a submerged breakwater). Water quality at these successful sites is characterized by lower levels of turbidity and lower concentrations of total suspended solids, chlorophyll *a*, and dissolved inorganic phosphorus than at sites where transplants were not successful (Batiuk

Northern Chesapeake Bay

Year	Hectares of SAV by Density Category				Segment Total	% of Tier I Restoration Goal	% of Tier III Restoration Goal
	<10%	10-40%	40-70%	70-100%			
'70	-	-	-	-	-	-	-
'71	-	-	-	-	-	-	-
'72	-	-	-	-	-	-	-
'73	-	-	-	-	-	-	-
'74	-	-	-	-	-	-	-
'75	-	-	-	-	-	-	-
'76	-	-	-	-	-	-	-
'77	-	-	-	-	-	-	-
'78	-	-	-	-	838	27%	12%
'79	-	-	-	-	-	-	-
'80	-	-	-	-	-	-	-
'81	-	-	-	-	-	-	-
'82	-	-	-	-	-	-	-
'83	-	-	-	-	-	-	-
'84	2,060	53	27	41	2,181	70%	31%
'85	1,921	40	59	31	2,051	66%	29%
'86	2,174	82	33	76	2,365	76%	34%
'87	2,075	41	20	92	2,228	72%	32%
'88	-	-	-	-	-	-	-
'89	1,850	67	37	0	1,954	63%	28%
'90	1,619	55	23	84	1,781	57%	26%
'91	1,504	50	14	123	1,691	55%	24%

Table 9. Hectares of SAV by density category and percentage of Tier I SAV restoration goal (3,101 hectares) and Tier III SAV restoration target (6,974 hectares) are listed for 1970 to 1991 for CBP Segment CB1 (Northern Chesapeake Bay).
Sources: Anderson and Macomber, 1980; Batiuk et al., 1992; Orth et al., 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Nowak, 1990.

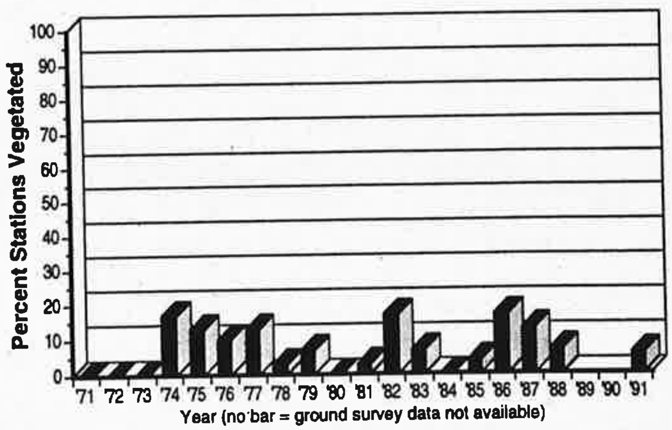


Figure 22. Percentage of Maryland Department of Natural Resources SAV Ground Survey Program stations sampled where SAV was observed for CBP Segment CB1 (Northern Chesapeake Bay). Ground survey data were not available for 1989 and 1990.
Source: Chesapeake Bay Program, unpublished data c.

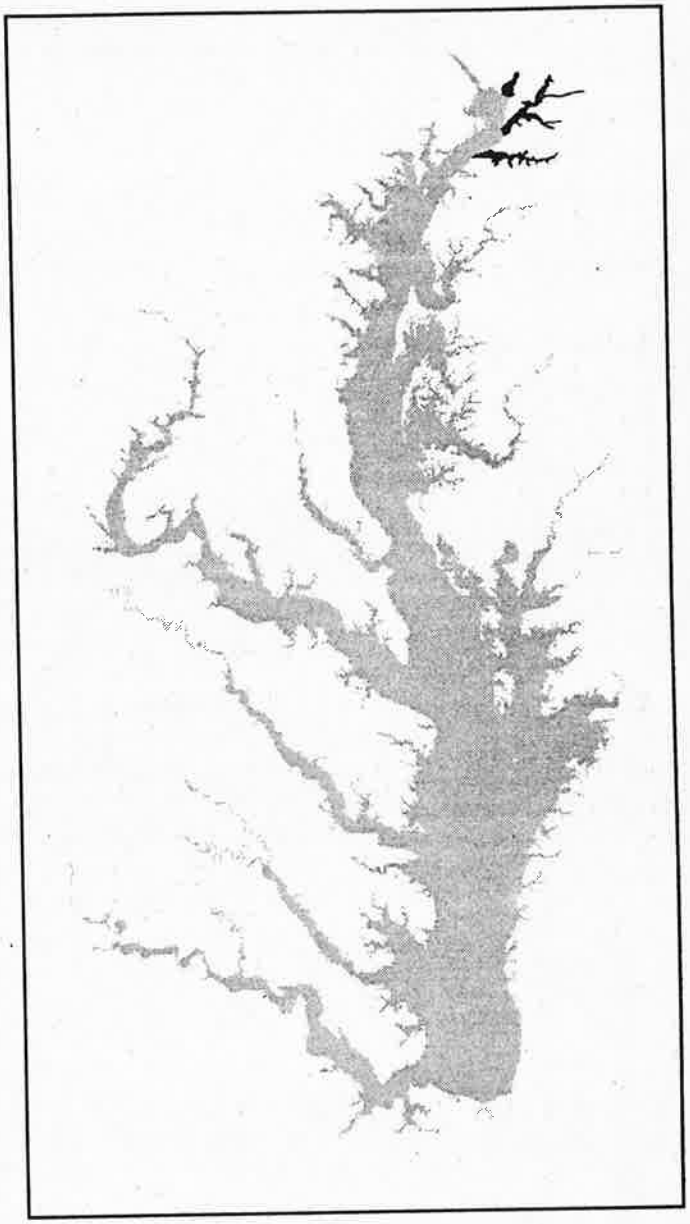
et al., 1992). These successful sites also had naturally occurring SAV beds both prior to and after the transplanting program.

Water quality conditions since 1984 have met all four of the SAV habitat requirements in the Susquehanna Flats region (Figure 21). Water quality for this segment is characterized by a single monitoring station located in the navigation channel at the mouth of the Susquehanna River. The slight downward trend in SAV distribution since 1986, as well as the lack of increase in bed density, may reflect the inadequacy of a single station to characterize the water quality of the entire Susquehanna Flats. More spatially intensive monitoring networks have shown significant differences in water quality conditions across the Susquehanna Flats (Batiuk et al., 1992). Full restoration of SAV to potential habitat (down to the two-meter depth contour) is currently limited by insufficient light penetration.

Achievement of the Tier I restoration goal (3,101 hectares) has ranged from 55 to 76 percent since 1984. Achievement of the Tier III restoration target (6,975 hectares) has ranged from 24 to 34 percent since 1984 (Table 9).

The lack of expansion of SAV through the Susquehanna Flats is anomalous since dense multispecies beds of SAV exist along both shorelines of the tidal Susquehanna River and the water quality generally seems adequate to support SAV. Patches of SAV do exist throughout the Susquehanna Flats but are composed of only one species (*M. spicatum*). Without the dense SAV beds that once stabilized sediments and baffled currents and waves, regular disturbance of sediments by wind and waves along the long, open fetch may create environmental conditions unsuitable for SAV to recolonize this area. Also, sedimentary conditions may have changed since Tropical Storm Agnes in 1972 and this change may still be playing a role in preventing the reestablishment of SAV.

Northeast, Elk, Bohemia, and Sassafras Rivers



The Northeast, Elk, Bohemia, and Sassafras rivers are the northernmost four of ten tributaries entering Chesapeake Bay from the Eastern Shore. The aerial survey reported a small amount of SAV (zero to 47 hectares) in these rivers between 1978 and 1987, principally near the mouths of the rivers and in protected coves and shallow embayments.

From a high of five hectares in 1978, no SAV was reported in the Northeast River by the aerial survey after 1989 (Figure 23 and Table 10). Submerged aquatic vegetation in the Elk River increased from 1987 to 1989 (from eight to 198 hectares) and again in 1990 (364 hectares), principally along the river's northern shore (Figure 25). The distribution then decreased to 271 hectares in 1991. Most SAV beds in the Elk River have been classified as very sparse (<1 to 10 percent coverage) or sparse (10 to 40 percent coverage), indicating the very patchy nature of the SAV in this region (Table11). The patchy nature of these SAV beds may have led to underestimating or underreporting SAV distribution in the late 1970s and early to mid-1980s. No SAV has been mapped in the Bohemia River except for one very sparse bed at Town Point at the river mouth. In the Sassafras River, SAV has been generally located near the mouth in small beds and has never exceeded a total of 40 hectares except in 1989, when the aerial survey reported 91 hectares (Figure 27 and Table 12).

The Maryland Department of Natural Resources ground survey reported SAV in the Northeast River in only two years between 1971 and 1991 (1979 and 1984) (Figure 29). They reported no SAV in the Elk and Bohemia rivers, although some SAV had been reported in the 1950s and 1960s. From 1989 through 1991, the Maryland survey reported rooted SAV (*M. spicatum*) inshore of its unvegetated stations in the Elk River. The survey also reported SAV in the Sassafras River in 1974, 1981, 1983, 1986, 1989, 1990 and 1991, with the most recorded in 1990 (Figure 30). Abundant SAV was found in the Sassafras River in the 1960s by earlier surveys. Discrepancies between the findings of the aerial survey and the Maryland Department of Natural Resources ground survey probably result from the denser SAV beds that grow very close to shore in areas not checked by survey crews or the very sparse nature of the beds.

Myriophyllum spicatum and *V. americana* were the two species most frequently reported in the Elk and Sassafras rivers by ground surveys. Other species reported in ground surveys were *P.*

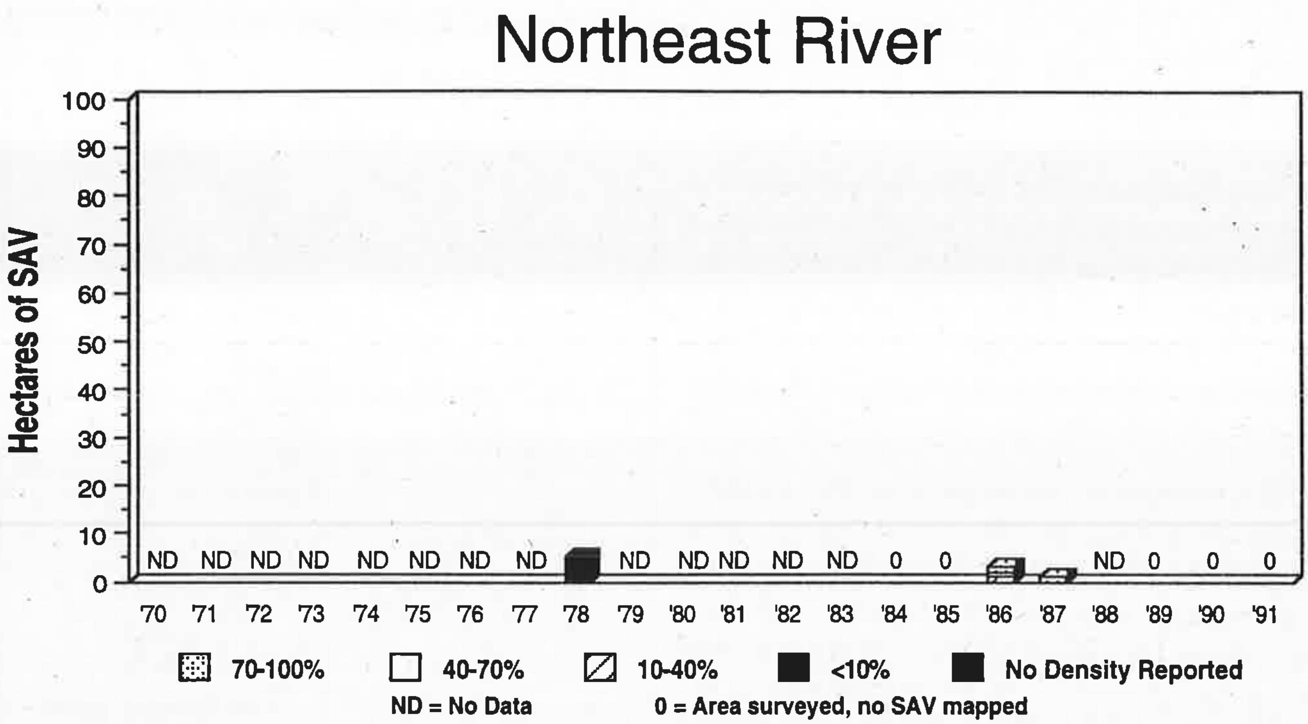


Figure 23. Hectares of SAV by density category for all years for which aerial survey data were available. For CBP Segment ET1 (Northeast River), the Tier I SAV restoration goal is seven hectares.
Sources: Anderson and Macomber, 1980; Batiuk et al., 1992; Orth et al. 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Nowak, 1990.

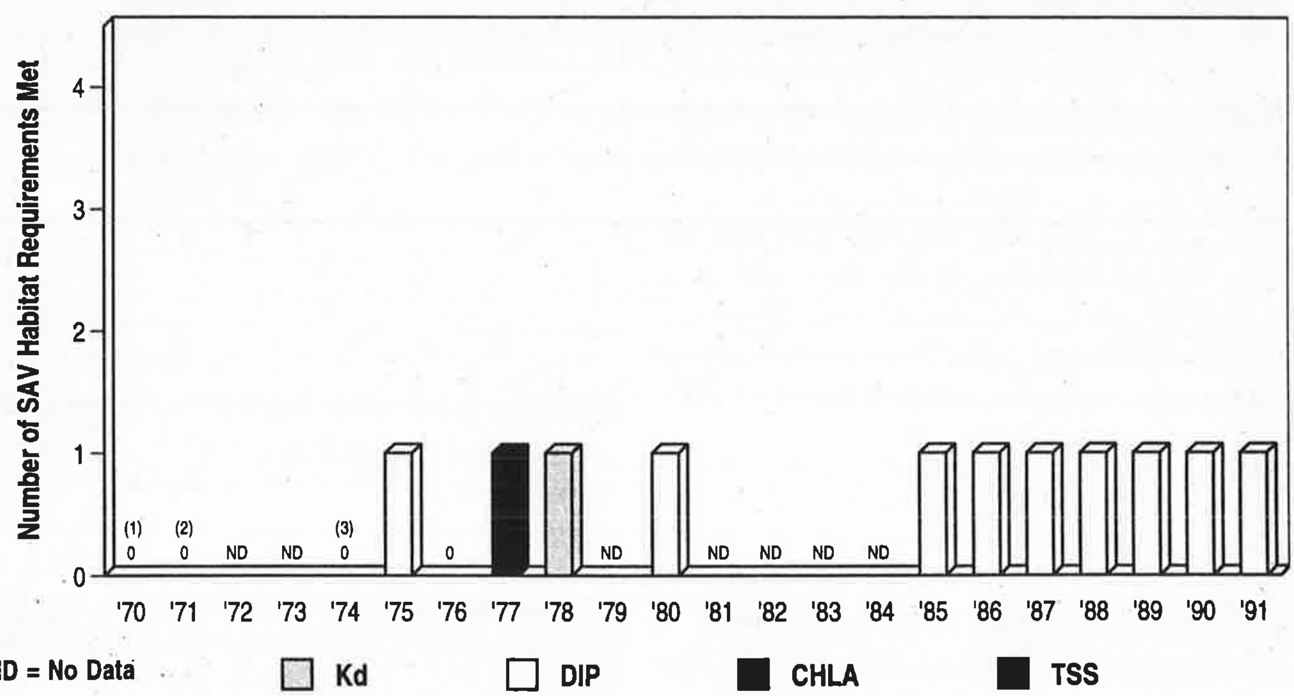


Figure 24. The number of SAV habitat requirements met over the SAV growing season from 1970 to 1991 for CBP Segment ET1 (Northeast River). No SAV habitat requirements met = 0; no water quality data available = ND. Sufficient data for the following parameters were not available to calculate growing season medians: Kd (1971-1974, 1979, 1981-1984); TSS (1970-1973, 1979, 1981-1984); CHLA (1970, 1972, 1973, 1979, 1981-1984); and DIP (1970, 1972, 1973, 1979, 1981-1984). Numbers of SAV habitat requirements with growing season medians are shown above bars when some values were missing.
Sources: Chesapeake Bay Program, 1993a and 1993b.

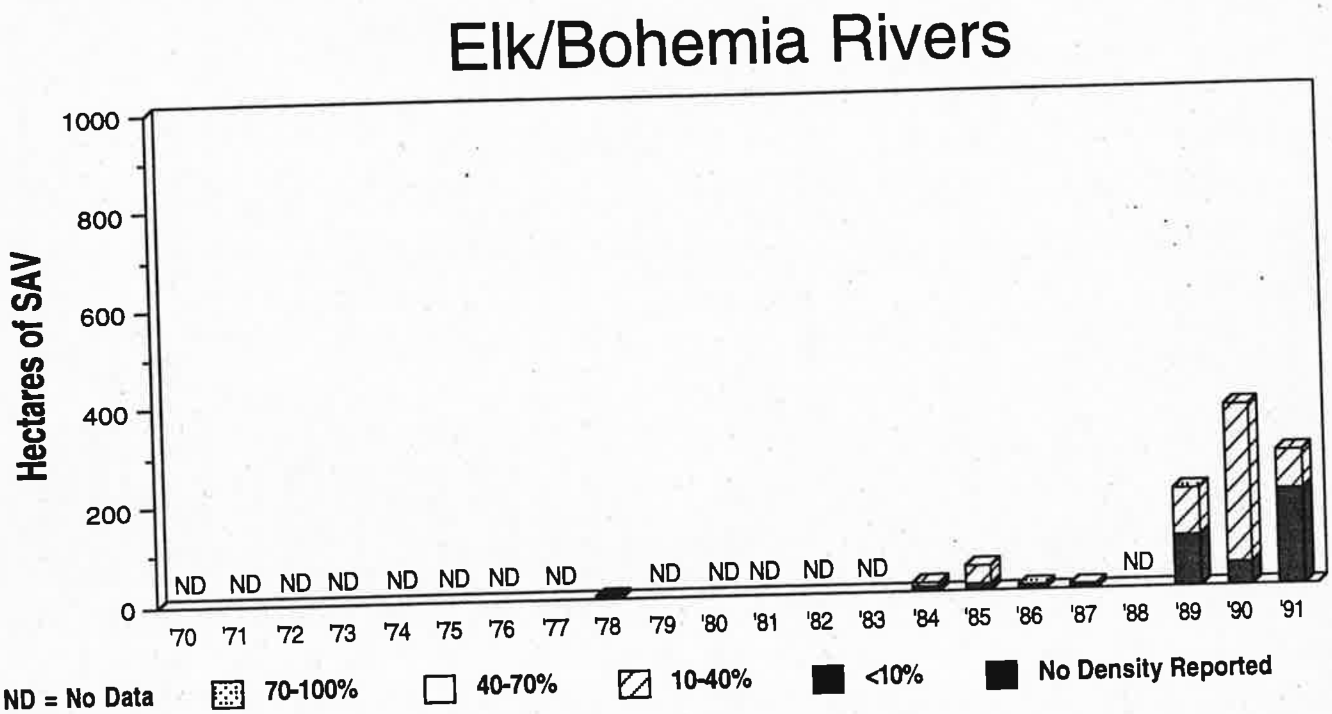


Figure 25. Hectares of SAV by density category for all years for which aerial survey data were available. For CBP Segment ET2 (Elk/Bohemia Rivers), the Tier I SAV restoration goal is 467 hectares.
Sources: Anderson and Macomber, 1980; Batiuk et al., 1992; Orth et al., 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Nowak, 1990.

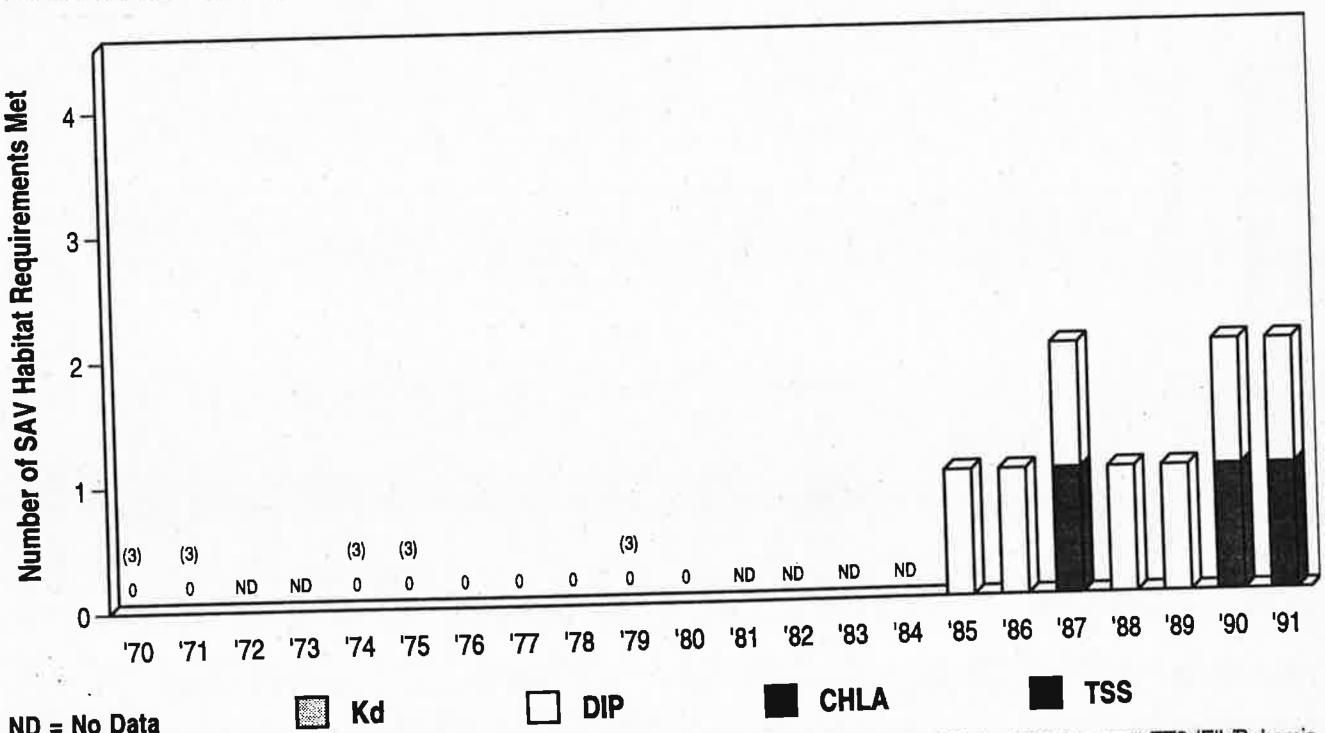


Figure 26. The number of SAV habitat requirements met over the SAV growing season from 1970 to 1991 for CBP Segment ET2 (Elk/Bohemia Rivers). No SAV habitat requirements met = 0; no water quality data available = ND. Sufficient data for the following parameters were not available to calculate growing season medians: Kd (1971-1975, 1981-1984); TSS (1972, 1973, 1981-1984); CHLA (1972, 1973, 1981-1984); and DIP (1970, 1972, 1973, 1979, 1981-1984). Numbers of SAV habitat requirements with growing season medians are shown above bars when some values were missing.
Sources: Chesapeake Bay Program, 1993a and 1993b.

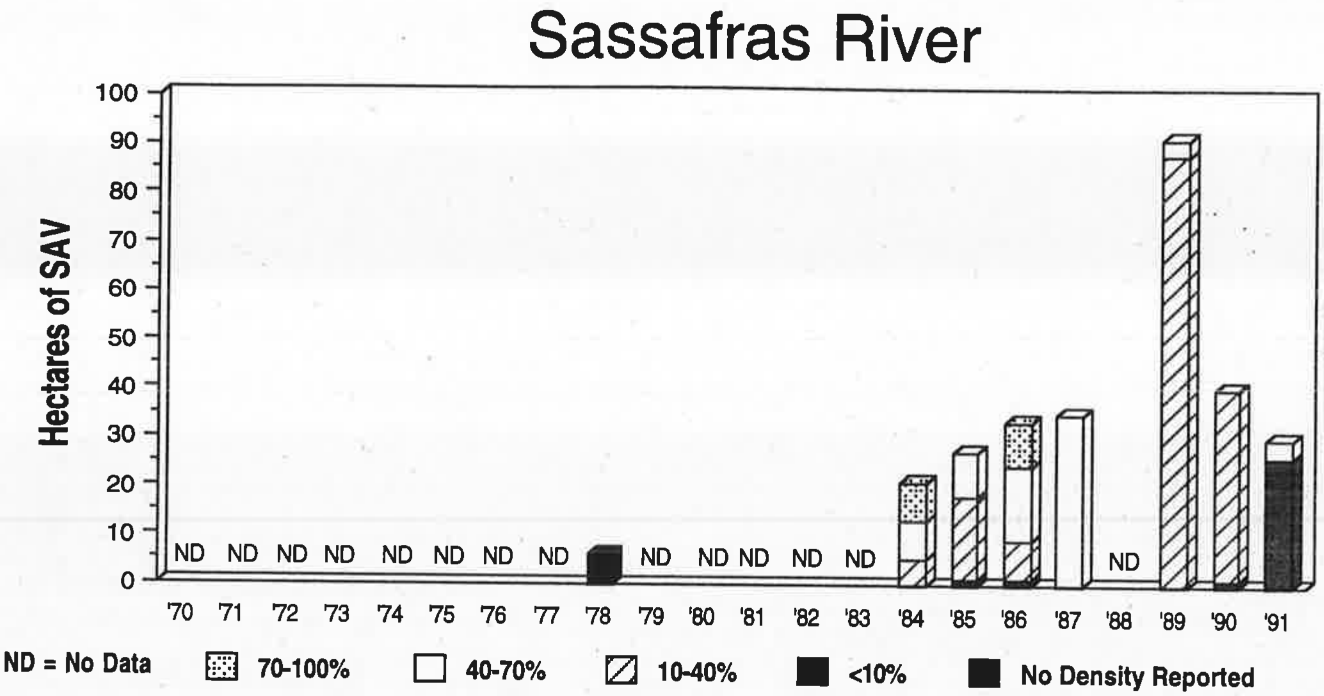


Figure 27. Hectares of SAV by density category for all years for which aerial survey data were available. For CBP Segment ET3 (Sassafras River), the Tier I SAV restoration goal is 167 hectares.
Sources: Anderson and Macomber, 1980; Batiuk et al., 1992; Orth et al., 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Nowak, 1990.

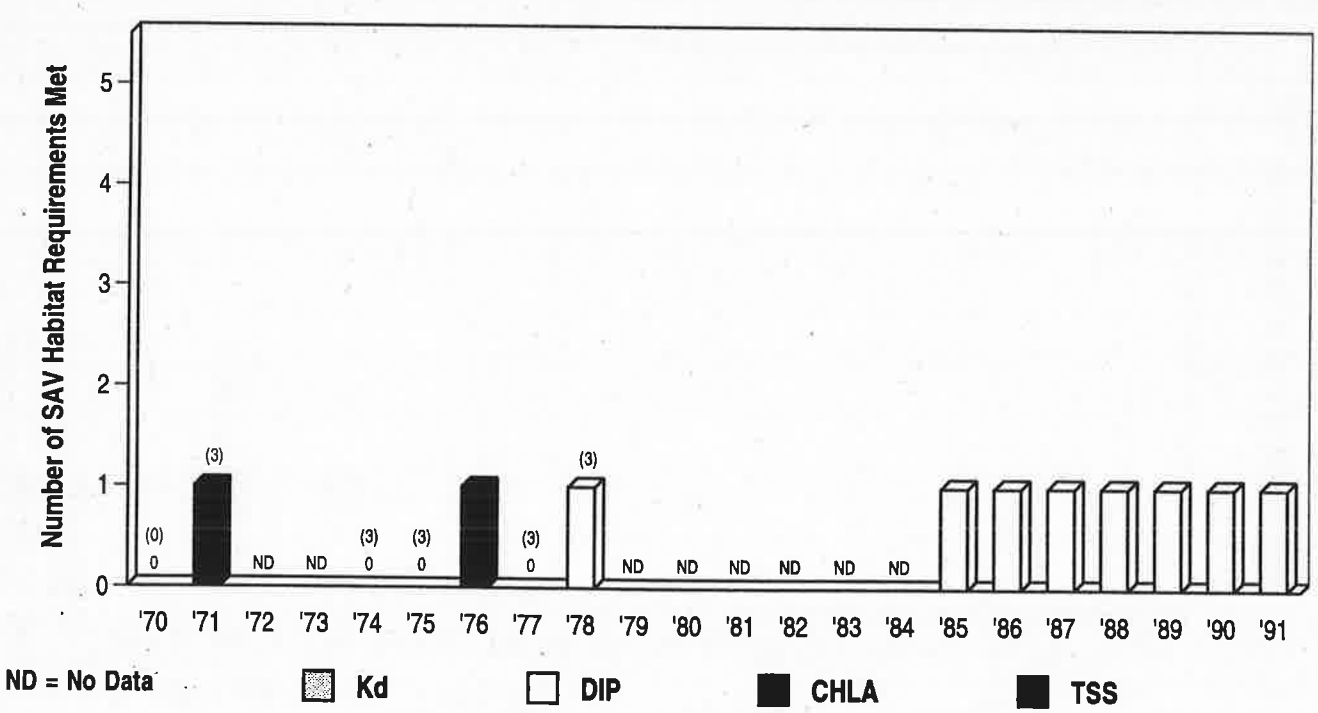


Figure 28. The number of SAV habitat requirements met over the SAV growing season from 1970 to 1991 for CBP Segment ET3 (Sassafras River). No SAV habitat requirements met = 0; no water quality data available = ND. Sufficient data for the following parameters were not available to calculate growing season medians: Kd (1971-1975, 1977-1984); TSS (1972, 1973, 1979-1984); CHLA (1972, 1973, 1979-1984); and DIP (1970, 1972, 1973, 1979-1984). Numbers of SAV habitat requirements with growing season medians are shown above bars when some values were missing.
Sources: Chesapeake Bay Program, 1993a and 1993b.

pectinatus, Z. palustris, E. canadensis, C. demersum, R. maritima, H. dubia, Najas spp., *H. verticillata,* and *P. crispus*.

Since 1984, Stan Kollar, Harford Community College, has transplanted SAV (primarily *V. americana*) into the Elk and Sassafras rivers (Kollar, 1985, 1986, 1987, and 1988). The most successful sites were at Elk Neck at the mouth of the Elk River, and below Ordinary Point along the north shore of the Sassafras River (with the exception of two sites adjacent to Betterton). Sites at the mouth of the Sassafras River had SAV beds of naturally occurring *M. spicatum* and *P. crispus*. Repeated transplant experiments above Ordinary Point were never successful. Transplanted plots failed in 1989 after two years of successful growth, although the surrounding natural vegetation survived with no apparent explanation. At Elk Neck, plots were surrounded by extensive SAV beds of naturally occurring *M. spicatum*. As in the Susquehanna Flats area, water quality at the successful transplant sites was characterized by lower levels of turbidity and lower concentrations of total suspended solids, chlorophyll *a*, and dissolved inorganic phosphorus compared to the unsuccessful transplant sites (Batiuk et al., 1992).

Water quality conditions in the Northeast, Elk, Bohemia, and Sassafras rivers have been unsuitable for SAV survival over the 1970 to 1991 data record, consistently meeting only the dissolved inorganic phosphorus habitat requirement since 1985 (Figures 24, 26, and 28, respectively). Documented year-to-year fluctuations in SAV distribution, as well as low overall distribution, reflect these unsuitable water quality conditions.

Because SAV abundance is very low or absent in the Northeast River, achievement of the Tier I restoration goal and the Tier III restoration target has also remained low (generally zero percent) (Table 10). Achievement of the Tier I restoration goal and the Tier III restoration target for both the Elk and Bohemia rivers had reached 58 percent and

Northeast River

Year	Hectares of SAV by Density Category				Segment Total	% of Tier I Restoration Goal	% of Tier III Restoration Goal
	<10%	10-40%	40-70%	70-100%			
'70	-	-	-	-	-	-	-
'71	-	-	-	-	-	-	-
'72	-	-	-	-	-	-	-
'73	-	-	-	-	-	-	-
'74	-	-	-	-	-	-	-
'75	-	-	-	-	-	-	-
'76	-	-	-	-	-	-	-
'77	-	-	-	-	-	-	-
'78	-	-	-	-	5	71%	<1%
'79	-	-	-	-	-		-
'80	-	-	-	-	-	-	-
'81	-	-	-	-	-	-	-
'82	-	-	-	-	-	-	-
'83	-	-	-	-	-	-	-
'84	0	0	0	0	0	0%	0%
'85	0	0	0	0	0	0%	0%
'86	0	<1	<1	<1	3	43%	<1%
'87	0	0	0	<1	<1	14%	<1%
'88	-	-	-	-	-	-	-
'89	0	0	0	0	0	0%	0%
'90	0	0	0	0	0	0%	0%
'91	0	0	0	0	0	0%	0%

Table 10. Hectares of SAV by density category and percentage of Tier I SAV restoration goal (seven hectares) and Tier III SAV restoration target (1,208 hectares) are listed for 1970 to 1991 for CBP Segment ET1 (Northeast River). Sources: Anderson and Macomber, 1980; Batiuk et al., 1992; Orth et al., 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Nowak, 1990.

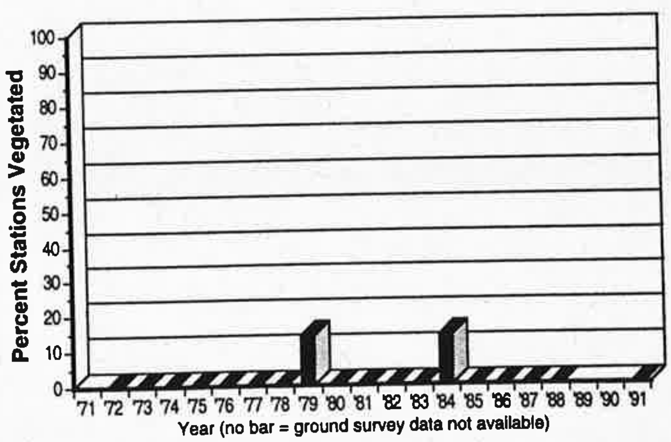


Figure 29. Percentage of Maryland Department of Natural Resources SAV Ground Survey Program stations where SAV was observed for CBP Segment ET1 (Northeast River). Ground Survey data were not available for 1971, 1989, and 1990.
Source: Chesapeake Bay Program, unpublished data c.

Elk/Bohemia Rivers

Year	Hectares of SAV by Density Category <10%	10-40%	40-70%	70-100%	Segment Total	% of Tier I Restoration Goal	% of Tier III Restoration Goal
'70	-	-	-	-	-	-	-
'71	-	-	-	-	-	-	-
'72	-	-	-	-	-	-	-
'73	-	-	-	-	-	-	-
'74	-	-	-	-	-	-	-
'75	-	-	-	-	-	-	-
'76	-	-	-	-	-	-	-
'77	-	-	-	-	-	-	-
'78	-	-	-	-	1	<1%	<1%
'79	-	-	-	-	-	-	-
'80	-	-	-	-	-	-	-
'81	-	-	-	-	-	-	-
'82	-	-	-	-	-	-	-
'83	-	-	-	-	-	-	-
'84	8	6	0	0	14	3%	<1%
'85	10	36	<1	0	47	10%	2%
'86	<1	3	2	2	8	2%	<1%
'87	0	3	5	0	8	2%	<1%
'88	-	-	-	-	-	-	-
'89	102	95	0	1	198	42%	7%
'90	42	322	0	0	364	78%	12%
'91	190	80	0	0	271	58%	9%

Table 11. Hectares of SAV by density category and percentage of Tier I SAV restoration goal (467 hectares) and Tier III SAV restoration target (2,967 hectares) are listed for 1970 to 1991 for CBP Segment ET2 (Elk/Bohemia Rivers). Sources: Anderson and Macomber, 1980; Batiuk et al., 1992; Orth et al., 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Nowak, 1990.

9 percent, respectively, in 1991, up from 1 percent achievement for both tiers in 1978 (Table 11). In the Sassafras River, SAV abundance was 18 percent and 2 percent of the Tier I restoration goal and the Tier III restoration target, respectively, in 1991 (Table 12).

Sassafras River

Year	Hectares of SAV by Density Category <10%	10-40%	40-70%	70-100%	Segment Total	% of Tier I Restoration Goal	% of Tier III Restoration Goal
'70	-	-	-	-	-	-	-
'71	-	-	-	-	-	-	-
'72	-	-	-	-	-	-	-
'73	-	-	-	-	-	-	-
'74	-	-	-	-	-	-	-
'75	-	-	-	-	-	-	-
'76	-	-	-	-	-	-	-
'77	-	-	-	-	-	-	-
'78	-	-	-	-	6	4%	<1%
'79	-	-	-	-	-	-	-
'80	-	-	-	-	-	-	-
'81	-	-	-	-	-	-	-
'82	-	-	-	-	-	-	-
'83	-	-	-	-	-	-	-
'84	0	5	8	7	20	13%	1%
'85	1	17	9	0	27	16%	2%
'86	<1	8	15	9	33	20%	2%
'87	0	0	35	0	35	21%	2%
'88	-	-	-	-	-	-	-
'89	0	88	3	0	91	55%	6%
'90	<1	39	0	0	40	23%	3%
'91	26	<1	4	0	31	19%	2%

Table 12. Hectares of SAV by density category and percentage of Tier I SAV restoration goal (167 hectares) and Tier III SAV restoration target (1,515 hectares) are listed for 1970 to 1991 for CBP Segment ET3 (Sassafras River). Sources: Anderson and Macomber, 1980; Batiuk et al., 1992; Orth et al., 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Nowak, 1990.

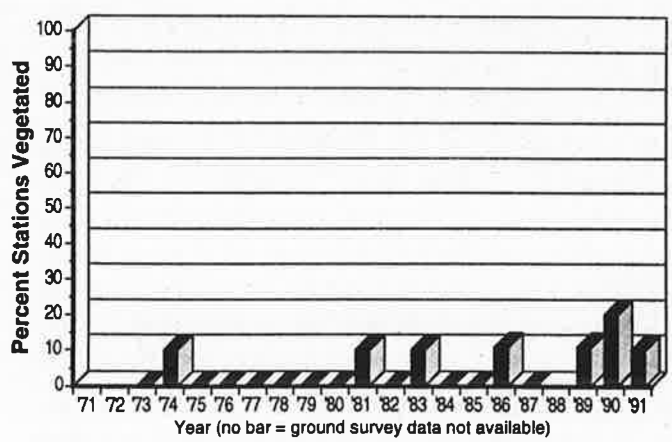
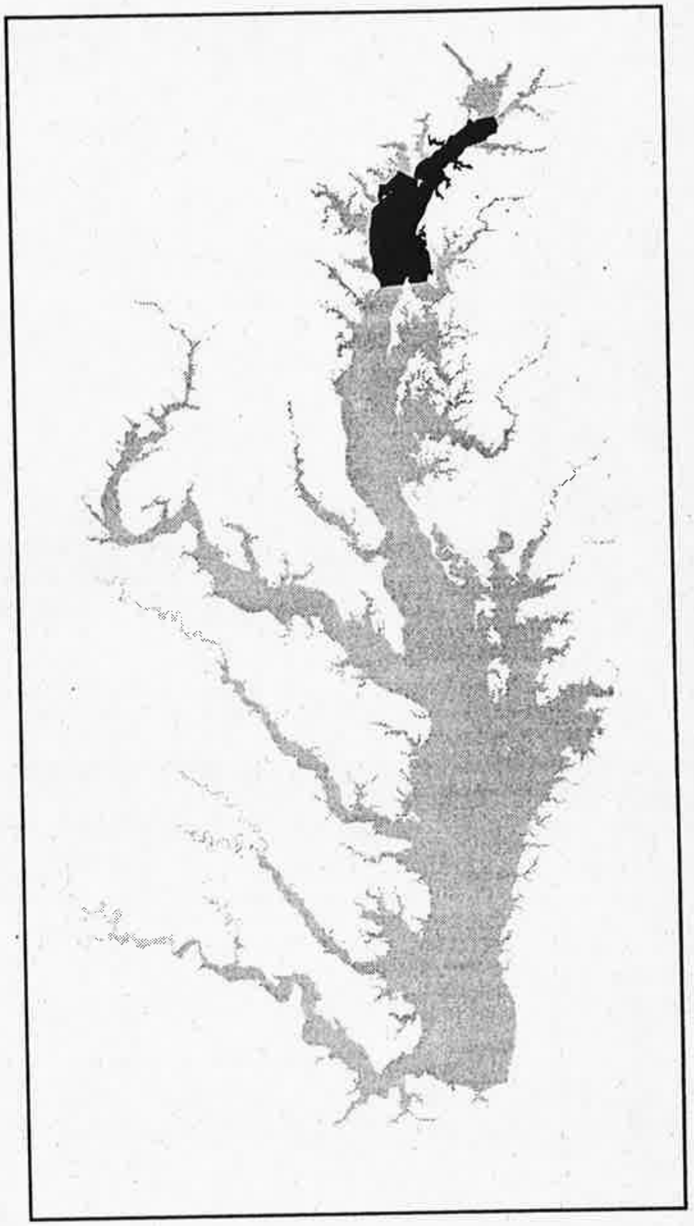


Figure 30. Percentage of Maryland Department of Natural Resources SAV Ground Survey Program stations sampled where SAV for CBP Segment (ET3) (Sassafras River). Ground survey data were not available for 1971, 1972, and 1988.
Source: Chesapeake Bay Program, unpublished data c.

Upper Chesapeake Bay and Upper Central Chesapeake Bay



The Upper Chesapeake Bay and Upper Central Chesapeake Bay segments include a large region of the upper mainstem of the Bay, from below the Susquehanna Flats south to the Chesapeake Bay Bridge. Included within these segments is the large shallow embayment west of Eastern Neck and Eastern Neck Island and some of the smaller tributaries entering the mainstem Bay from Pond Creek, from above the mouth of the Sassafras River south to just below Swan Point.

Submerged aquatic vegetation has been mapped continuously in both segments over the course of the aerial survey, although abundance levels have fluctuated. Most of the SAV has been reported from the Eastern Shore side of both segments. Submerged aquatic vegetation beds have been mapped in Pond, Stillpond, Churn, Worton, Huntington, and Swan creeks. Since 1987, however, the overall abundance has declined. Upper Chesapeake Bay SAV has fluctuated annually from a low of 16 hectares in 1978 to a high of 67 hectares in 1987, dropping to 29 hectares by 1991 (Figure 31, Table 13).

The largest concentrations of SAV and the most diverse SAV beds in the Upper Central Chesapeake Bay segment have historically been in the shallow embayment between Eastern Neck and Eastern Neck Island. In 1978, Anderson and Macomber (1980) listed seven species (*M. spicatum*, *P. pectinatus*, *V. americana*, *Z. palustris*, *E. canadensis*, *P. perfoliatus*, and *R. maritima*) in a large continuous bed along Eastern Neck Island and Eastern Neck (578 hectares). Only 385 hectares were reported in 1984, increasing to 446 in 1985, but declining in overall distribution and abundance since 1985. By 1991, only small isolated beds totaling 22 hectares were present (Figure 33, Table 14).

The Maryland Department of Natural Resources ground survey reported no vegetated stations in the Upper Chesapeake Bay segment. In the Upper Central Chesapeake Bay segment, they reported SAV during 11 of the past 21 years, with the percentage of vegetated stations ranging from 0 to 22 percent (Figure 35).

Numerous species have been recorded in both segments. Diversity has been greatest in the Eastern Neck embayment. *Ruppia maritima* was the most commonly reported species in all years, es-

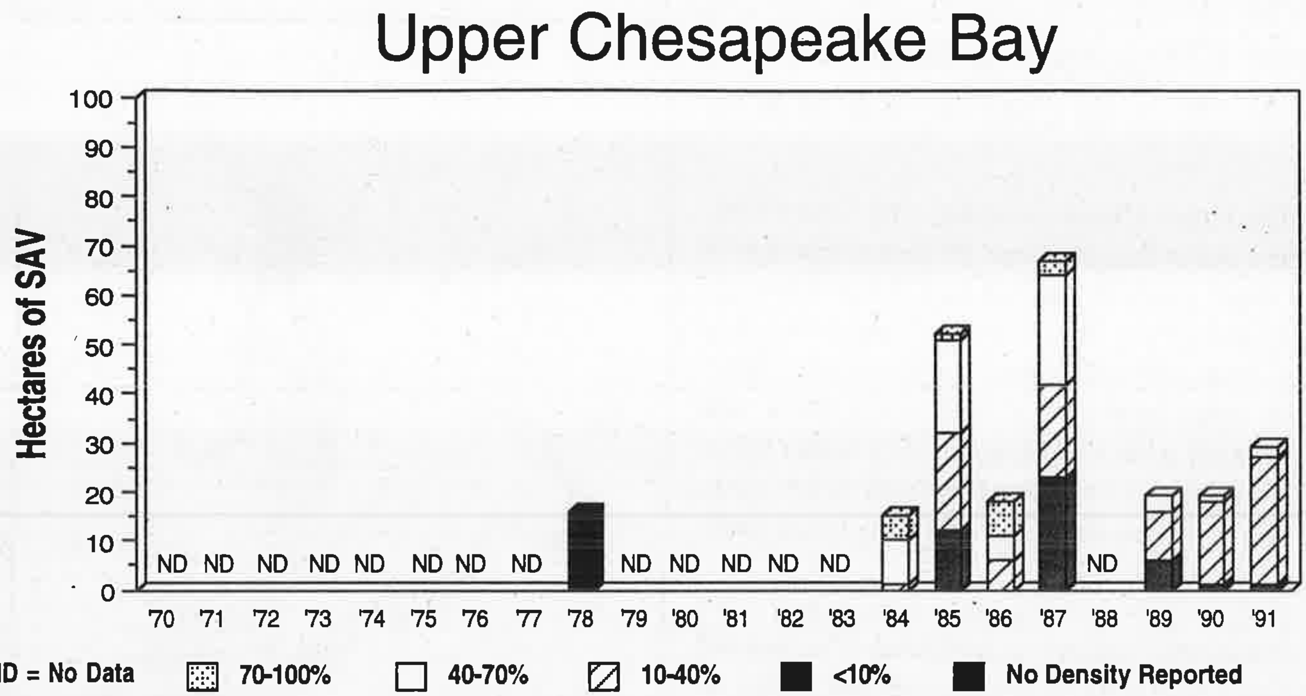


Figure 31. Hectares of SAV by density category for all years for which aerial survey data were available. For CBP Segment CB2 (Upper Chesapeake Bay), the Tier I SAV restoration goal is 139 hectares.
Sources: Anderson and Macomber, 1980; Batiuk et al., 1992; Orth et al., 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Nowak, 1990.

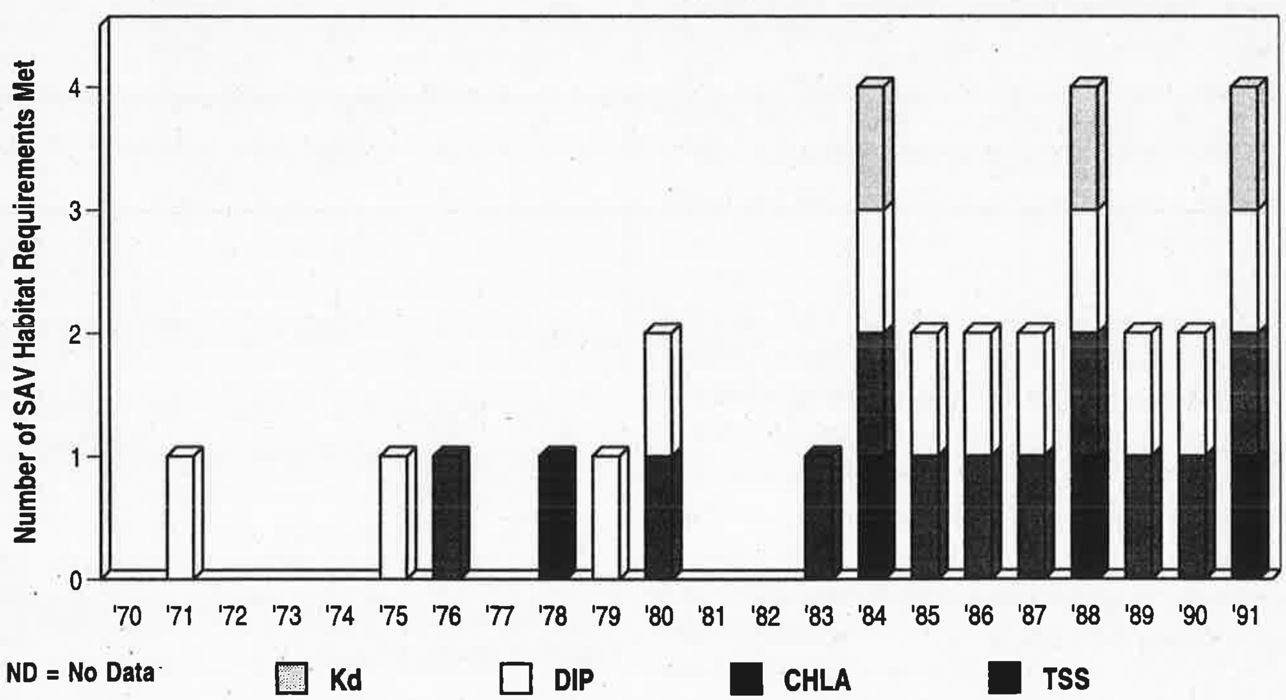


Figure 32. The number of SAV habitat requirements met over the SAV growing season from 1970 to 1991 for CBP Segment CB2 (Upper Chesapeake Bay). No SAV habitat requirements met = 0; no water quality data available = ND. Sufficient data for the following parameters were not available to calculate growing season medians: Kd (1970-1975); TSS (1971-1976); CHLA (1972-1974); and DIP (1973). Numbers of SAV habitat requirements with growing season medians are shown above bars when some values were missing.
Sources: Chesapeake Bay Program, 1993a and 1993b.

Upper Chesapeake Bay

Year	Hectares of SAV by Density Category <10%	10-40%	40-70%	70-100%	Segment Total	% of Tier I Restoration Goal	% of Tier III Restoration Goal
'70	-	-	-	-	-	-	-
'71	-	-	-	-	-	-	-
'72	-	-	-	-	-	-	-
'73	-	-	-	-	-	-	-
'74	-	-	-	-	-	-	-
'75	-	-	-	-	-	-	-
'76	-	-	-	-	-	-	-
'77	-	-	-	-	-	-	-
'78	-	-	-	-	16	12%	<1%
'79	-	-	-	-	-	-	-
'80	-	-	-	-	-	-	-
'81	-	-	-	-	-	-	-
'82	-	-	-	-	-	-	-
'83	-	-	-	-	-	-	-
'84	0	<1	9	6	15	11%	<1%
'85	12	20	19	<1	52	38%	2%
'86	0	6	5	7	18	13%	<1%
'87	23	19	22	3	67	49%	2%
'88	-	-	-	-	-	-	-
'89	6	10	3	0	19	14%	<1%
'90	1	17	<1	0	19	14%	<1%
'91	1	26	2	0	29	21%	1%

Table 13. Hectares of SAV by density category and percentage of Tier I SAV restoration goal (139 hectares) and Tier III SAV restoration target (3,086 hectares) are listed for 1970 to 1991 for CBP Segment CB2 (Upper Chesapeake Bay).
Sources: Anderson and Macomber, 1980; Batiuk et al., 1992; Orth et al., 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Nowak, 1990.

pecially in the embayment. *Myriophyllum spicatum* was also cited frequently, primarily in the above-mentioned creeks. Other species found were *P. perfoliatus*, *V. americana*, *P. pectinatus*, *Z. palustris*, and *E. canadensis*.

A 1970 survey found extensive beds of four species (*Najas* spp., *R. maritima*, *P. pectinatus*, and *Z. palustris*) along the western shore of Eastern Neck Island as well as pockets of SAV on the eastern side (Stevenson and Confer, 1978). A subsequent survey in 1972 showed no SAV on the western side while pockets of SAV remained on the eastern side.

Water quality conditions in the Upper Chesapeake Bay segment have fluctuated from unsuitable to fully suitable for SAV survival (Figure 32). Prior to 1984, one or less SAV habitat requirements were met, with the exception of 1980 when two SAV habitat requirements were met. From 1984 to 1991, all four SAV habitat requirements were met in 1984, 1988, and 1991, with only the chlorophyll *a* and dissolved inorganic phosphorus requirements met during the other five years.

In the Upper Central Chesapeake Bay segment, water quality conditions have never met all five SAV habitat requirements during a single growing season from 1970 to 1991; only during five years since 1983 were at least four of the five SAV habitat requirements achieved (Figure 34). Since 1983, the dissolved inorganic nitrogen and light attenuation coefficient habitat requirements were usually not met.

Achievement of the Tier I restoration goal for the Upper Chesapeake Bay segment has fluctuated from a high of 49 percent in 1987 to a low of 11 percent in 1984, reaching only 21 percent in 1991 (Table 13). Achievement of the Tier III restoration target has remained at 2 percent or less. Achievement of the Tier I restoration goal and the Tier III restoration target in the Upper Central Chesapeake Bay segment was highest in 1978 (70 percent and 17 percent, respectively) and declined to 3 percent and 1 percent, respectively, by 1991 (Table 14).

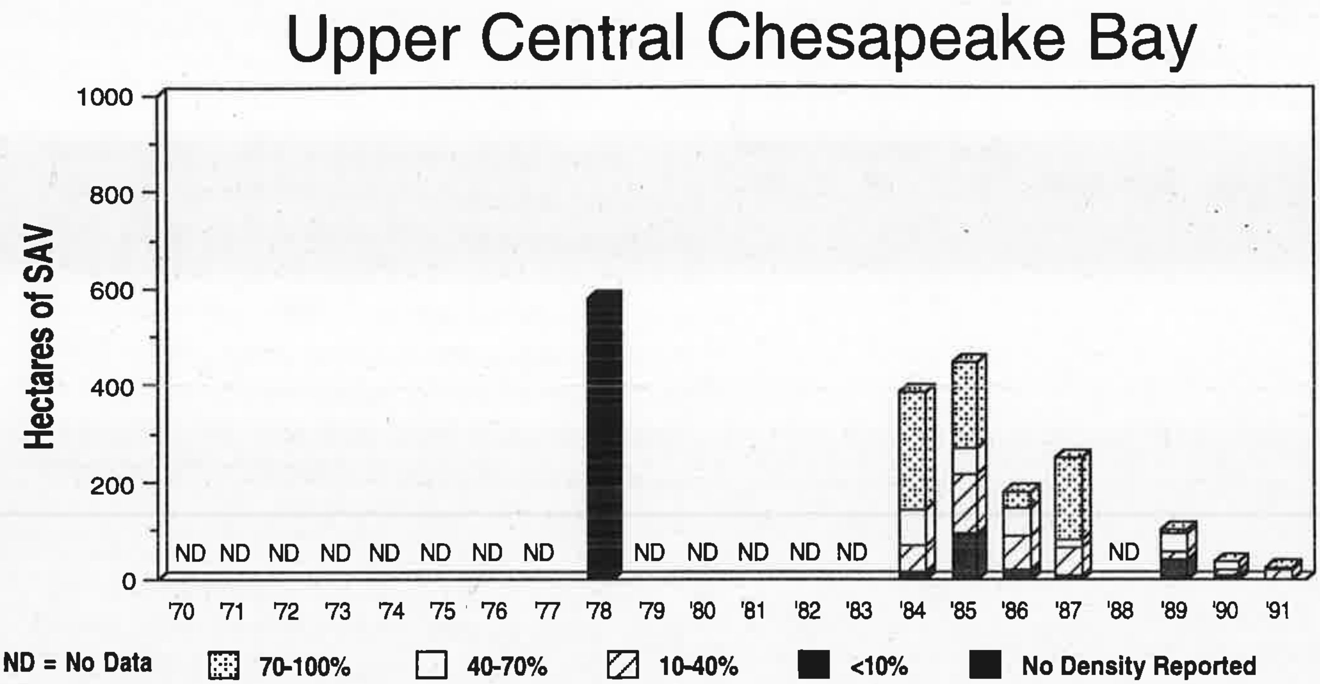


Figure 33. Hectares of SAV by density category for all years for which aerial survey data were available. For CBP Segment CB3 (Upper Central Chesapeake Bay), the Tier I SAV restoration goal is 817 hectares.
Sources: Anderson and Macomber, 1980; Batiuk et al., 1992; Orth et al. 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Nowak, 1990.

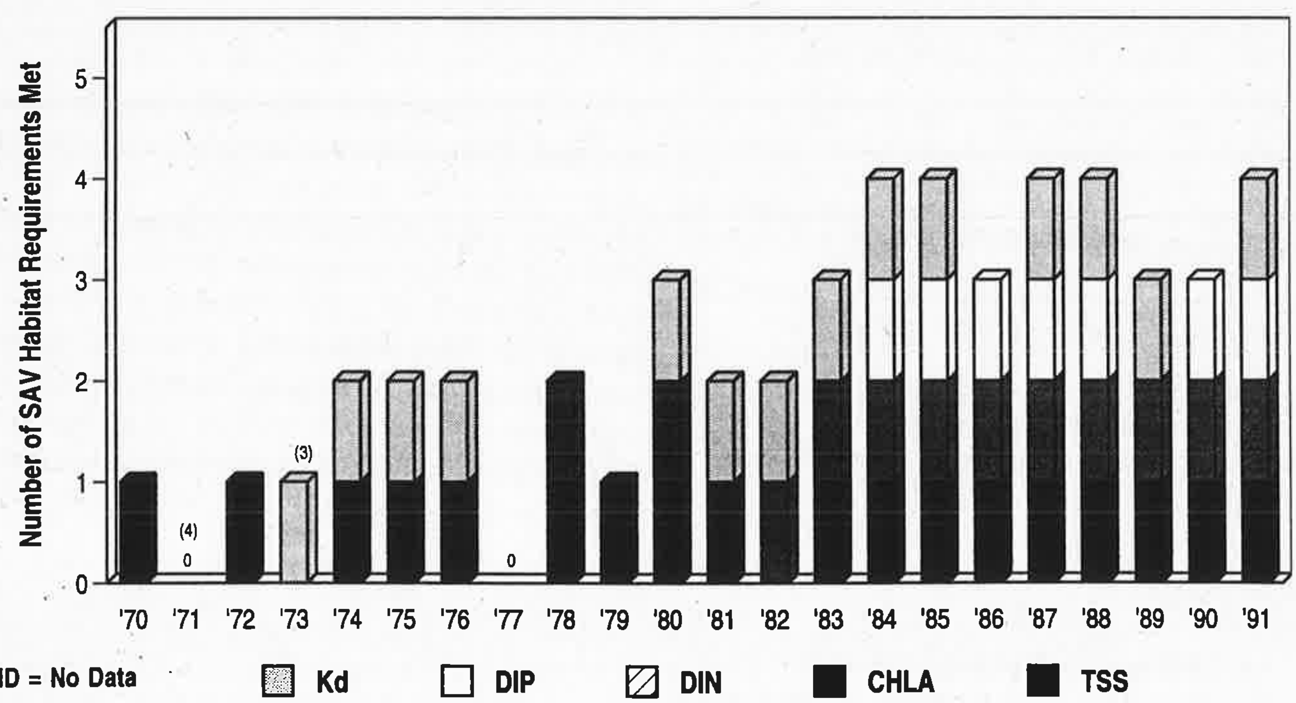


Figure 34. The number of SAV habitat requirements met over the SAV growing season from 1970 to 1991 for CBP Segment CB3 (Upper Central Chesapeake Bay). No SAV habitat requirements met = 0; no water quality data available = ND. Sufficient data for the following parameters were not available to calculate growing season medians: TSS (1971, 1973) and DIN (1973). Numbers of SAV habitat requirements with growing season medians are shown above bars when some values were missing.
Sources: Chesapeake Bay Program, 1993a and 1993b.

Upper Central Chesapeake Bay

Year	Hectares of SAV by Density Category <10%	10-40%	40-70%	70-100%	Segment Total	% of Tier I Restoration Goal	% of Tier III Restoration Goal
'70	-	-	-	-	-	-	-
'71	-	-	-	-	-	-	-
'72	-	-	-	-	-	-	-
'73	-	-	-	-	-	-	-
'74	-	-	-	-	-	-	-
'75	-	-	-	-	-	-	-
'76	-	-	-	-	-	-	-
'77	-	-	-	-	-	-	-
'78	-	-	-	-	577	70%	17%
'79	-	-	-	-	-	-	-
'80	-	-	-	-	-	-	-
'81	-	-	-	-	-	-	-
'82	-	-	-	-	-	-	-
'83	-	-	-	-	-	-	-
'84	16	52	73	244	385	47%	11%
'85	95	123	54	174	446	54%	13%
'86	18	69	58	33	178	22%	5%
'87	5	59	18	169	251	31%	7%
'88	-	-	-	-	-	-	-
'89	38	18	35	8	99	12%	3%
'90	8	10	17	<1	36	4%	1%
'91	0	17	2	3	22	3%	1%

Table 14. Hectares of SAV by density category and percentage of Tier I (817 hectares) SAV restoration goal and Tier III (3,426 hectares) SAV restoration target are listed for 1970 to 1991 for CBP Segment CB3 (Upper Central Chesapeake Bay).
Sources: Anderson and Macomber, 1980; Batiuk et al., 1992; Orth et al., 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Nowak, 1990.

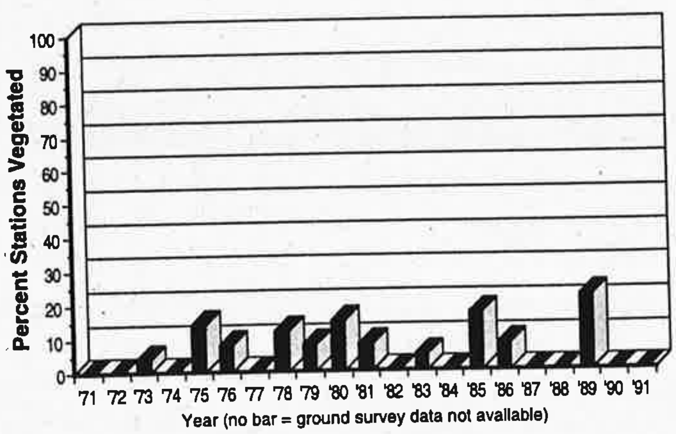


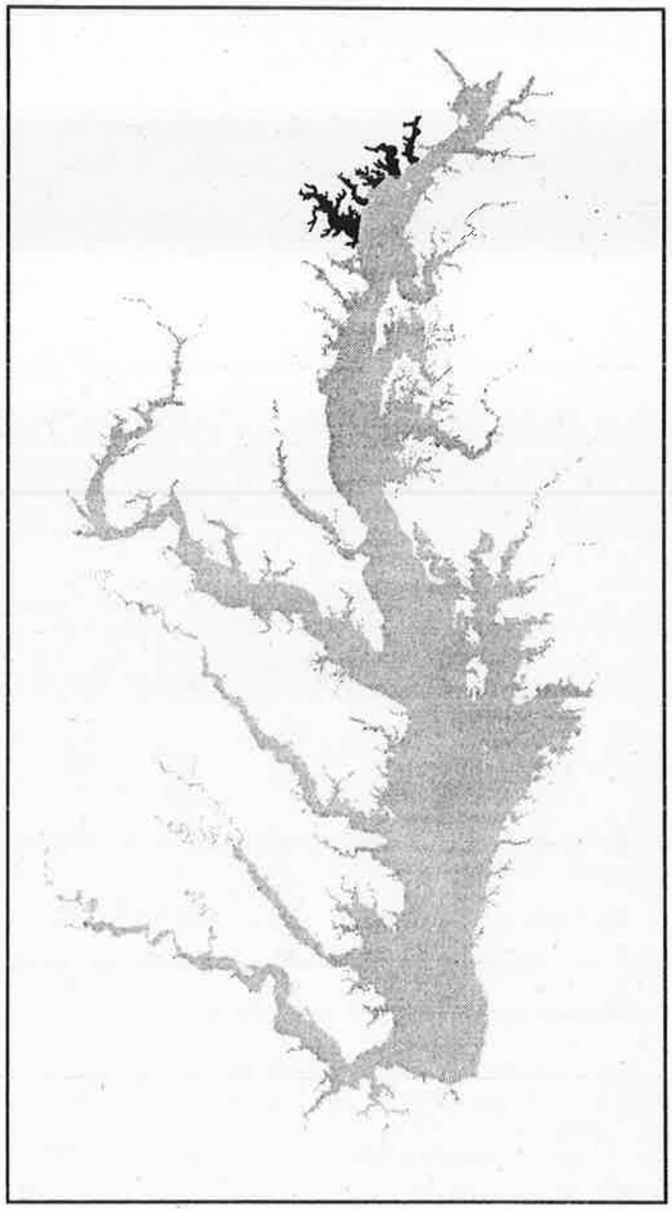
Figure 35. Percentage of Maryland Department of Natural Resources SAV Ground Survey Program stations sampled where SAV was observed for CBP Segment CB3 (Upper Central Chesapeake Bay).
Source: Chesapeake Bay Program, unpublished data c.

Bush, Gunpowder, Middle, Back, and Patapsco Rivers

These rivers constitute five of the ten tributaries along the Bay's upper western shore. Records from historical ground surveys documented abundant SAV and numerous species in these tidal rivers in the late 1950s and early 1960s (Stevenson and Confer, 1978). The Bush River had 15 hectares or less reported for four years of the aerial survey record, with no SAV reported in 1986 or from 1989 to 1991 (Figure 36, Table 15). From a high of 198 hectares in 1978, SAV in the Gunpowder River declined to zero hectares in 1986, then increased to 81 hectares in 1991 (Figure 38, Table 16). The Gunpowder River had SAV present at higher distribution levels more consistently across the years of the survey than the other four tributaries, with SAV beds located principally in Saltpeter, Seneca, and Dundee creeks.

Submerged aquatic vegetation was more abundant in the Middle River in 1978 (114 hectares) than in subsequent years when only eight hectares were reported by the 1991 aerial survey (Figure 40, Table 17). Since the baywide aerial survey began in 1978, no SAV has been mapped from Back River (Figure 42, Table 18). A small amount of SAV was reported in the Patapsco River in 1978 (52 hectares), primarily at the river mouth (Figure 44, Table 19). *Potamogeton perfoliatus* and *V. americana* were found in these beds (Anderson and Macomber, 1980). After 1978, the aerial survey recorded no SAV in the Patapsco River.

This region is under one of the most restricted air zones in the Bay (Aberdeen Proving Grounds), making it even more difficult to acquire good photography. These areas have had highly variable abundances of SAV as reported from the Maryland Department of Natural Resources ground survey, indicating that the aerial survey results are still a good approximation of current abundances.



The Maryland Department of Natural Resources ground survey found no SAV in the Bush River. Although the Bush River had abundant SAV in the mid-1960s, especially *M. spicatum*, much of the SAV was gone by the late 1960s. The Maryland ground survey found SAV sporadically abundant in the Gunpowder and Middle rivers. Ground survey crews most frequently reported *M. spicatum* and *V. americana*. Submerged aquatic vegetation was reported in seven of the 15 years surveyed in the Gunpowder River, with the percentage of vegetated stations ranging from 25 to 50 percent (Figure

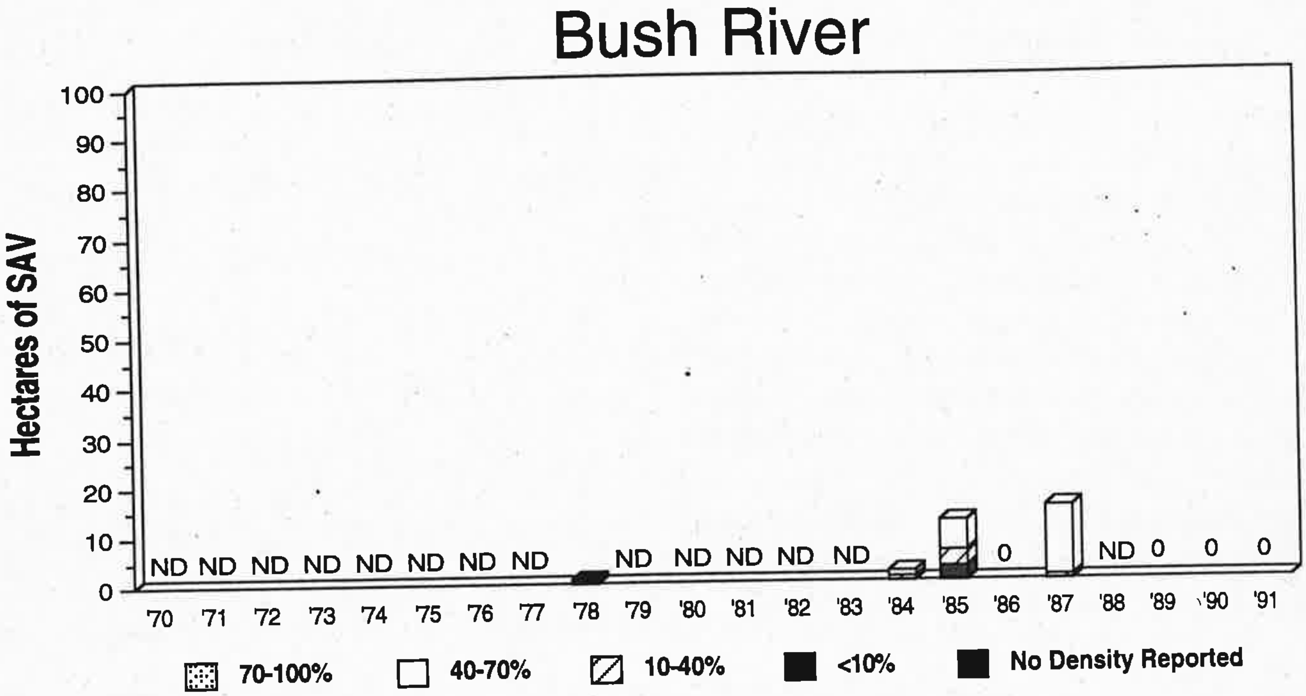


Figure 36. Hectares of SAV by density category for all years for which aerial survey data were available. For CBP Segment WT1 (Bush River), the Tier 1 SAV restoration target is 24 hectares.
Sources: Anderson and Macomber, 1980; Batiuk et al., 1992; Orth et al., 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Nowak, 1990.

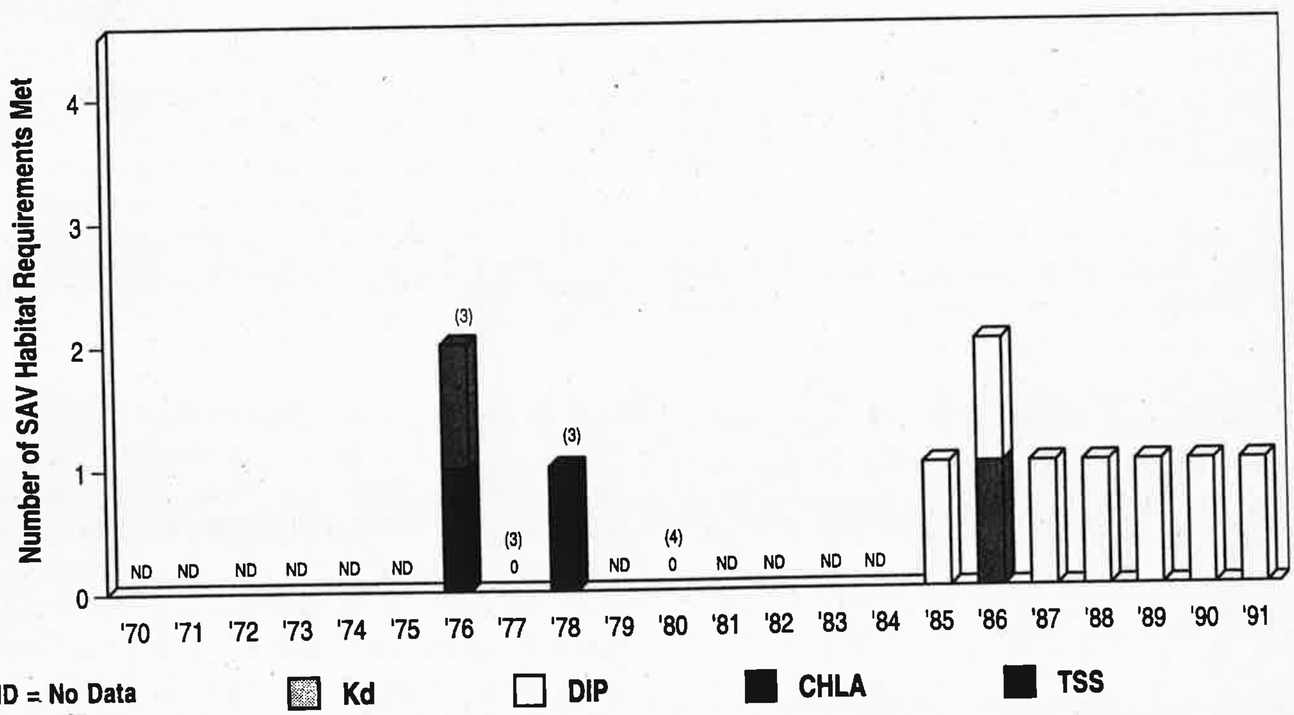


Figure 37. The number of SAV habitat requirements met over the SAV growing season from 1970 to 1991 for CBP Segment WT1 (Bush River). No SAV habitat requirements met = 0; no water quality data available = ND. Sufficient data for the following parameters were not available to calculate growing season medians: Kd (1970-1979, 1981-1984); TSS (1970-1975, 1979, 1981-1984); CHLA (1970-1975, 1979, 1981-1984); and DIP (1970-1975, 1979, 1981-1984). Numbers of SAV habitat requirements with growing season medians are shown above bars when some values were missing.
Sources: Chesapeake Bay Program, 1993a and 1993b.

46). In the Middle River, SAV was reported in 13 of the 21 years surveyed, with the percentage of stations ranging from 14 to 57 percent (Figure 47). Submerged aquatic vegetation was most frequently observed in the same areas indicated by the aerial survey—Dundee, Saltpeter, and Seneca creeks. Submerged aquatic vegetation was more abundant in these two rivers over the last 20 years than in the Back and Patapsco rivers. The Maryland Department of Natural Resources ground survey in Back River has reported no SAV during the 1971 to 1991 data record. In the Patapsco River, SAV (*V. americana* and two species of *Potamogeton*) had been reported until 1983 (14 percent or less of the stations vegetated), but was absent thereafter (Figure 48).

The 1990 U.S. Fish and Wildlife Service clam survey found SAV at only 10.8 percent of 37 sites visited in the Gunpowder River (Jorde et al., 1991). *Vallisneria americana* was the only species reported.

Ground surveys coupled with the aerial survey found several SAV species in the Gunpowder (Saltpeter, Seneca, and Dundee creeks) and Middle rivers, with *M. spicatum* and *V. americana* most commonly cited. *Najas guadalupensis*, *E. canadensis*, *C. demersum*, *P. pectinatus*, and *R. maritima* were reported less frequently. These surveys often reported SAV from regions not visible on aerial photographs. It is likely that these beds were narrow, fringing the shoreline, or very patchy and did not produce a distinct image on the aerial photographs at a scale of 1:24,000.

Documented water quality conditions in all five tributaries have been unsuitable for SAV survival for most years since 1970. Only the dissolved inorganic phosphorus habitat requirement has been consistently met since 1984 in the Bush River, with two or less SAV habitat requirements met in any one year (Figure 37).

In the Gunpowder River, all four SAV habitat requirements were met only in 1985 (probably due to the availability of only two data points from which to derive a growing season median; see Appendix B) (Figure 39). Since 1987, only the dissolved inorganic phosphorus habitat requirement has been achieved. Similar to the Gunpowder River, all four SAV habitat requirements were met in Middle River only in 1984 (again, probably due to the availability of only three data points from which to derive a growing season median; see Appendix B) (Figure 41). Since 1984, only the dissolved inorganic phosphorus habitat requirement has been met consistently, although the total suspended solids requirement was also met in five of seven years. Only one SAV habitat requirement

Bush River

Year	Hectares of SAV by Density Category: <10%	10-40%	40-70%	70-100%	Segment Total	% of Tier I Restoration Goal	% of Tier III Restoration Goal
'70	-	-	-	-	-	-	-
'71	-	-	-	-	-	-	-
'72	-	-	-	-	-	-	-
'73	-	-	-	-	-	-	-
'74	-	-	-	-	-	-	-
'75	-	-	-	-	-	-	-
'76	-	-	-	-	-	-	-
'77	-	-	-	-	-	-	-
'78	-	-	-	-	<1	4%	<1%
'79	-	-	-	-	-	-	-
'80	-	-	-	-	-	-	-
'81	-	-	-	-	-	-	-
'82	-	-	-	-	-	-	-
'83	-	-	-	-	-	-	-
'84	0	1	1	0	2	8%	<1%
'85	3	3	6	0	12	50%	<1%
'86	0	0	0	0	0	0%	0%
'87	0	<1	14	0	15	63%	<1%
'88	-	-	-	-	-	-	-
'89	0	0	0	0	0	0%	0%
'90	0	0	0	0	0	0%	0%
'91	0	0	0	0	0	0%	0%

Table 15. Hectares of SAV by density category and percentage of Tier I (24 hectares) SAV restoration goal and Tier III (1,836 hectares) SAV restoration target are listed for 1970 to 1991 for CBP Segment WT1 (Bush River). Sources: Anderson and Macomber, 1980; Batiuk et al., 1992; Orth et al., 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Nowak, 1990.

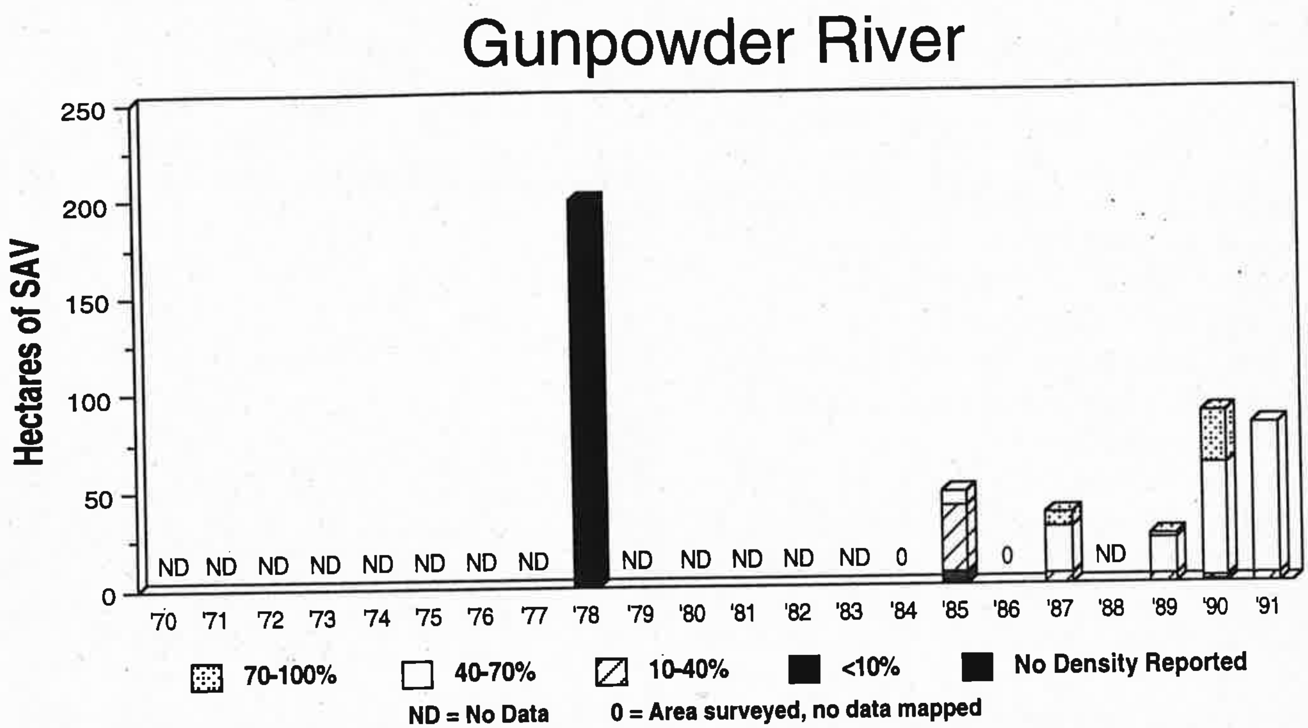


Figure 38. Hectares of SAV by density category for all years for which aerial survey data were available. For CBP Segment WT2 (Gunpowder River), the Tier I SAV restoration goal is 353 hectares.
Sources: Anderson and Macomber, 1980; Batiuk et al., 1992; Orth et al., 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Nowack, 1990.

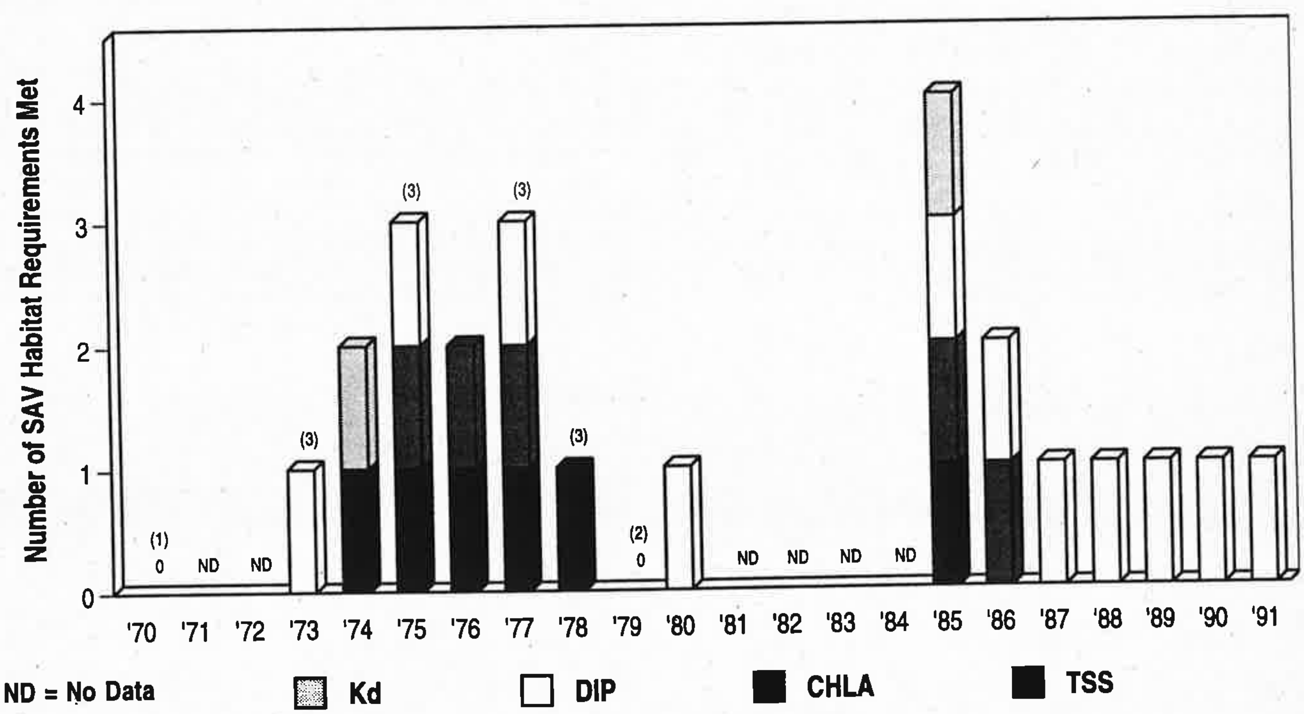


Figure 39. The number of SAV habitat requirements met over the SAV growing season from 1970 to 1991 for CBP Segment WT2 (Gunpowder River). No SAV habitat requirements met = 0; no water quality data available = ND. Sufficient data for the following parameters were not available to calculate growing season medians: Kd (1970-1975, 1977-1979, 1981-1984); TSS (1971, 1972, 1981-1984); CHLA (1970-1973, 1979, 1981-1984); and DIP (1970-1972, 1981-1984). Numbers of SAV habitat requirements with growing season medians are shown above bars when some values were missing.
Sources: Chesapeake Bay Program, 1993a and 1993b.

(or none) was met in any given year in Back River from 1970 to 1991 (Figure 43). Dissolved inorganic phosphorus was the only SAV habitat requirement achieved since 1985. With the exception of 1976, only two or fewer habitat requirements were achieved in the Patapsco River from 1970 to 1991 (Figure 45). Since 1988, the dissolved inorganic phosphorus habitat requirement has been consistently met; the total suspended solids habitat requirement has been met in six of the eight years from 1984 to 1992.

Achievement of the Tier I restoration goal and the Tier III restoration target has been minimal in these five tributary segments, especially since 1984, due to water quality unsuitable for SAV survival. With very low and fluctuating abundances of SAV, the percent achievement of the Tier I restoration goal has varied widely from year to year in the Bush, Gunpowder, and Middle rivers (Tables 15, 16, and 17).

Since 1978, there has been no measurable achievement of the Tier I restoration goal in the Back and Patapsco rivers (Tables 18, and 19). In all five rivers, achievement of the Tier III restoration targets has been generally below 5 percent and in most years under 1 percent.

Gunpowder River

	Hectares of SAV by Density Category						
Year	<10%	10-40%	40-70%	70-100%	Segment Total	% of Tier I Restoration Goal	% of Tier III Restoration Goal
'70	-	-	-	-	-	-	-
'71	-	-	-	-	-	-	-
'72	-	-	-	-	-	-	-
'73	-	-	-	-	-	-	-
'74	-	-	-	-	-	-	-
'75	-	-	-	-	-	-	-
'76	-	-	-	-	-	-	-
'77	-	-	-	-	-	-	-
'78	-	-	-	-	200	56%	6%
'79	-	-	-	-	-	-	-
'80	-	-	-	-	-	-	-
'81	-	-	-	-	-	-	-
'82	-	-	-	-	-	-	-
'83	-	-	-	-	-	-	-
'84	0	0	0	0	0	0%	0%
'85	6	35	7	0	47	13%	2%
'86	0	0	0	0	0	0%	0%
'87	0	5	23	8	36	10%	1%
'88	-	-	-	-	-	-	-
'89	0	4	19	2	25	7%	<1%
'90	1	2	57	27	87	25%	3%
'91	0	4	77	0	81	23%	3%

Table 16. Hectares of SAV by density category and percentage of Tier I SAV restoration goal (353 hectares) and Tier III SAV restoration target (3,056 hectares) are listed for 1970 to 1991 for CBP Segment WT2 (Gunpowder River). In 1979, 162 hectares of SAV were mapped through the regional aerial survey of Maryland. These aerial survey data were included in the calculation of the Tier I restoration goal, but not in the SAV trend analysis for the reasons described in Chapter I. Sources: Anderson and Macomber, 1980; Batiuk et al.,1992; Orth et a.l,1985, 1986, 1987, 1989, 1991, and 1992; Orth and Nowak, 1990.

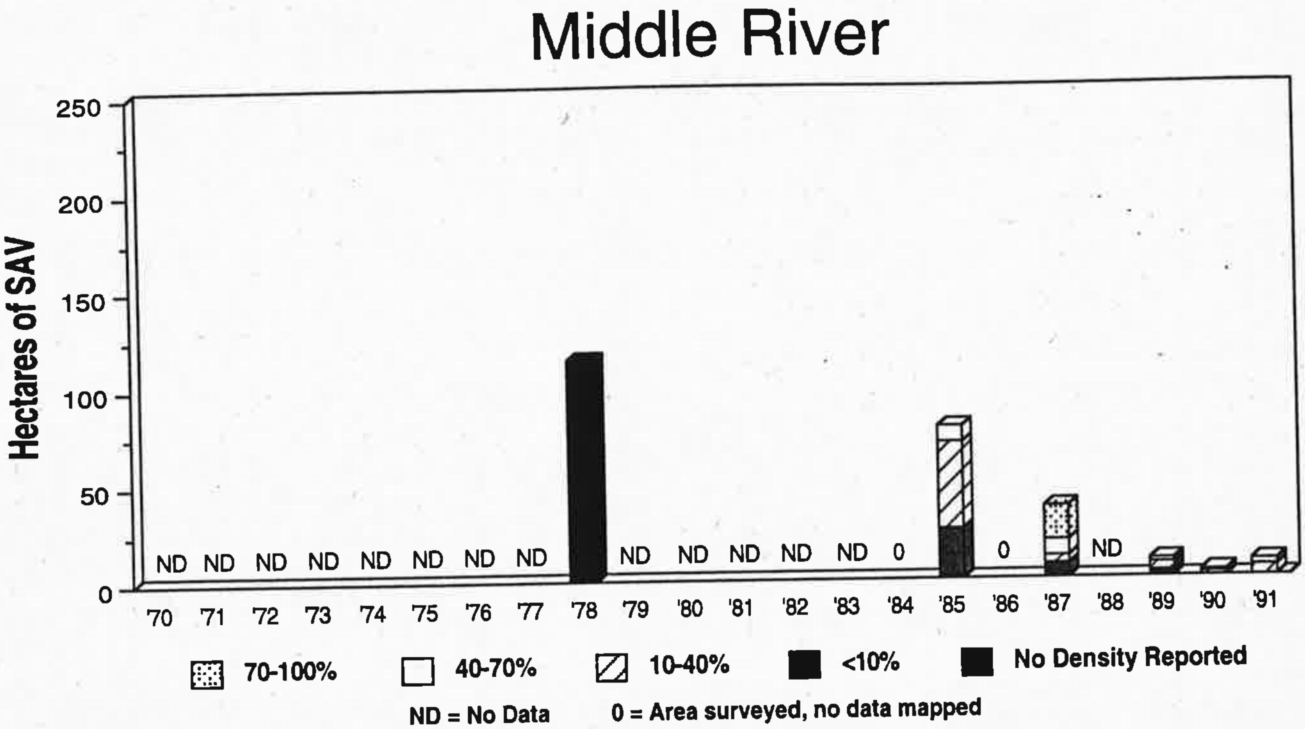


Figure 40. Hectares of SAV by density category for all years for which aerial survey data were available. For CBP Segment WT3 (Middle River), the Tier I SAV restoration goal is 349 hectares.
Sources: Anderson and Macomber, 1980; Batiuk et al., 1992; Orth et al., 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Nowak, 1990.

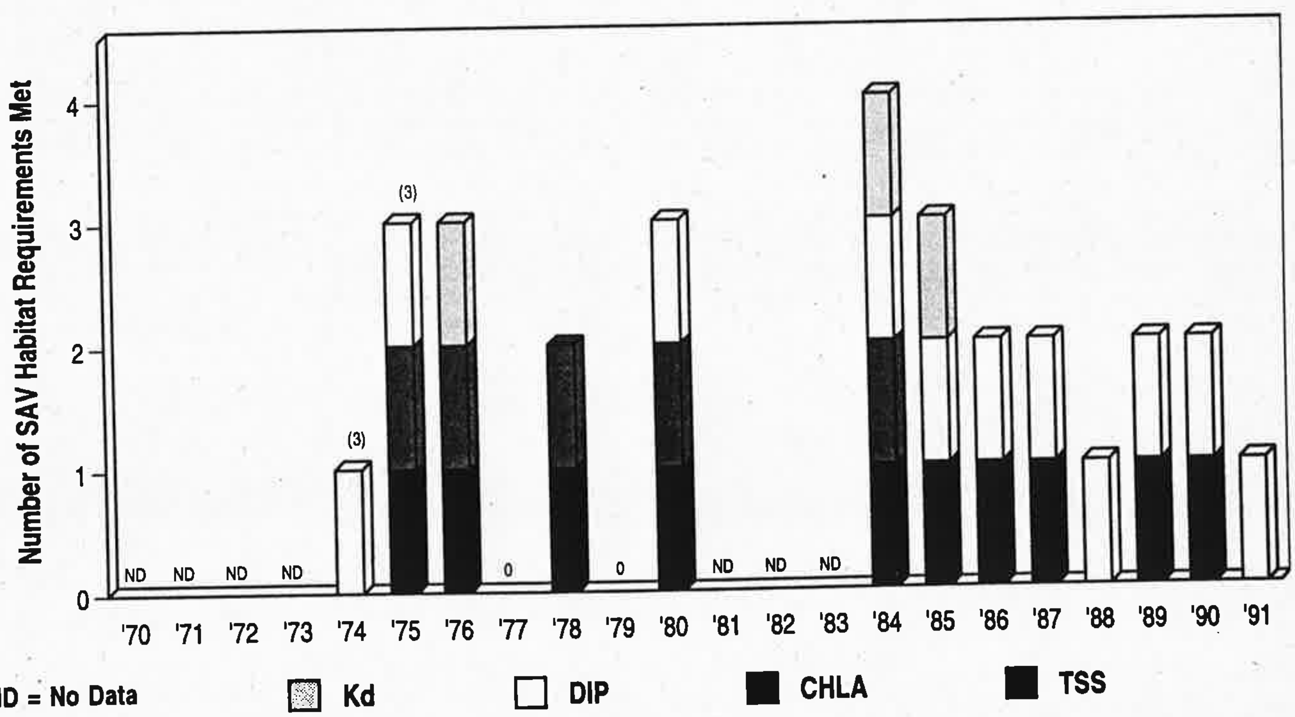


Figure 41. The number of SAV habitat requirements met over the SAV growing season from 1970 to 1991 for CBP Segment WT3 (Middle River). No SAV habitat requirements met = 0; no water quality data available = ND. Sufficient data for the following parameters were not available to calculate growing season medians: Kd (1970-1975, 1979, 1981-1983); TSS (1970-1973, 1979, 1981-1983); CHLA (1970-1973, 1979, 1981-1983); and DIP (1970-1973, 1979, 1981-1983). Numbers of SAV habitat requirements with growing season medians are shown above bars when some values were missing.
Sources: Chesapeake Bay Program, 1993a and 1993b.

Middle River

Year	Hectares of SAV by Density Category <10%	10-40%	40-70%	70-100%	Segment Total	% of Tier I Restoration Goal	% of Tier III Restoration Goal
'70	-	-	-	-	-	-	-
'71	-	-	-	-	-	-	-
'72	-	-	-	-	-	-	-
'73	-	-	-	-	-	-	-
'74	-	-	-	-	-	-	-
'75	-	-	-	-	-	-	-
'76	-	-	-	-	-	-	-
'77	-	-	-	-	-	-	-
'78	-	-	-	-	113	33%	14%
'79	-	-	-	-	-	-	-
'80	-	-	-	-	-	-	-
'81	-	-	-	-	-	-	-
'82	-	-	-	-	-	-	-
'83	-	-	-		-	-	-
'84	0	0	0	0	0	0%	0%
'85	26	43	8	0	78	22%	9%
'86	0	0	0	0	0	0%	0%
'87	7	4	8	18	37	10%	4%
'88	-	-	-	-	-	-	-
'89	3	4	1	0	8	3%	1%
'90	0	2	<1	0	3	<1%	<1%
'91	0	5	3	0	8	2%	1%

Table 17. Hectares of SAV by density category and percentage of Tier I SAV restoration goal (349 hectares) and Tier III SAV restoration target (839 hectares) are listed for 1970 to 1991 for CBP Segment WT3 (Middle River). In 1979, 217 hectares of SAV were mapped through the regional aerial survey of Maryland. These aerial survey data were included in the calculation of the Tier I restoration goal, but not in the SAV trend analysis for the reasons described in Chapter I. Sources: Anderson and Macomber, 1980; Batiuk et al., 1992; Orth et al., 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Nowak, 1990.

Back River

Year	Hectares of SAV by Density Category <10%	10-40%	40-70%	70-100%	Segment Total	% of Tier I Restoration Goal	% of Tier III Restoration Goal
'70	-	-	-	-	-	-	-
'71	-	-	-	-	-	-	-
'72	-	-	-	-	-	-	-
'73	-	-	-	-	-	-	-
'74	-	-	-	-	-	-	-
'75	-	-	-	-	-	-	-
'76	-	-	-	-	-	-	-
'77	-	-	-	-	-	-	-
'78	0	0	0	0	0	0%	0%
'79	-	-	-	-	-	-	-
'80	-	-	-	-	-	-	-
'81	-	-	-	-	-	-	-
'82	-	-	-	-	-	-	-
'83	-	-	-	-	-	-	-
'84	0	0	0	0	0	0%	0%
'85	0	0	0	0	0	0%	0%
'86	0	0	0	0	0	0%	0%
'87	0	0	0	0	0	0%	0%
'88	-	-	-	-	-	-	-
'89	0	0	0	0	0	0%	0%
'90	0	0	0	0	0	0%	0%
'91	0	0	0	0	0	0%	0

Table 18. Hectares of SAV by density category and percentage of Tier III SAV restoration target (1,061 hectares) are listed for 1970 and 1991 for CBP Segment WT4 (Back River). In 1979, two hectares of SAV were mapped through the regional aerial survey of Maryland. These aerial survey data were included in the calculation of the Tier I restoration goal, but not in the SAV trend analysis for the reasons described in Chapter I.
Sources: Batiuk et al., 1992; Chesapeake Bay Program, unpublished data a, b; Orth et al., 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Nowak, 1990.

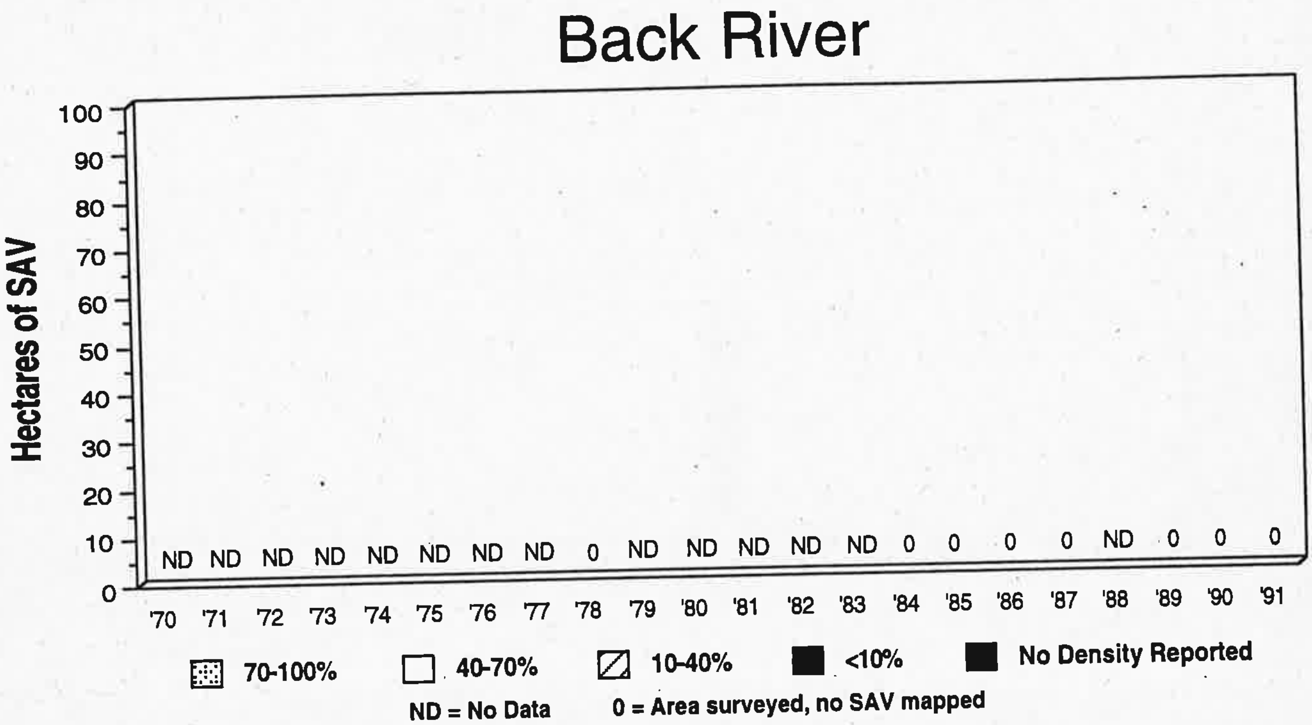


Figure 42. Hectares of SAV by density category for all years for which aerial survey data were available. For CBP Segment WT4 (Back River), the Tier I SAV restoration goal is two hectares.
Sources: Anderson and Macomber, 1980; Batiuk et al., 1992; Orth et al., 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Nowak, 1990.

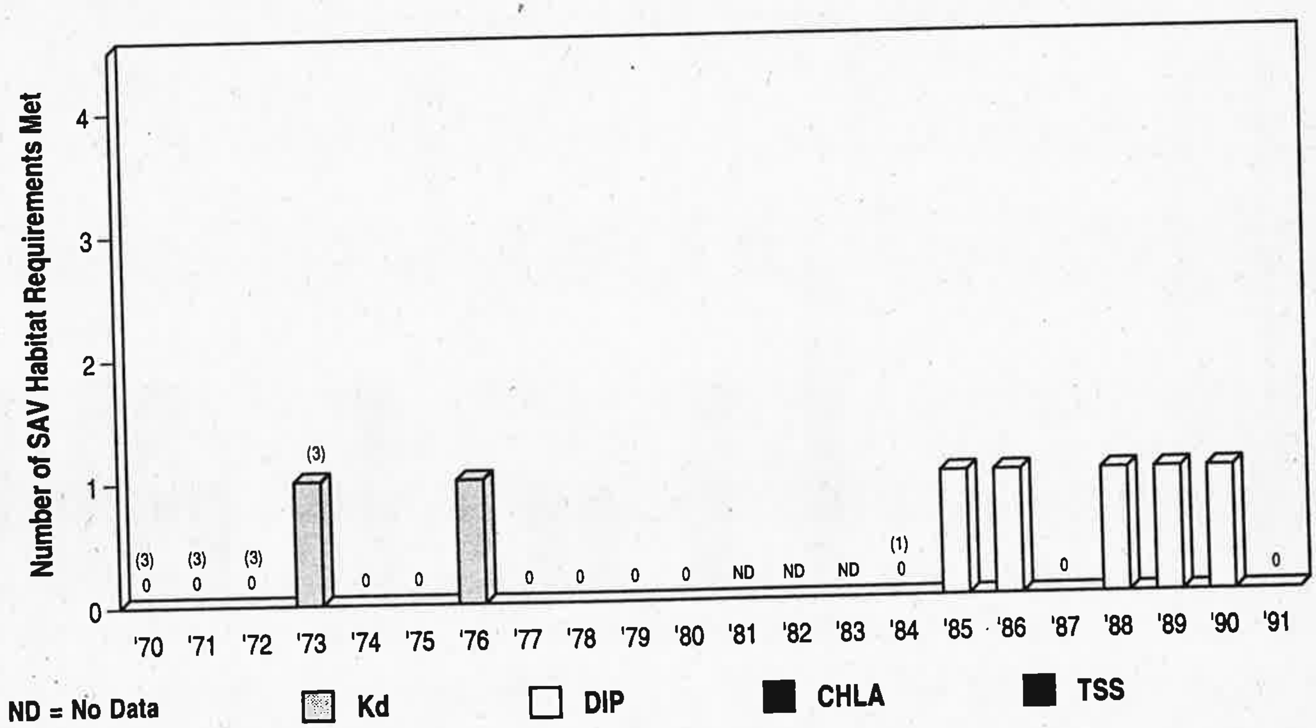


Figure 43. The number of SAV habitat requirements met over the SAV growing season from 1970 to 1991 for CBP Segment WT4 (Back River). No SAV habitat requirements met = 0; no water quality data available = ND. Sufficient data for the following parameters were not available to calculate growing season medians: Kd (1979, 1981-1984); TSS (1970-1973, 1979, 1981-1984); CHLA (1979, 1981-1983); and DIP (1979, 1981-1984). Numbers of SAV habitat requirements with growing season medians are shown above bars when some values were missing.
Sources: Chesapeake Bay Program, 1993a and 1993b.

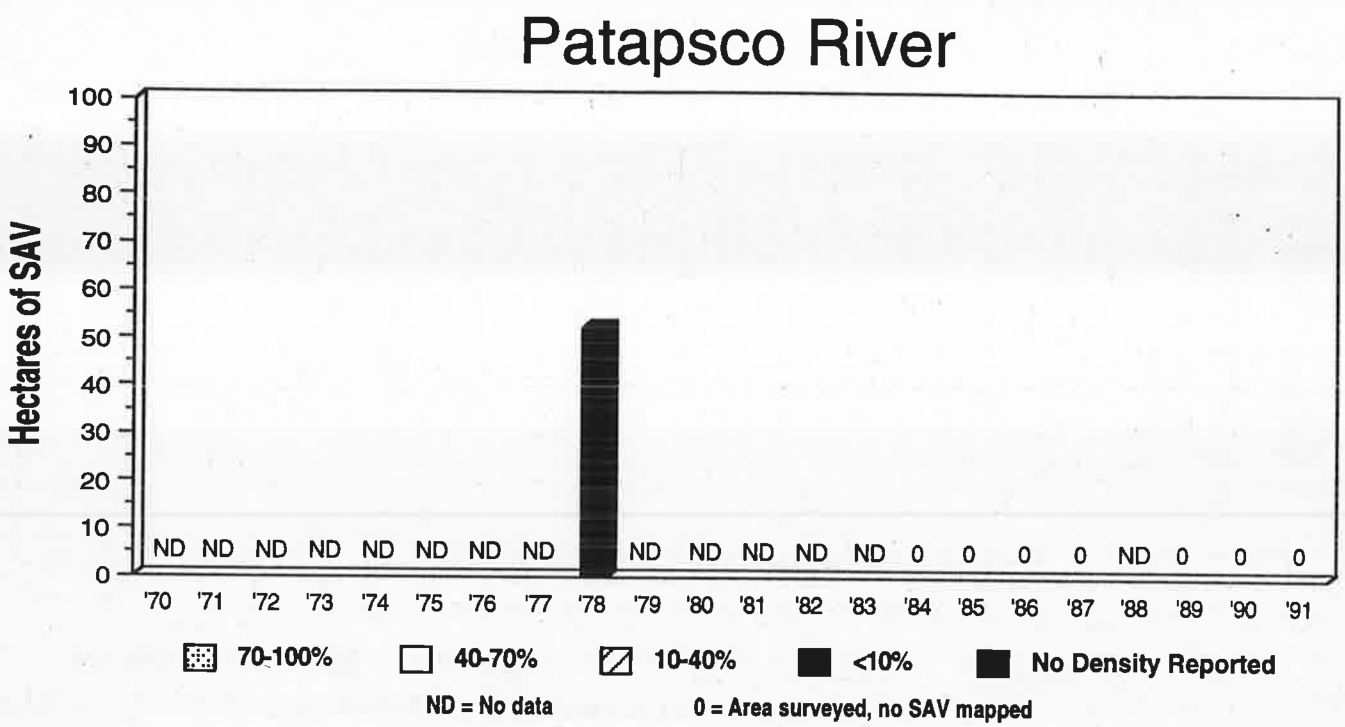


Figure 44. Hectares of SAV by density category for all years for which aerial survey data were available. For CBP Segment WT5 (Patapsco River), the Tier I SAV restoration goal is 53 hectares.
Sources: Anderson and Macomber, 1980; Batiuk et al., 1992; Orth et al., 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Nowak, 1990.

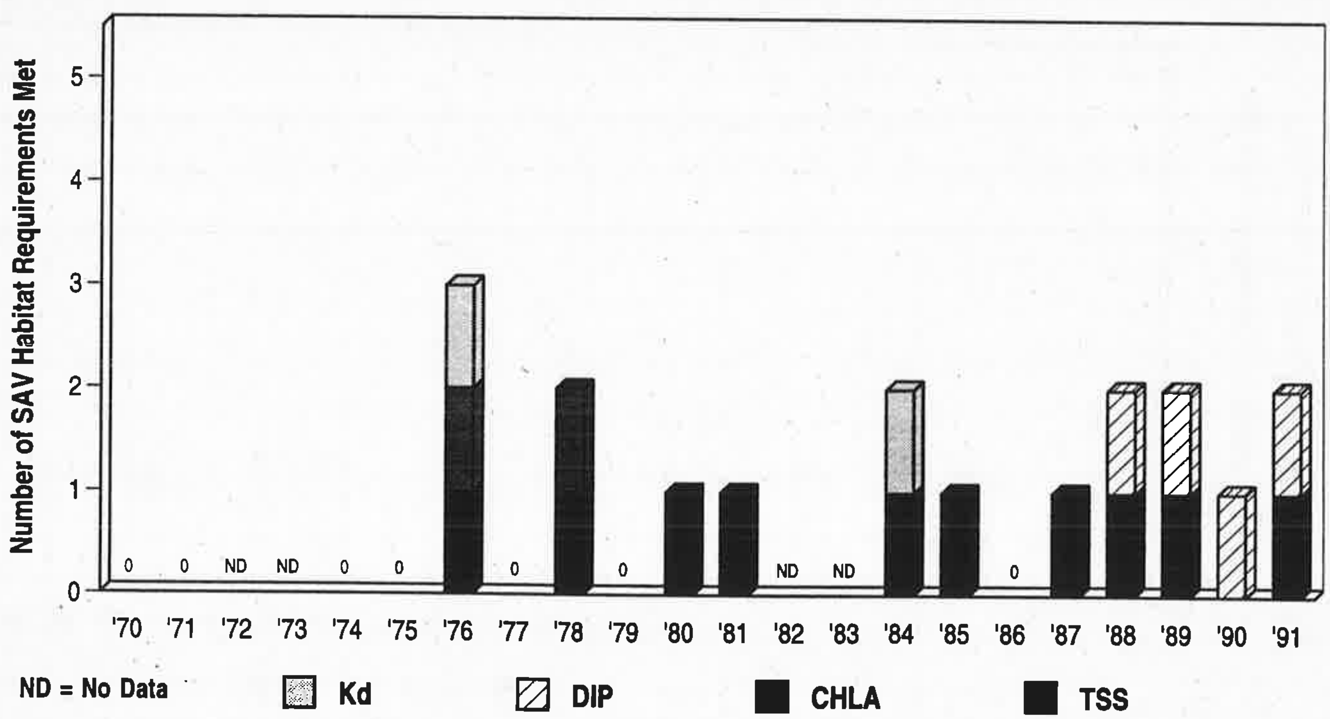


Figure 45. The number of SAV habitat requirements met over the SAV growing season from 1970 to 1991 for CBP Segment WT5 (Patapsco River). No SAV habitat requirements met = 0; no water quality data available = ND. Sufficient data for the following parameters were not available to calculate growing season medians: Kd (1972-1975, 1977, 1981-1983); TSS (1970-1973, 1982, 1983); CHLA (1972, 1973, 1981-1983); DIP (1970-1973, 1981-1983); and DIN (1972, 1973, 1981-1983). Numbers of SAV habitat requirements with growing season medians are shown above bars when some values were missing.
Sources: Chesapeake Bay Program, 1993a and 1993b.

Patapsco River

Year	Hectares of SAV by Density Category <10%	10-40%	40-70%	70-100%	Segment Total	% of Tier I Restoration Goal	% of Tier III Restoration Goal
'70	-	-	-	-	-	-	-
'71	-	-	-	-	-		-
'72	-	-	-	-	-	-	-
'73	-	-	-	-	-	-	-
'74	-	-	-	-	-	-	-
'75	-	-	-	-	-	-	-
'76	-	-	-	-	-	-	-
'77	-	-	-	-	-	-	-
'78	-	-	-	-	52	98%	4%
'79	-	-	-	-	-	-	-
'80	-	-	-	-	-	-	-
'81	-	-	-	-	-	-	-
'82	-	-	-	-	-	-	-
'83	-	-	-	-	-	-	-
'84	0	0	0	0	0	0%	0%
'85	0	0	0	0	0	0%	0%
'86	0	0	0	0	0	0%	0%
'87	0	0	0	0	0	0%	0%
'88	-	-	-	-	-	-	-
'89	0	0	0	0	0	0%	0%
'90	0	0	0	0	0	0%	0%
'91	0	0	0	0	0	0%	0%

Table 19. Hectares of SAV by density category and percentage of Tier I SAV restoration goal (53 hectares) and Tier III SAV restoration target (1,452 hectares) are listed for 1970 to 1991 for CBP Segment WT5 (Patapsco River). In 1979, two hectares of SAV were mapped through Maryland's regional aerial survey. These data were included in the calculation of the Tier I restoration goal, but not in the SAV trend analysis for the reasons described in Chapter I.
Sources: Anderson and Macomber, 1980; Batiuk et al., 1992; Orth et al., 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Nowak, 1990.

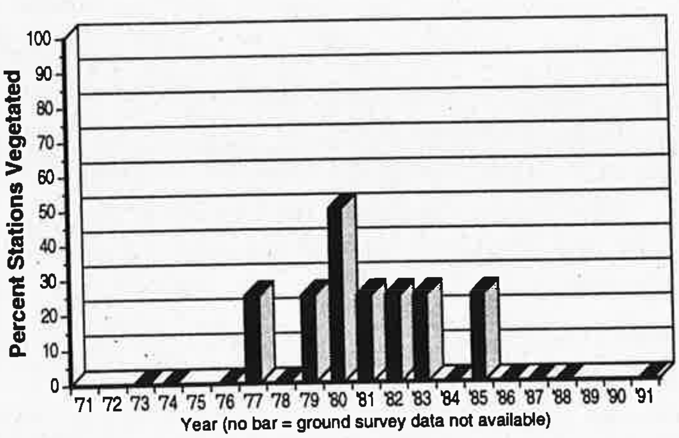


Figure 46. Percentage of Maryland Department of Natural Resources SAV Ground Survey Program stations sampled where SAV was observed for CBP Segment WT2 (Gunpowder River). Ground survey data were not available for 1971, 1972, 1975, 1989, and 1990.
Source: Chesapeake Bay Program, unpublished data c.

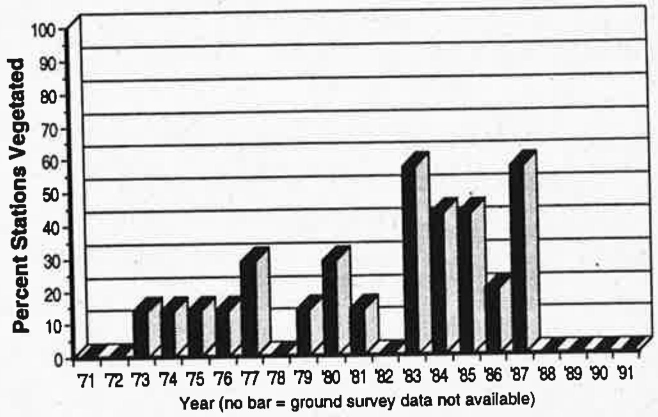


Figure 47. Percentage of Maryland Department of Natural Resources SAV Ground Survey Program stations sampled where SAV was observed for CBP Segment WT3 (Middle River).
Source: Chesapeake Bay Program, unpublished data c.

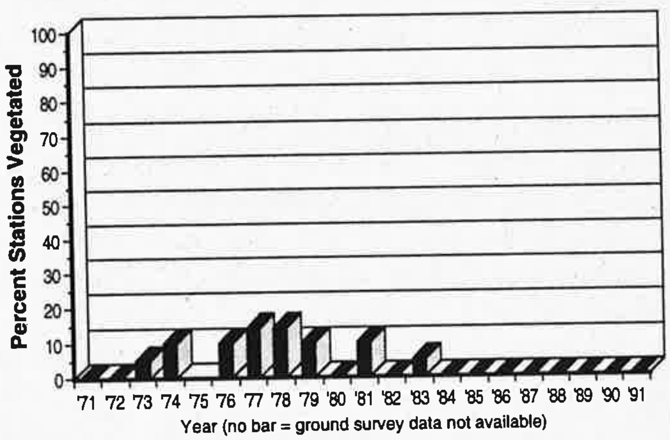


Figure 48. Percentage of Maryland Department of Natural Resources SAV Ground Survey Program stations sampled where SAV was observed for CBP Segment WT5 (Patapsco River). Ground survey data were not available for 1975.
Source: Chesapeake Bay Program, unpublished data c.

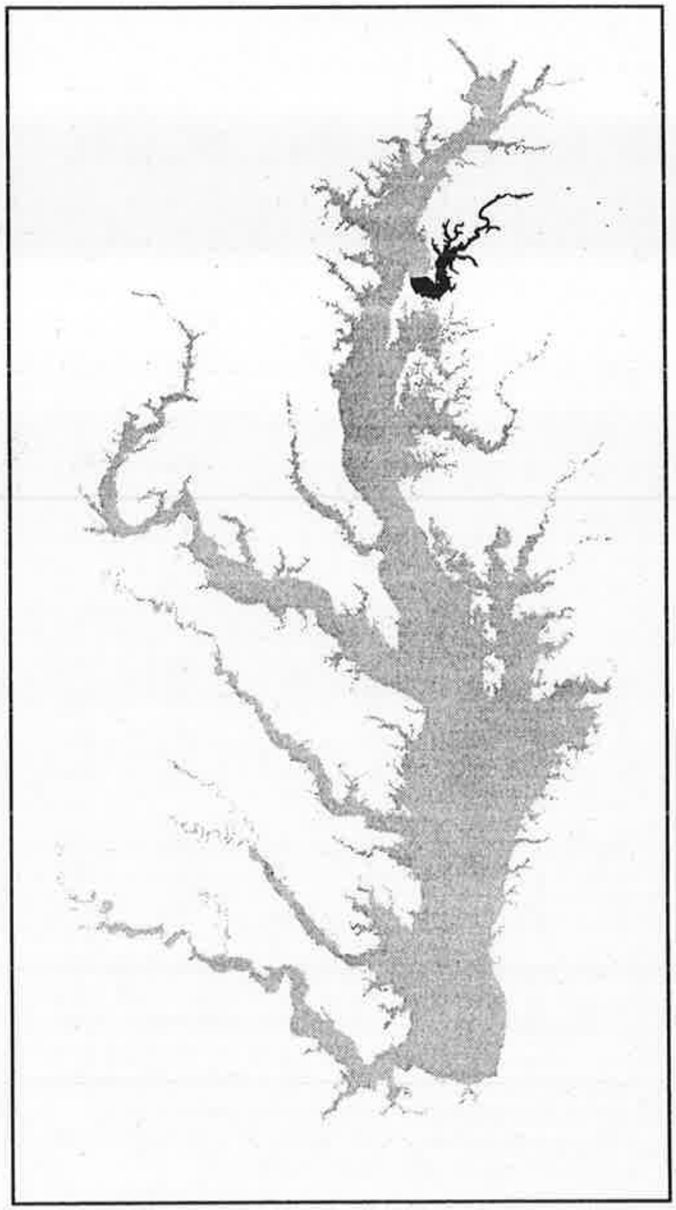
Chester River

Scientists have long studied the distribution of SAV in the Chester River, a tributary to the Bay on the Eastern Shore. Several surveys prior to 1971 provide excellent documentation on its historical SAV distribution (Stevenson and Staver, in press).

The baywide aerial survey reported more SAV in 1978 than in subsequent years, with concentrations of SAV primarily along the western shore and in Grays Inn and Langford creeks (Figure 49, Table 20). Less than one-half of the SAV reported in 1978 (1,072 hectares) was present in 1984 (417 hectares); levels declined further in 1990 to their lowest level (33 hectares). Most of the reported SAV beds grew along the western shore of the river, principally adjacent to Eastern Neck and Eastern Neck Island and in Grays Inn and Langford creeks. Much of the remaining SAV in 1991 (35 hectares) was located in Eastern Neck Narrows, between Eastern Neck and Eastern Neck Island. In addition, SAV has persisted in Robin Cove on the western shore.

The Maryland Department of Natural Resources ground survey found SAV occurring more consistently over the years in this river than in any other section of the Bay (Figure 51). Submerged aquatic vegetation was more abundant in the 1970s than the 1980s. The overall pattern of change recorded by the ground survey since 1984 is similar to that documented by the aerial survey (Figure 49). The Maryland Department of Natural Resources ground survey recorded only two species in 1989 (*R. maritima* and *P. perfoliatus*) and one species in 1991 (*R. maritima*), whereas, the ground surveys associated with the aerial survey reported six species in both years (*Z. palustris*, *P. perfoliatus*, *P. pectinatus*, *E. canadensis*, *M. spicatum*, and *R. maritima*).

The 1990 U.S. Fish and Wildlife Service clam survey found SAV at only 1.2 percent of the 253 sites visited (Jorde et al., 1991). *Zannichellia palustris* was the only species reported.



Ruppia maritima and *P. perfoliatus* were most commonly reported from several areas in the Chester River. In addition, *M. spicatum*, *E. canadensis*, *P. pectinatus*, and *Z. palustris* were found less frequently. All six species were reported in Robin Cove in 1991.

Water quality in the Chester River was unsuitable for SAV survival over the 1970 to 1991 data record. Only in 1984 were four of the five SAV

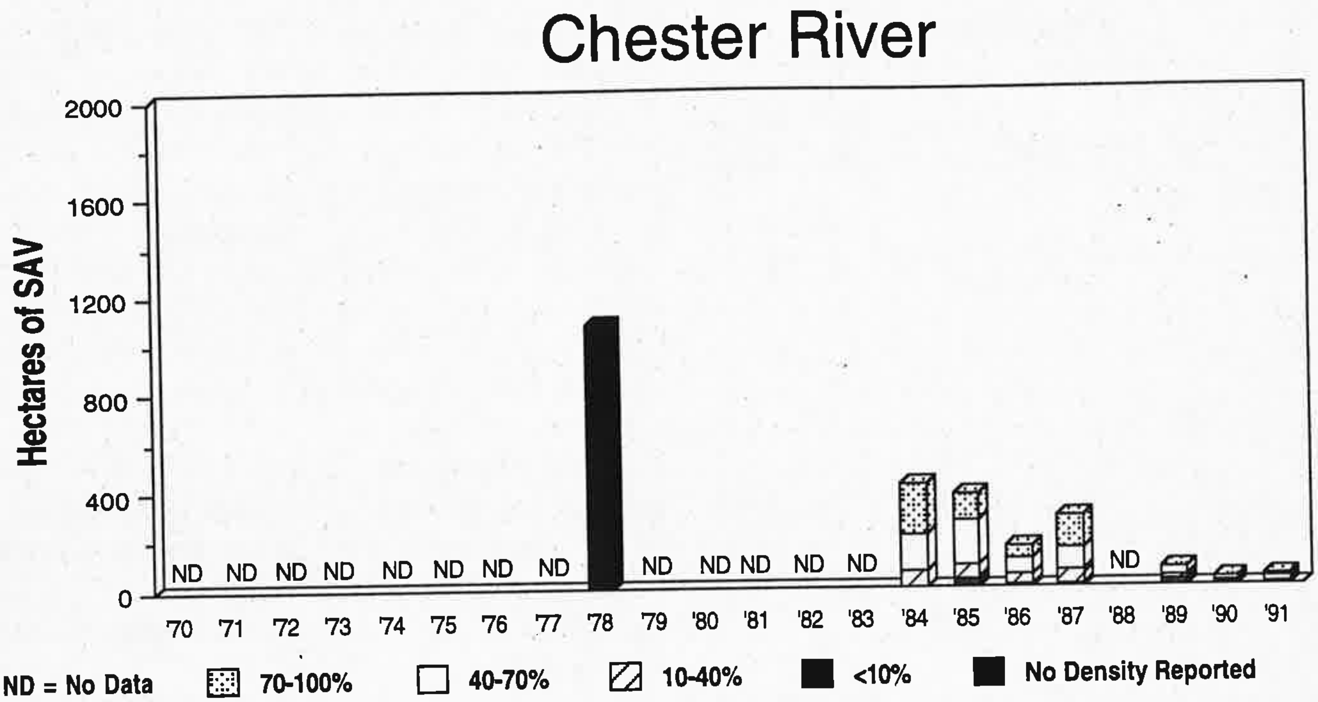


Figure 49. Hectares of SAV by density category for all years for which aerial survey data were available. For CBP Segment ET4 (Chester River), the Tier I SAV restoration goal is 1,506 hectares.
Sources: Anderson and Macomber, 1980; Batiuk et al., 1992; Orth et al., 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Nowak, 1990.

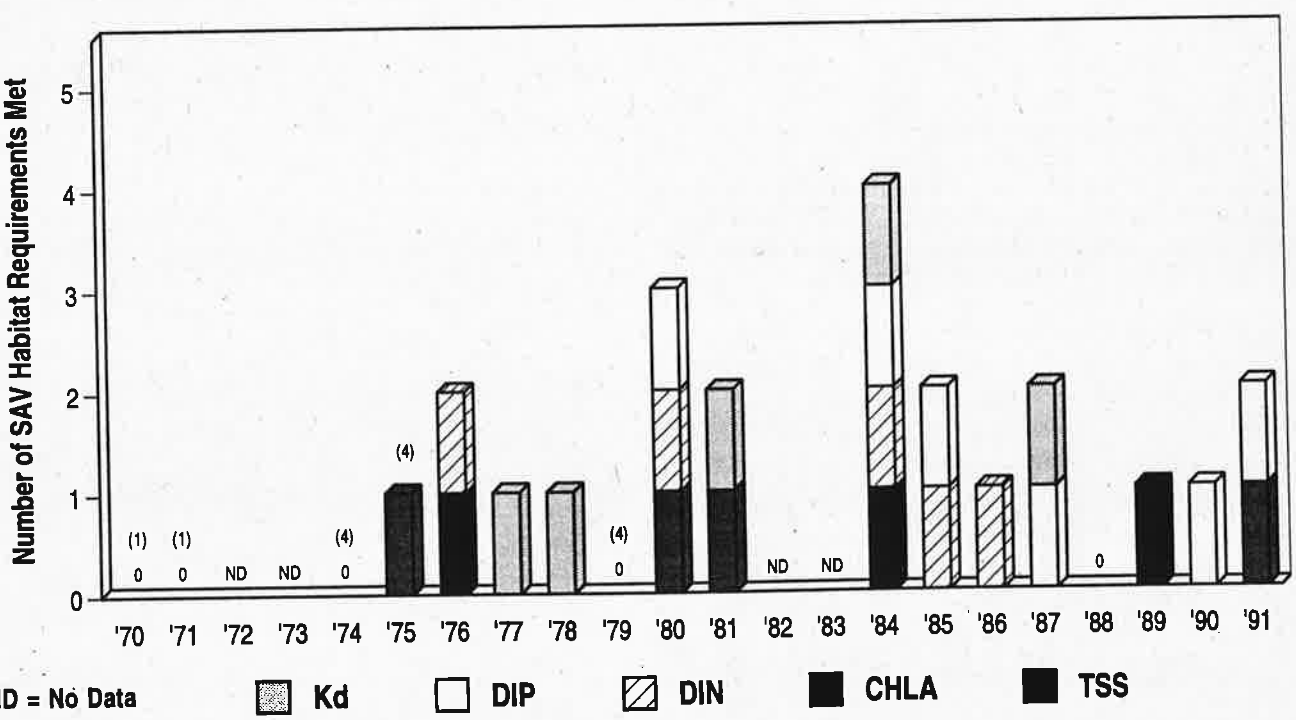


Figure 50. The number of SAV habitat requirements met over the SAV growing season from 1970 to 1991 for CBP Segment ET4 (Chester River). No SAV habitat requirements met = 0; no water quality data available = ND. Sufficient data for the following parameters were not available to calculate growing season medians: Kd (1970-1975, 1979, 1982, 1983); TSS (1972, 1973, 1982, 1983); CHLA (1970-1973, 1982, 1983); DIN (1970-73, 1982, 1983); and DIP (1970-1973, 1982, 1983). Numbers of SAV habitat requirements with growing season medians are shown above bars when some values were missing.
Sources: Chesapeake Bay Program, 1993a and 1993b.

Chester River

Year	Hectares of SAV by Density Category <10%	10-40%	40-70%	70-100%	Segment Total	% of Tier I Restoration Goal	% of Tier III Restoration Goal
'70	-	-	-	-	-	-	-
'71	-	-	-	-	-	-	-
'72	-	-	-	-	-	-	-
'73	-	-	-	-	-	-	-
'74	-	-	-	-	-	-	-
'75	-	-	-	-	-	-	-
'76	-	-	-	-	-	-	-
'77	-	-	-	-	-	-	-
'78	-	-	-	-	1,074	71%	18%
'79	-	-	-	-	-	-	-
'80	-	-	-	-	-	-	-
'81	-	-	-	-	-	-	-
'82	-	-	-	-	-	-	-
'83	-	-	-	-	-	-	-
'84	<1	59	149	209	418	28%	7%
'85	33	56	177	106	372	25%	6%
'86	4	45	67	48	164	11%	3%
'87	3	61	87	137	288	19%	5%
'88	-	-	-	-	-	-	-
'89	24	15	30	6	75	5%	1%
'90	5	6	21	1	33	2%	<1%
'91	0	2	30	2	34	2%	<1%

Table 20. Hectares of SAV by density category and percentage of Tier I SAV restoration goal (1,506 hectares) and Tier III SAV restoration target (5,812 hectares) are listed for 1970 to 1991 for CBP Segment ET4 (Chester River). Sources: Anderson and Macomber, 1980; Batiuk et al., 1992; Orth et al., 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Nowak, 1990.

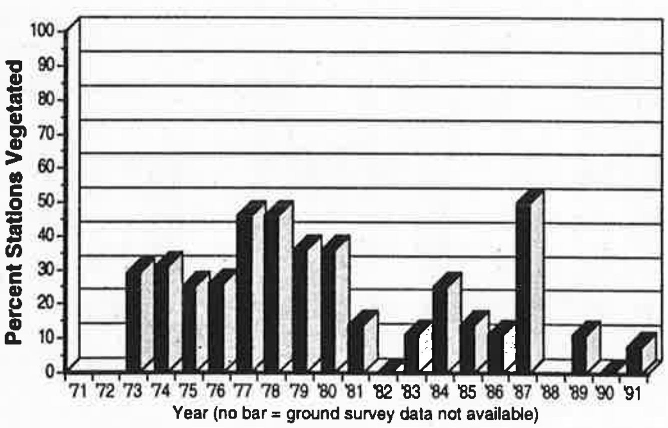
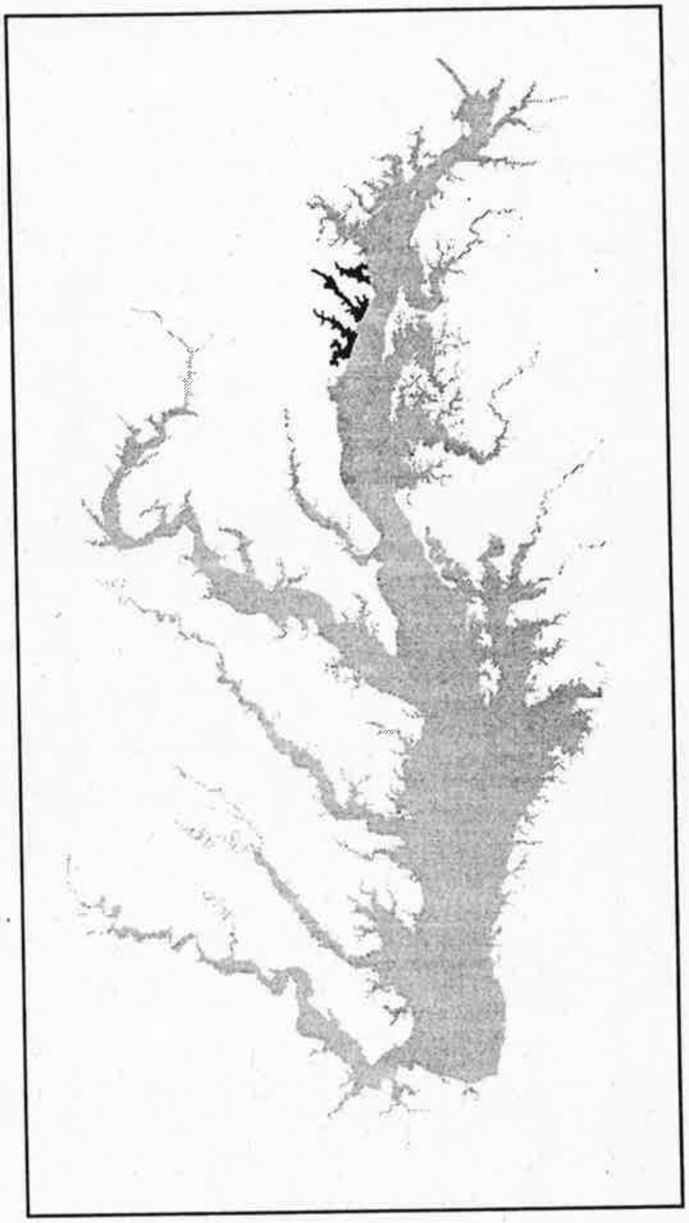


Figure 51. Percentage of Maryland Department of Natural Resources SAV Ground Survey Program stations sampled where SAV was observed for CBP Segment ET4 (Chester River). Ground survey data were not available for 1971, 1972, and 1988.
Source: Chesapeake Bay Program, unpublished data c.

habitat requirements met; three or fewer SAV habitat requirements were met for all other years (Figure 50). During the most significant decline in SAV distribution (1985 to 1991), the light attenuation habitat requirement was generally not met. In 1986 and 1988, no SAV habitat requirements were met. The SAV decline since 1984, along with the virtual absence of SAV in the Chester River by 1991, indicates that water quality conditions were unsuitable for SAV survival since 1984.

Achievement of the Tier I restoration goal and the Tier III restoration target in the Chester River was greatest in 1978 (71 percent and 18 percent, respectively) and declined to its lowest levels in 1990 (2 percent and <1 percent, respectively) (Table 20).

Magothy, Severn, South, Rhode, and West Rivers



These five rivers constitute the remaining upper western shore tributaries. Since 1984, SAV has been nearly absent in all five tributaries, with no more than ten hectares mapped through the aerial survey in any one year (Figures 52, 54, and 56). Significantly more SAV was found in each tributary in 1978: 146 hectares in the Magothy River, 136 hectares in the Severn River, and 78 hectares in the South, Rhode, and West rivers combined (Tables 21, 22, and 23).

The Maryland Department of Natural Resources ground survey recorded a greater percentage of vegetated stations in the Magothy and Severn rivers in the 1970s. Since 1982, no stations with vegetation were reported except in 1984 and 1991 in the Magothy River (29 percent and 8 percent, respectively) and in 1983 in the Severn River (8 percent) (Figures 58 and 59, respectively). The Maryland ground survey recorded the presence of SAV (14 percent) in only one year (1976) in the South, West, and Rhode rivers (Figure 60). The same species were recorded by the other ground surveys (*C. demersum*, *Z. palustris*, *P. perfoliatus*, *P. pectinatus*, and *R. maritima*).

The 1990 U.S. Fish and Wildlife Service clam survey found SAV at only 0.9 percent of the 109 sites visited (Jorde et al., 1991). *Zannichellia palustris* was the only species reported.

Ground surveys have reported SAV in all these tributaries with *C. demersum*, *Z. palustris*, *P. perfoliatus*, *P. pectinatus*, and *R. maritima* recorded. In particular, *Z. palustris* was recorded frequently through the Citizens' SAV Survey in 1991, especially in the South River.

Water quality in these five tributaries, as with the other upper western shore tributaries, has been consistently unsuitable for SAV survival over the 1970 to 1991 data record. All five SAV habitat requirements were met only in the Magothy River in 1987 (Figure 53). In the Severn River, four of the five SAV habitat requirements were met between 1986 and 1988 and again in 1991 (Figure 55). In most years, no more than two or three of the SAV habitat requirements were met in either the Magothy or Severn rivers. Within the South, Rhode, and West rivers, no more than two SAV habitat requirements were met in most years of the data record (Figure 57).

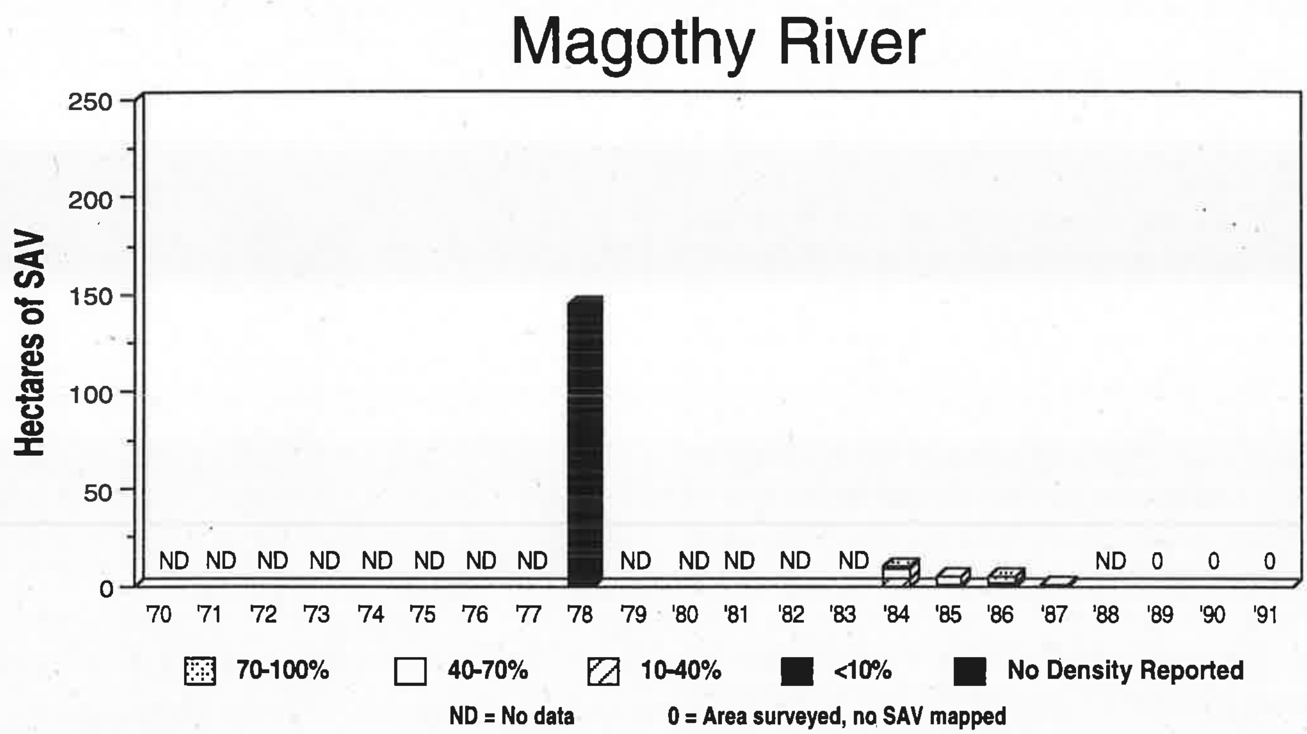


Figure 52. Hectares of SAV by density category for all years for which aerial survey data were available. For CBP Segment WT6 (Magothy River), the Tier I SAV restoration goal is 240 hectares.
Sources: Anderson and Macomber, 1980; Batiuk et al., 1992; Orth et al., 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Nowak, 1990.

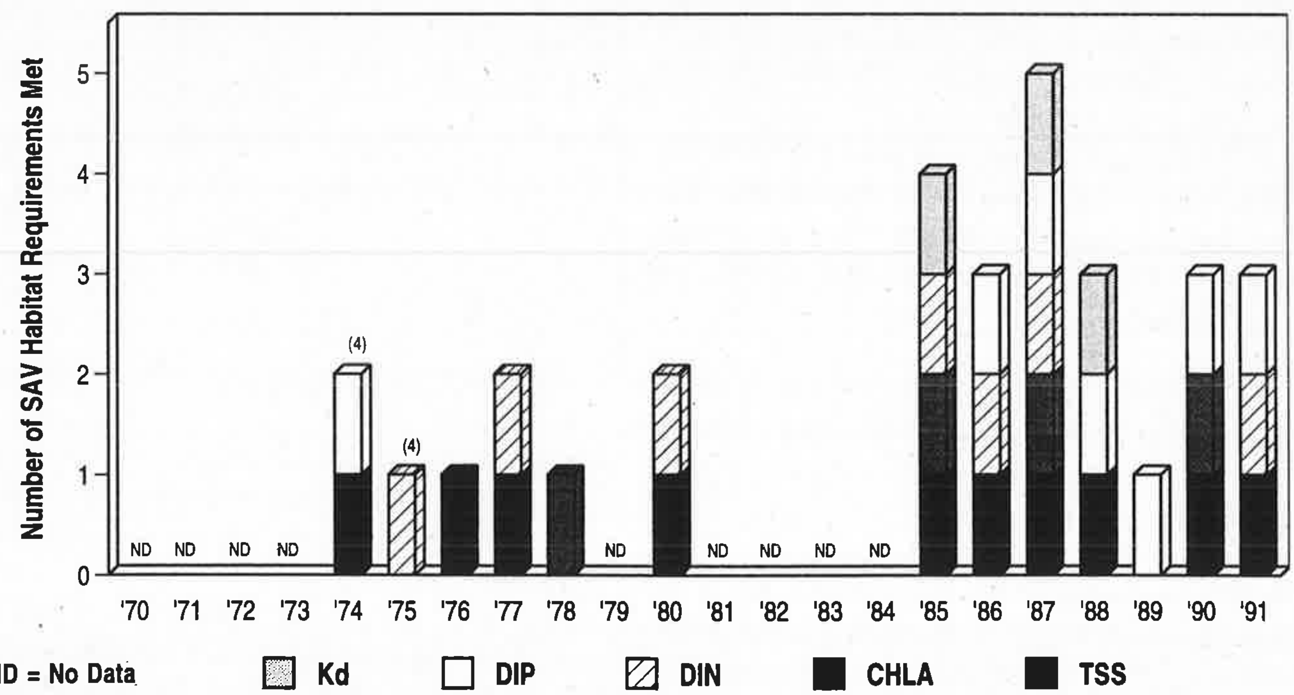


Figure 53. The number of SAV habitat requirements met over the SAV growing season from 1970 to 1991 for CBP Segment WT6 (Magothy River). No SAV habitat requirements met = 0; no water quality data available = ND. Sufficient data for the following parameters were not available to calculate growing season medians: Kd (1970-1975, 1979, 1981-1984); TSS (1970-1973, 1979, 1981-1984); CHLA (1970-1973, 1979, 1981-1984); DIP (1970-1973, 1979, 1981-1984); and DIN (1970-1973, 1979, 1981-1984). Numbers of SAV habitat requirements with growing season medians are shown above bars when some values were missing.
Sources: Chesapeake Bay Program, 1993a and 1993b.

Magothy River

Year	Hectares of SAV by Density Category <10%	10-40%	40-70%	70-100%	Segment Total	% of Tier I Restoration Goal	% of Tier III Restoration Goal
'70	-	-	-	-	-	-	-
'71	-	-	-	-	-	-	-
'72	-	-	-	-	-	-	-
'73	-	-	-	-	-	-	-
'74	-	-	-	-	-	-	-
'75	-	-	-	-	-	-	-
'76	-	-	-	-	-	-	-
'77	-	-	-	-	-	-	-
'78	-	-	-	-	146	61%	17%
'79	-	-	-	-	-	-	-
'80	-	-	-	-	-	-	-
'81	-	-	-	-	-	-	-
'82	-	-	-	-	-	-	-
'83	-	-	-	-	-	-	-
'84	0	4	5	<1	10	4%	1%
'85	0	<1	4	<1	6	2%	<1%
'86	0	<1	<1	3	5	2%	<1%
'87	0	0	<1	0	<1	<1%	<1%
'88	-	-	-	-	-	-	-
'89	0	0	0	0	0	0%	0%
'90	0	0	0	0	0	0%	0%
'91	0	0	0	0	0	0%	0%

Table 21. Hectares of SAV by density category and percentage of Tier I SAV restoration goal (240 hectares) and Tier III SAV restoration target (838 hectares) are listed for 1970 to 1991 for CBP Segment WT6 (Magothy River). In 1979, 192 hectares of SAV were mapped through the regional aerial survey of Maryland. These aerial survey data were included in the calculation of the Tier I restoration goal, but not in the SAV trend analysis for the reasons described in Chapter I. Sources: Anderson and Macomber, 1980; Batiuk et al., 1992; Orth et al., 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Nowak, 1990.

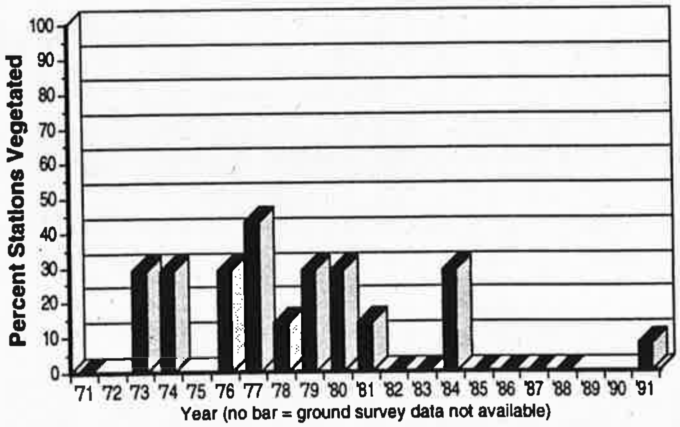


Figure 58. Percentage of Maryland Deparment of Natural Resources SAV Ground Survey Program stations sampled where SAV was observed for CBP Segment WT6 (Magothy River). Ground survey data were not available for 1971, 1972, 1975, 1989, and 1990.
Source: Chesapeake Bay Program, unpublished data c.

After 1978, achievement of the Tier I restoration goal and the Tier III restoration target has not been above 4 percent and 1 percent, respectively, in the Magothy, Severn, South, West, and Rhode rivers (Tables 21, 22, and 23).

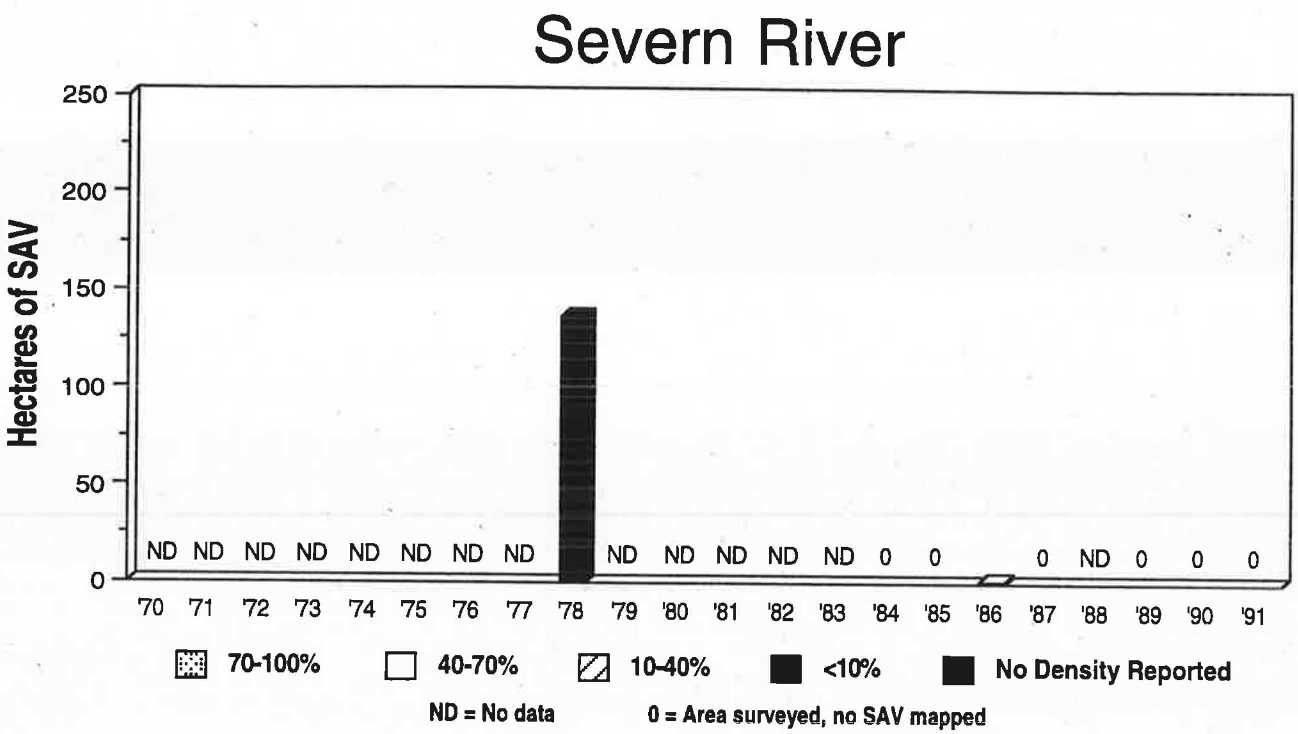


Figure 54. Hectares of SAV by density category for all years for which aerial survey data were available. For CBP Segment WT7 (Severn River), the Tier I SAV restoration goal is 189 hectares.
Sources: Anderson and Macomber, 1980; Batiuk et al., 1992; Orth et al., 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Nowak, 1990.

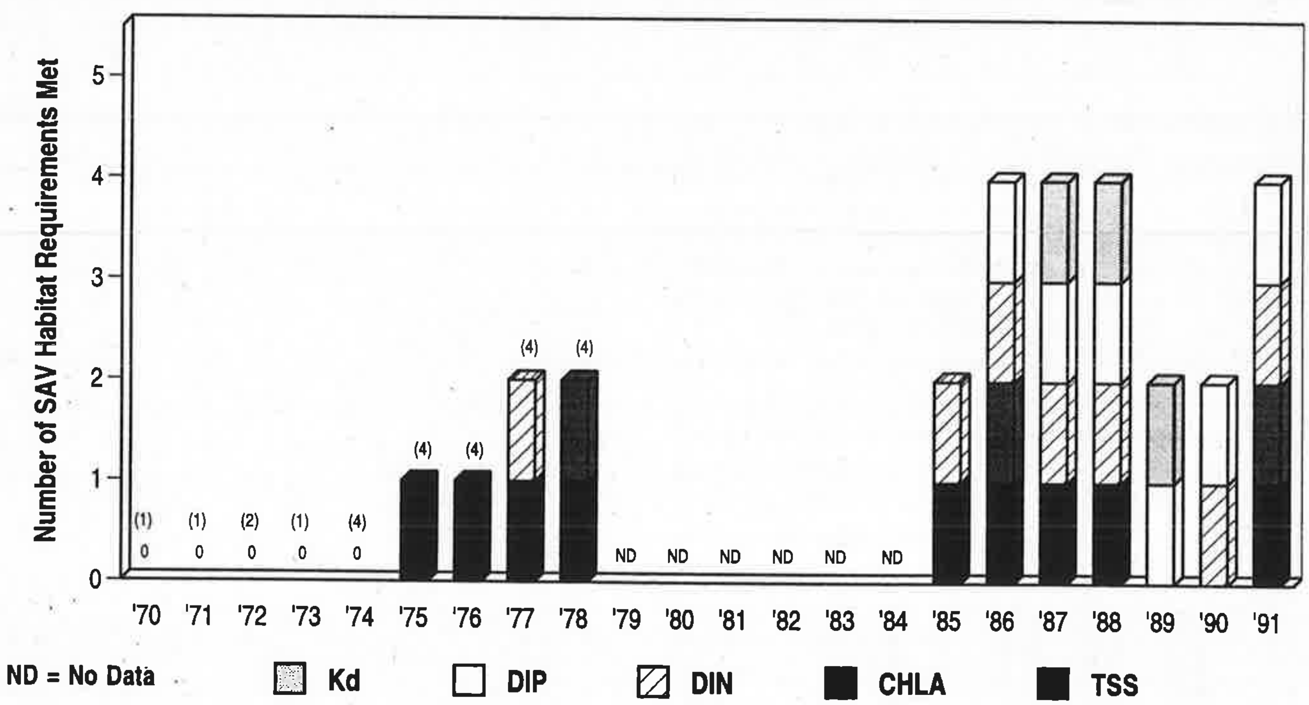


Figure 55. The number of SAV habitat requirements met over the SAV growing season from 1970 to 1991 for CBP Segment WT7 (Severn River). No SAV habitat requirements met = 0; no water quality data available = ND. Sufficient data for the following parameters were not available to calculate growing season medians: Kd (1970-1976, 1978-1984); TSS (1970-1973, 1979-1984); CHLA (1973, 1979-1984); DIP (1970, 1971, 1979-1984); and DIN (1970-1973, 1979-1984). Numbers of SAV habitat requirements with growing season medians are shown above bars when some values were missing.
Sources: Chesapeake Bay Program, 1993a and 1993b.

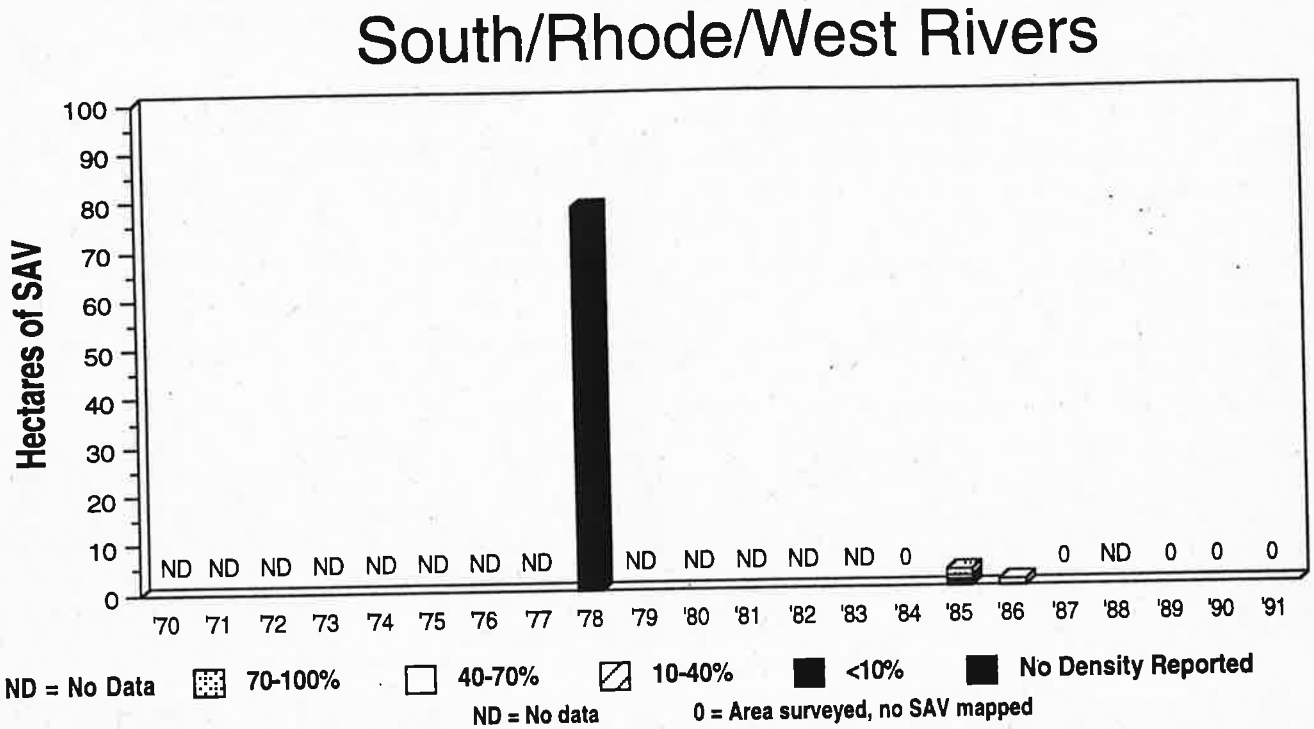


Figure 56 Hectares of SAV by density category for all years for which aerial survey data were available. For CBP Segment WT8 (South/Rhode/ West Rivers), the Tier I SAV restoration goal is 78 hectares.
Sources: Anderson and Macomber, 1980; Batiuk et al., 1992; Orth et al., 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Nowak, 1990..

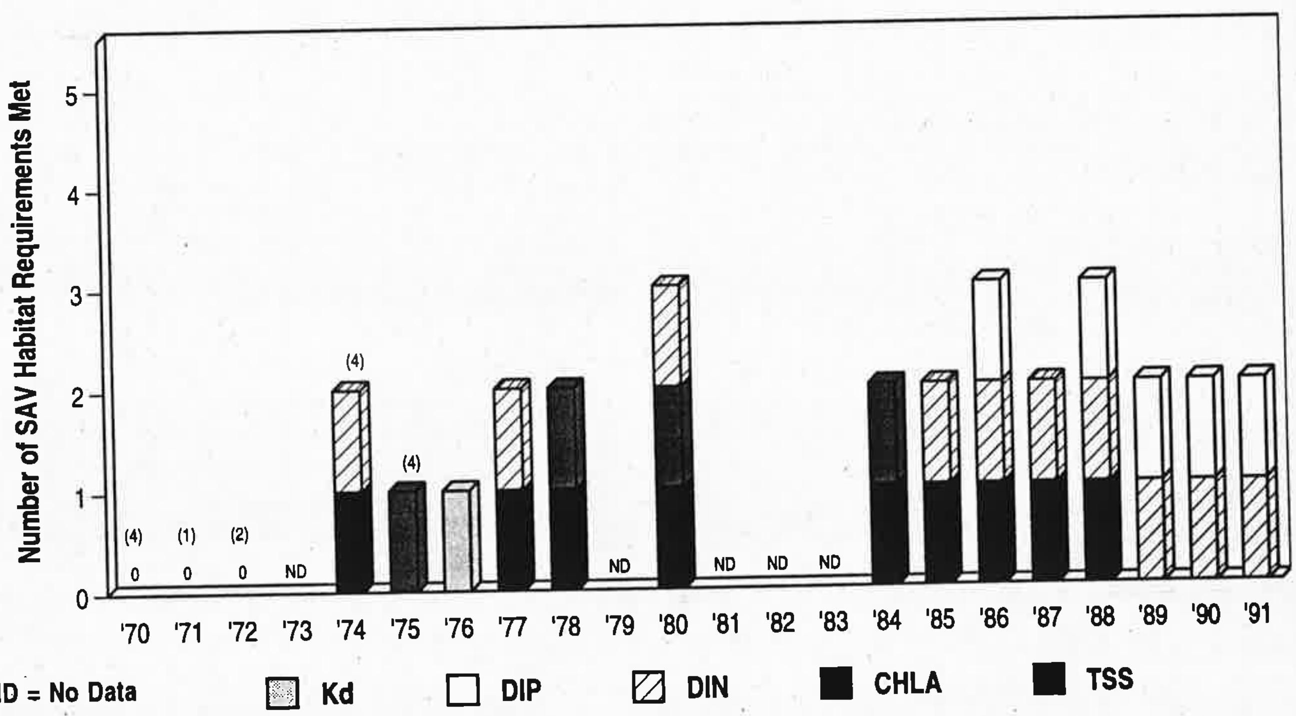


Figure 57. The number of SAV habitat requirements met over the SAV growing season from 1970 to 1991 for CBP Segment WT8 (South/Rhode/ West rivers). No SAV habitat requirements met = 0; no water quality data available = ND. Sufficient data for the following parameters were not available to calculate growing season medians: Kd (1971-1975, 1979, 1981-1983); TSS (1971-1973, 1979, 1981-1983); CHLA (1973, 1979, 1981-1983); DIP (1971, 1973, 1979, 1981-1983); and DIN (1970-1973, 1979, 1981-1983). Numbers of SAV habitat requirements with growing season medians are shown above bars when some values were missing.
Sources: Chesapeake Bay Program, 1993a and 1993b.

Severn River

Year	Hectares of SAV by Density Category <10%	10-40%	40-70%	70-100%	Segment Total	% of Tier I Restoration Goal	% of Tier III Restoration Goal
'70	-	-	-	-	-	-	-
'71	-	-	-	-	-	-	-
'72	-	-	-	-	-	-	-
'73	-	-	-	-	-	-	-
'74	-	-	-	-	-	-	-
'75	-	-	-	-	-	-	-
'76	-		-	-	-	-	-
'77	-	-	-	-	-		-
'78	-	-	-	-	136	72%	15%
'79	-	-	-	-	-	-	-
'80	-	-	-	-	-	-	-
'81	-	-	-	-	-	-	-
'82	-	-	-	-	-	-	-
'83	-	-	-	-	-	-	-
'84	0	0	0	0	0	0%	0%
'85	0	0	0	0	0	0%	0%
'86	0	0	<1	0	<1	<1%	<1%
'87	0	0	0	0	0	0%	0%
'88	-	-	-	-	-	-	-
'89	0	0	0	0	0	0%	0%
'90	0	0	0	0	0	0%	0%
'91	0	0	0	0	0	0%	0%

Table 22. Hectares of SAV by density category and percentage of Tier I SAV restoration goal (189 hectares) and Tier III SAV restoration target (883 hectares) are listed for 1970 to 1991 for CBP Segment WT7 (Severn River). In 1979, 130 hectares were mapped through the regional aerial survey of Maryland. These aerial survey data were included in the calculation of the Tier I restoration goal, but not in the SAV trend analysis for the reasons described in Chapter I. Sources: Anderson and Macomber, 1980; Batiuk et al.,1992; Orth et al., 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Nowak,1990.

South/Rhode/West Rivers

Year	Hectares of SAV by Density Category <10%	10-40%	40-70%	70-100%	Segment Total	% of Tier I Restoration Goal	% of Tier III Restoration Goal
'70	-	-	-	-	-	-	-
'71	-	-	-	-	-	-	-
'72	-	-	-	-	-	-	-
'73	-	-	-	-	-	-	-
'74	-	-	-	-	-	-	-
'75	-	-	-	-	-	-	-
'76	-	-	-	-	-	-	-
'77	-	-	-	-	-	-	-
'78	-	-	-	-	78	100%	4%
'79	-	-	-	-	-	-	-
'80	-	-	-	-	-	-	-
'81	-	-	-	-	-	-	-
'82	-	-	-	-	-	-	-
'83	-	-	-	-	-	-	-
'84	0	0	0	0	0	0%	0%
'85	<1	0	<1	1	3	4%	<1%
'86	0	0	<1	0	<1	1%	<1%
'87	0	0	0	0	0	0%	0%
'88	-	-	-	-	-	-	-
'89	0	0	0	0	0	0%	0%
'90	0	0	0	0	0	0%	0%
'91	0	0	0	0	0	0%	0%

Table 23. Hectares of SAV by density category and percentage of Tier I SAV restoration goal (78 hectares) and Tier III SAV restoration target (1,970 hectares) are listed for 1970 to 1991 for CBP Segment WT8 (South/Rhode/West Rivers). Sources: Anderson and Macomber, 1980; Batiuk et al., 1992; Orth et al., 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Nowak, 1990.

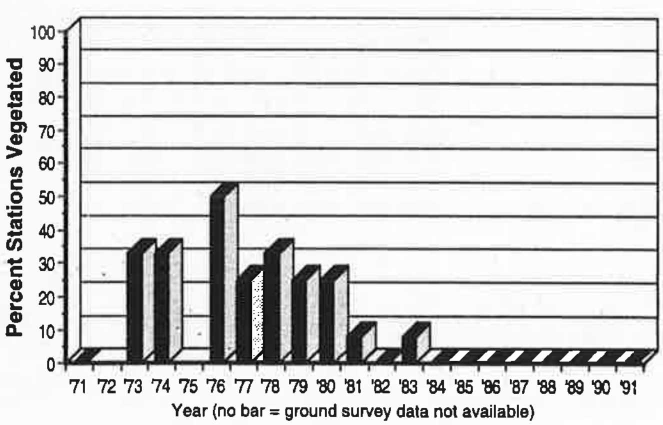


Figure 59. Percentage of Maryland Department of Natural Resources SAV Ground Survey Program stations sampled where SAV was observed for CBP Segment WT7 (Severn River). Ground survey data were not available for 1972 and 1975.
Source: Chesapeake Bay Program, unpublished data c

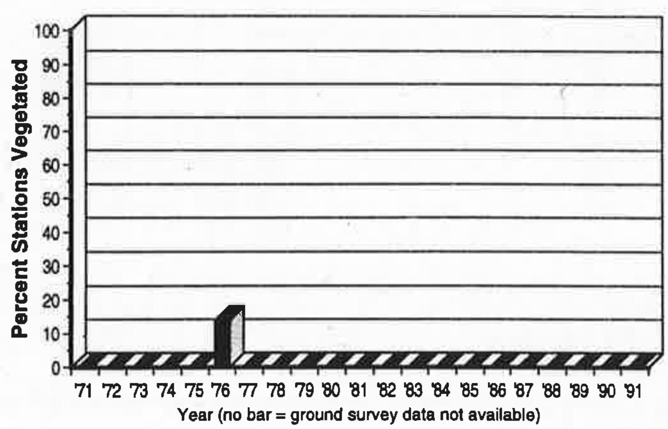
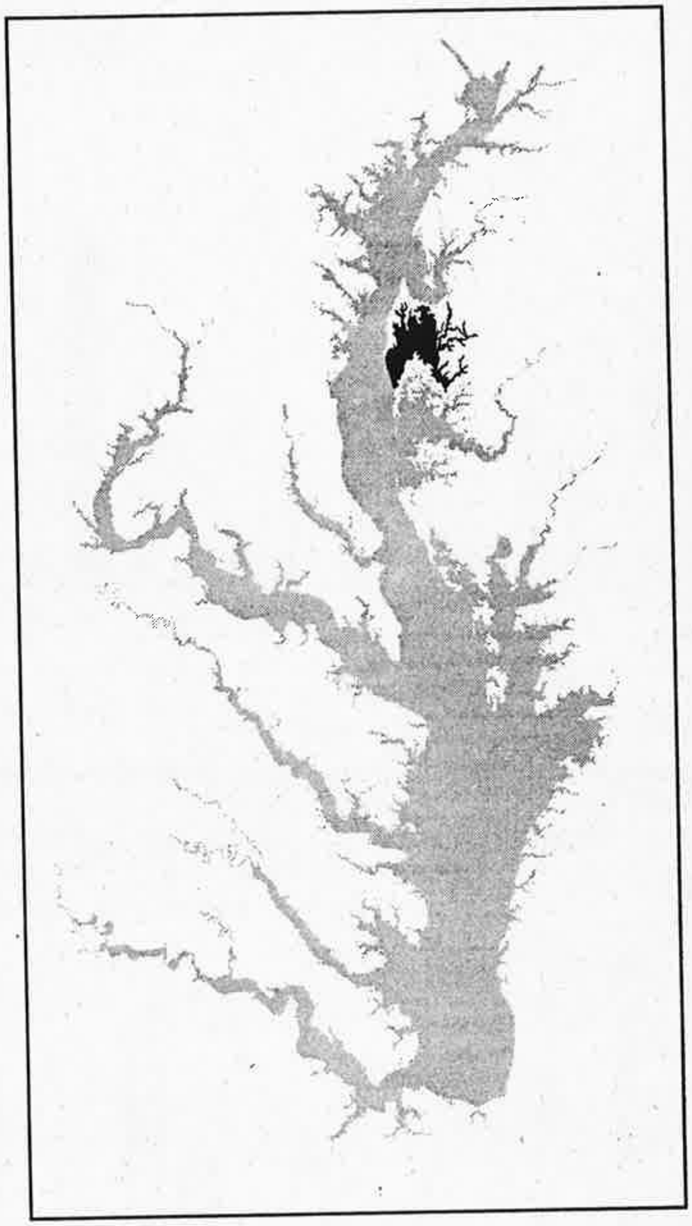


Figure 60. Percentage of Maryland Department of Natural Resources SAV Ground Survey Program stations sampled where SAV was observed for CBP Segment WT8 (South/Rhode/West Rivers).
Source: Chesapeake Bay Program, unpublished data c.

Eastern Bay



The Eastern Bay segment extends east of a line extending from Kent Point at the southern tip of Kent Island south to Tilghman Island. This segment also includes the Miles and Wye rivers and the many small tidal creeks and rivers entering Eastern Bay.

In the first baywide survey (1978), 1,440 hectares of SAV were mapped in Eastern Bay. This number represented a large proportion of the SAV in the entire mid-Bay area at that time (Figure 61, Table 24). By 1984, SAV distribution had dropped dramatically with only 89 hectares recorded, but it had increased to 899 hectares by 1987. By 1991, SAV abundance again had declined with only 68 hectares reported. Submerged aquatic vegetation was most abundant during the 1980s on the western side of Eastern Bay along the shores of Kent Island, Cox Creek, Crab Alley Bay, Prospect Bay, lower Miles River, and Parson Island.

The Maryland Department of Natural Resources ground survey reported consistently high percentages of vegetated stations in the early 1970s, with these percentages declining in the late 1970s (Figure 63). Between 1980 and 1991, the percentage of vegetated stations fluctuated widely reaching the second highest level of the 21-year survey in 1987 (47 percent) and then declining to the survey's lowest levels in 1989 (0 percent), 1990 (2 percent), and 1991 (9 percent). The patterns of SAV change documented here for the 1980s and early 1990s parallel the distribution patterns reported through the aerial survey, especially with the rapid spread (1985 and 1987) and subsequent decline of *R. maritima* (1990 and 1991).

Davis (1985) sampled Leeds Creek in 1979 for SAV seeds. This creek was extensively sampled for SAV seeds in 1977 and 1978 (Davis, unpublished data). Seeds of three species (*Z. palustris*, *P. pectinatus*, and *R. maritima*) were found. Their seeds were collected more frequently along the creek margins than in the center of the creek.

The 1990 U.S. Fish and Wildlife Service clam survey found SAV at only 9.9 percent of the 354 sites visited in Eastern Bay (Jorde et al., 1991). *Zannichellia palustris* was the only species reported.

Ruppia maritima has been the dominant species reported throughout this segment since the 1978 aerial survey. The 1986 and 1987 ground surveys documented *R. maritima* throughout East-

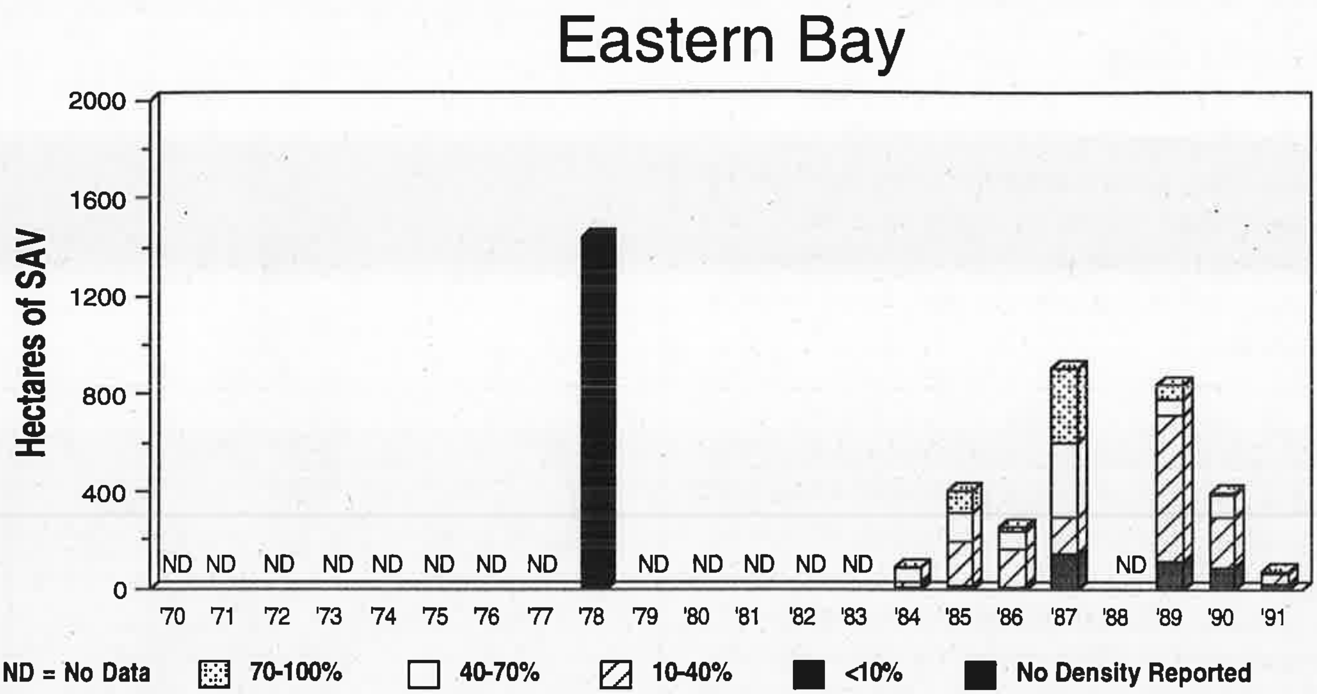


Figure 61. Hectares of SAV by density category for all years for which aerial survey data were available. For CBP Segment EE1 (Eastern Bay), the Tier I SAV restoration goal is 2,474 hectares.
Sources: Anderson and Macomber, 1980; Batiuk et al., 1992; Orth et al., 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Nowak, 1990.

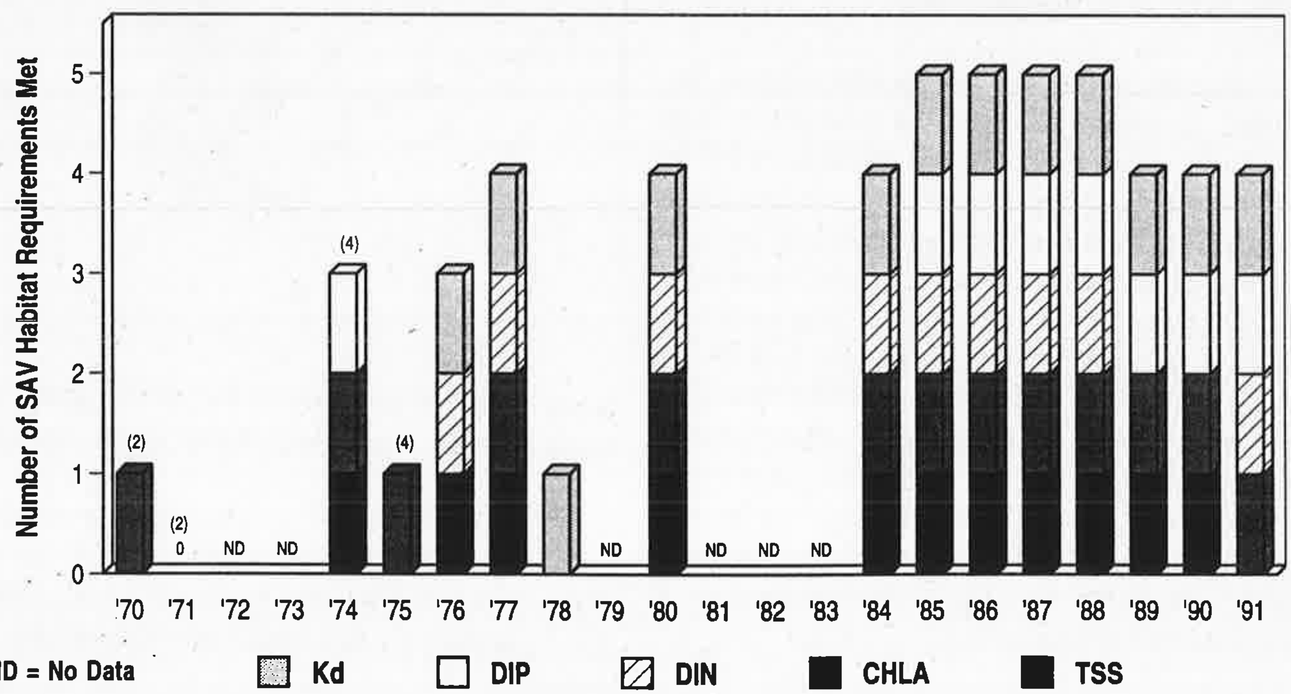


Figure 62. The number of SAV habitat requirements met over the SAV growing season from 1970 to 1991 for CBP Segment EE1 (Eastern Bay). No SAV habitat requirements met = 0; no water quality data available = ND. Sufficient data for the following parameters were not available to calculate growing season medians: Kd (1970-1975, 1979, 1981-1983); TSS (1970-1973, 1979, 1981-1983); CHLA (1972, 1973, 1979, 1981-1983); DIP (1972, 1973, 1979, 1981-1983); and DIN (1970-1973, 1979, 1981-1983). Numbers of SAV habitat requirements with growing season medians are shown above bars when some values were missing.
Sources: Chesapeake Bay Program, 1993a and 1993b.

Eastern Bay

Year	Hectares of SAV by Density Category <10%	10-40%	40-70%	70-100%	Segment Total	% of Tier I Restoration Goal	% of Tier III Restoration Goal
'70	-	-	-	-	-	-	-
'71	-	-	-	-	-	-	-
'72	-	-	-	-	-	-	-
'73	-	-	-	-	-	-	-
'74	-	-	-	-	-	-	-
'75	-	-	-	-	-	-	-
'76	-	-	-	-	-	-	-
'77	-	-	-	-	-	-	-
'78	-	-	-	-	1,439	58%	16%
'79	-	-	-	-	-	-	-
'80	-	-	-	-	-	-	-
'81	-	-	-	-	-	-	-
'82	-	-	-	-	-	-	-
'83	-	-	-	-	-	-	-
'84	4	23	57	4	88	4%	<1%
'85	10	188	114	88	400	16%	5%
'86	8	152	73	22	255	10%	3%
'87	145	151	302	301	899	36%	10%
'88	-	-	-	-	-	-	-
'89	115	602	64	52	833	34%	9%
'90	87	209	89	5	390	16%	4%
'91	20	39	3	6	68	3%	<1%

Table 24. Hectares of SAV by density category and percentage of Tier I SAV restoration goal (2,474 hectares) and Tier III SAV restoration target (8,815 hectares) are listed for 1970-1991 for CBP Segment EE1 (Eastern Bay). Sources: Anderson and Macomber, 1980; Batiuk et al., 1992; Orth et al., 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Nowak, 1990.

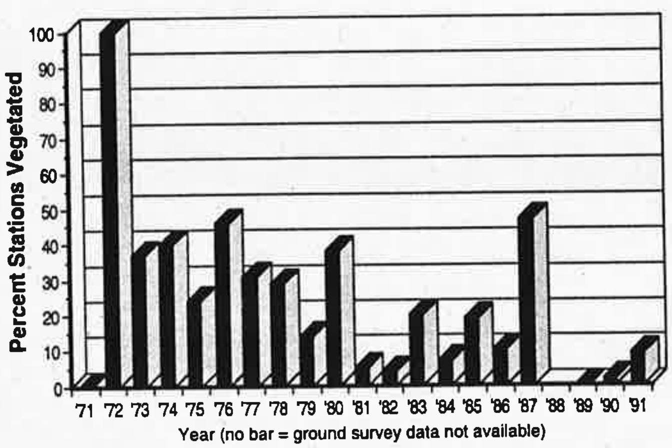


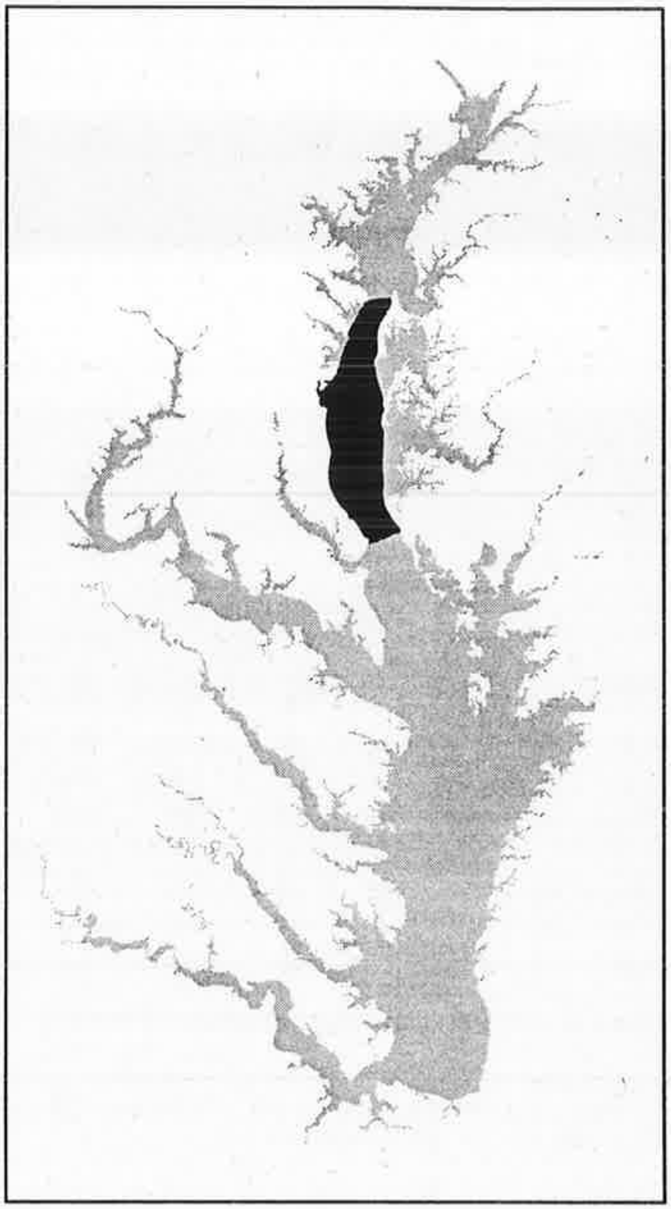
Figure 63. Percentage of Maryland Department of Natural Resources SAV Ground Survey Program stations sampled where SAV was observed for CBP Segment EE1 (Eastern Bay). Ground survey data were not available for 1988. Source: Chesapeake Bay Program, unpublished data c.

ern Bay, including numerous areas where SAV beds were not mapped through the aerial survey. Many of these areas were most likely small fringing beds that were not visible from the aerial photography, but they indicated the widespread occurrence of this species during those few years. The ground surveys also showed the rapid decline of SAV indicated by the aerial survey. Although several other species were documented (*Z. palustris*, *P. perfoliatus*, and *P. pectinatus*), their reported occurrence was much less than *R. maritima*.

Water quality for Eastern Bay met all five SAV habitat requirements from 1985 to 1988 and at least four of the five SAV habitat requirements between 1984 and 1991 (Figure 62). Rapid fluctuations of SAV in this segment even while the water quality seemed suitable (based on the SAV habitat requirements) remains problematic. A single station, located in the middle of Eastern Bay, was used to characterize 1984 to 1991 water quality conditions throughout this shallow embayment. This station may not be truly representative of water quality in shoal areas because the shoreline is highly dissected by smaller tidal tributaries. In addition, most or all of the SAV beds in this segment are monospecific and are composed of *R. maritima*. Fluctuations in abundance may occur naturally due to the biology of this species regardless of water quality.

Achievement of the Tier I restoration goal and the Tier III restoration target was highest in 1978 (58 percent and 16 percent, respectively) and lowest in 1991 (3 percent and <1 percent, respectively) (Table 24).

Middle Central Chesapeake Bay



The Middle Central Chesapeake Bay segment covers a broad area of the middle mainstem Bay, from the Chesapeake Bay Bridge south to Cove Point (just north of the Patuxent River mouth). Over the last two decades, no more than 77 hectares of SAV have been reported by the aerial survey, with only 12 hectares or less reported annually since 1986 (Figure 64, Table 25).

The Maryland Department of Natural Resources ground survey also reported very little SAV (0-2 percent of the stations vegetated) in this segment since 1971 (Figure 66). The 1990 U.S. Fish and Wildlife Service clam survey found SAV at only 2.2 percent of 45 sites visited, primarily in Herring Bay (Jorde et al., 1991). *Ruppia maritima* was the only species reported.

The shoreline of this segment is quite exposed. Because of high wave and current energy, much shoal habitat is unsuitable for SAV growth. A considerable amount of bottom habitat under two meters in depth remains, however, along the shorelines of Kent Island and below the Little Choptank River and at the mouths of Eastern Bay and the Choptank River that could potentially support SAV.

Some ground surveys reported SAV in small tidally-influenced ponds and creeks along this segment's shorelines (e.g., along the western shore of Kent Island). Species reported from this segment were *C. demersum*, *Z. palustris*, *P. pectinatus*, *M. spicatum*, *P. perfoliatus*, and *R. maritima*.

Water quality in this mainstem Bay segment met all five SAV habitat requirements from 1984 to 1988 and in 1991; four of the five SAV habitat requirements were met in 1989 and 1990 (Figure 65). In 1978, achievement of the Tier I restoration goal and the Tier III restoration target was 75 percent and 2 percent, respectively, which declined to 2 percent and <1 percent, respectively, by 1991 (Table 25). Excessive wave energy and currents and the lack of a sufficient local source of propagules— rather than unsuitable water quality conditions—may be preventing SAV from gaining a foothold in most of the potential habitats described above.

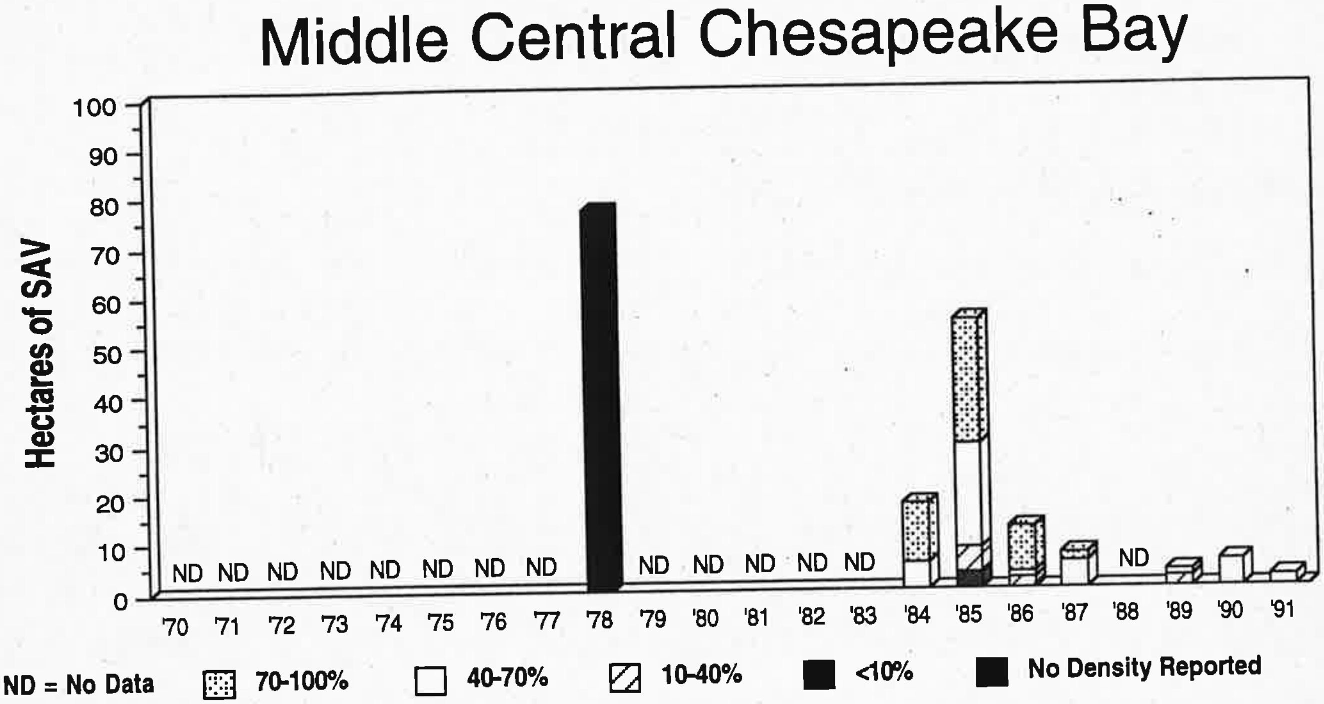


Figure 64. Hectares of SAV by density category for all years for which aerial survey data were available. For CBP Segment CB4 (Middle Central Chesapeake Bay), the Tier I SAV restoration goal is 103 hectares.
Sources: Anderson and Macomber, 1980; Batiuk, 1992; Orth et al., 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Nowak, 1990.

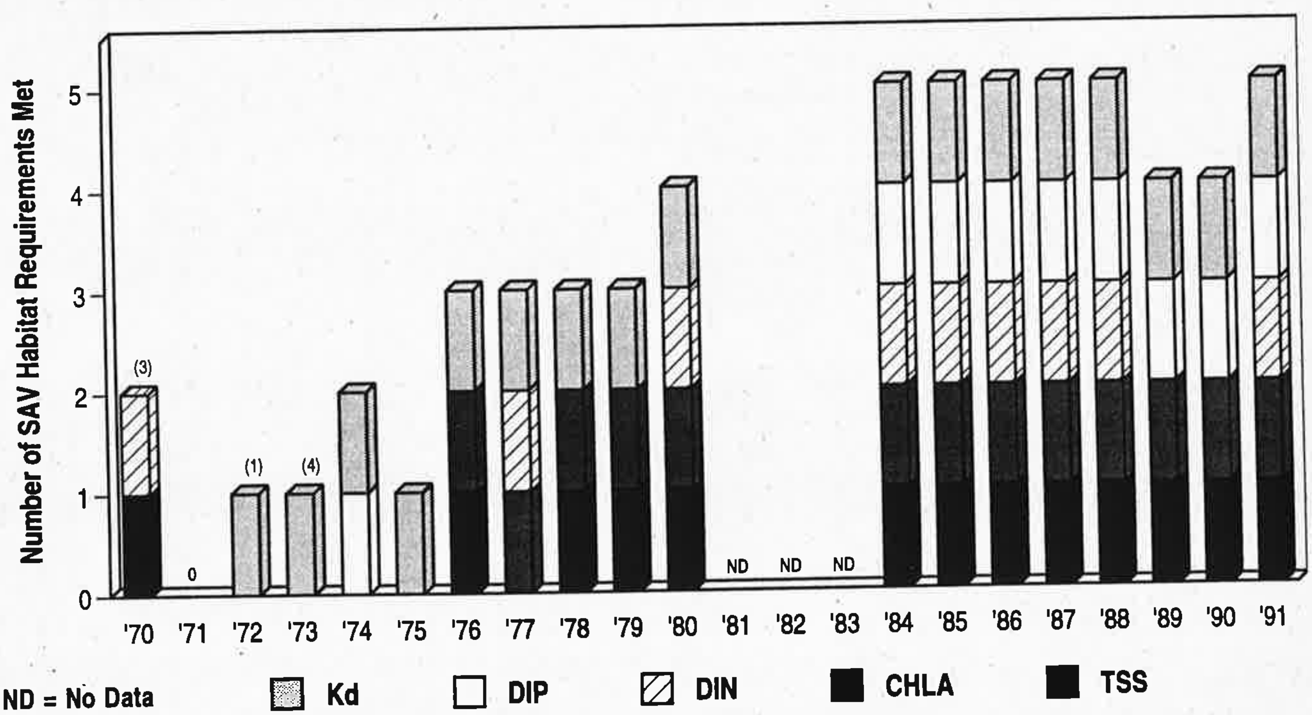


Figure 65. The number of SAV habitat requirements met over the SAV growing season from 1970 to 1991 for CBP Segment CB4 (Middle Central Chesapeake Bay). No SAV habitat requirements met = 0; no water quality data available = ND. Sufficient data for the following parameters were not available to calculate growing season medians: Kd (1970, 1971, 1981-1983); TSS (1971-1973, 1981-1983); CHLA (1970-1972, 1981-1983); DIP (1971, 1972, 1981-1983); and DIN (1971, 1972, 1981-1983). Numbers of SAV habitat requirements with growing season medians are shown above bars when some values were missing.
Sources: Chesapeake Bay Program, 1993a and 1993b.

Middle Central Chesapeake Bay

Year	Hectares of SAV by Density Category <10%	10-40%	40-70%	70-100%	Segment Total	% of Tier I Restoration Goal	% of Tier III Restoration Goal
'70	-	-	-	-	-	-	-
'71	-	-	-	-	-	-	-
'72	-	-	-	-	-	-	-
'73	-	-	-	-	-	-	-
'74	-	-	-	-	-	-	-
'75	-	-	-	-	-	-	-
'76	-	-	-	-	-	-	-
'77	-	-	-	-	-	-	-
'78	-	-	-	-	77	75%	2%
'79	-	-	-	-	-	-	-
'80	-	-	-	-	-	-	-
'81	-	-	-	-	-	-	-
'82	-	-	-	-	-	-	-
'83	-	-	-	-	-	-	-
'84	0	0	5	12	17	17%	<1%
'85	3	5	21	25	54	52%	1%
'86	0	2	<1	9	12	12%	<1%
'87	0	0	5	2	7	7%	<1%
'88	-	-	-	-	-	-	-
'89	0	2	<1	0	3	3%	<1%
'90	0	0	5	0	5	5%	<1%
'91	0	<1	2	0	2	2%	< 1%

Table 25. Hectares of SAV by density category and percentage of Tier I SAV restoration goal (103 hectares) and Tier III SAV restoration target (3,496 hectares) are listed for 1970 to 1991 for CBP Segment CB4 (Middle Central Chesapeake Bay).
Sources: Anderson and Macomber, 1980; Batiuk et al., 1992; Orth et al., 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Nowak, 1990.

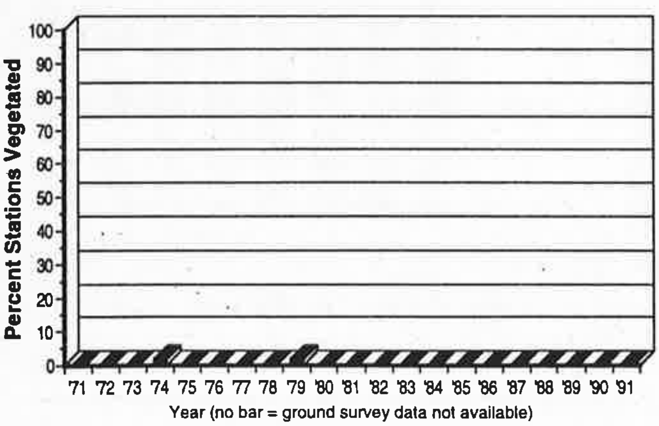
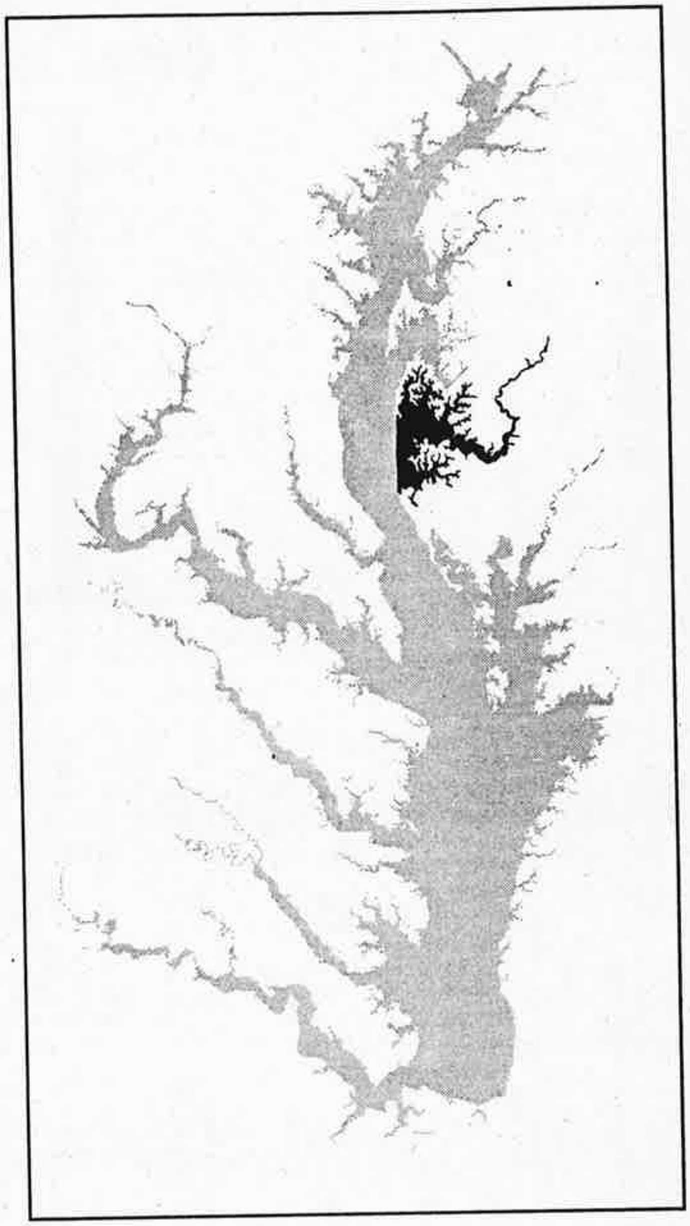


Figure 66. Percentage of Maryland Department of Natural Resources SAV Ground Survey Program stations sampled where SAV was observed for CBP Segment CB4 (Middle Central Chesapeake Bay).
Source: Chesapeake Bay Program, unpublished data c.

Choptank River



The Choptank River region includes the Choptank and Little Choptank rivers, the many small creeks and rivers entering the Choptank River (e.g., Harris and Broad creeks and the Tred Avon River), and the broad lower Choptank River extending from the mainstem Bay to Cambridge, Maryland. Extensive documentation exists on the recent history of SAV distribution in the Choptank River because of its proximity to the University of Maryland Horn Point Environmental Laboratory and the regular monitoring of many SAV beds in this river (Stevenson et al., 1993).

The greatest distribution of SAV reported through the aerial survey program was in 1978 when 1,999 hectares were reported in the lower Choptank and Little Choptank rivers (Figure 67, Table 26), and 100 hectares were mapped in the Choptank River (Figure 69, Table 27). By 1984, SAV had declined dramatically; only 86 hectares were mapped in the lower Choptank and Little Choptank rivers while no SAV was recorded in the Choptank River. In the lower Choptank and Little Choptank rivers, SAV distribution increased substantially by 1985 (1,778 hectares), but has fluctuated widely from 1985 through 1991. In 1991, 112 hectares were reported. Submerged aquatic vegetation has consistently been present in several areas, notably Blackwalnut and Cook Point coves at the mouth of the Choptank River, Chapel Creek, the mouth of both Harris and Broad creeks, and Brannock Bay. Although SAV was abundant in the Little Choptank River in the early 1980s, very little SAV has been mapped in recent years. Small beds of SAV were mapped in the Choptank River (36 hectares in 1985 and 10 hectares in 1986), however, no SAV has been mapped upriver from the Route 50 Choptank River bridge at Cambridge, Maryland since 1986.

The Maryland Department of Natural Resources ground survey reported abundant SAV in the lower Choptank and Little Choptank rivers in the 1970s, with the percentage of vegetated stations declining and remaining low from the early to mid-1980s (Figure 71). The percentage of vegetated stations increased in the late 1980s, with the highest number reported in 1988 (45 percent), declining to only 4 percent by 1991. Very few of the stations in the Choptank River had SAV in the 1970s; after 1980, SAV was not found at any of the stations (Figure 72). The survey documented *Z. marina* in the lower portions of the Choptank and Little Choptank rivers in the 1970s, but this species has not been found since the late 1970s by any survey

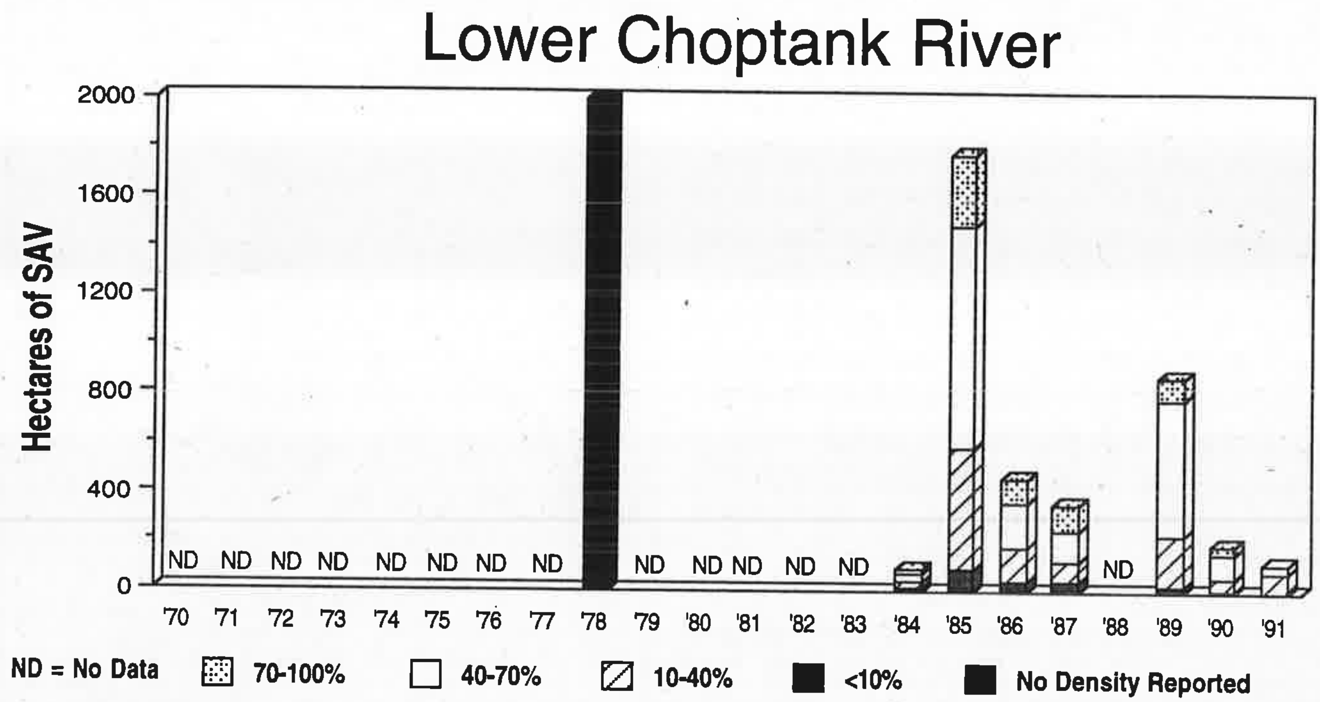


Figure 67. Hectares of SAV by density category for all years for which aerial survey data were available. For CBP Segment EE2 (Lower Choptank River), the Tier I SAV restortation target is 3,646 hectares.
Sources: Anderson and Macomber, 1980; Batiuk et al., 1992; Orth et al., 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Nowak, 1990.

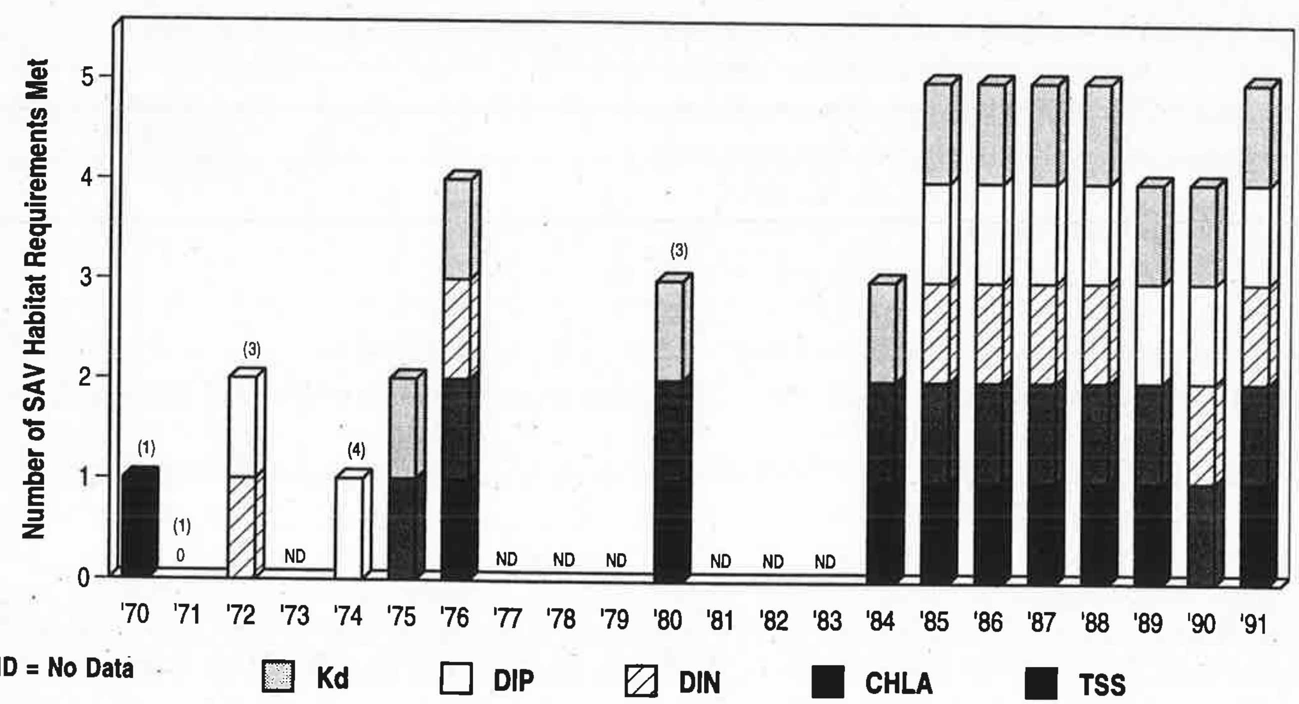


Figure 68. The number of SAV habitat requirements met over the SAV growing season from 1970 to 1991 for CBP Segment EE2 (Lower Choptank River). No SAV habitat requirements met = 0; no water quality data available = ND. Sufficient data for the following parameters were not available to calculate growing season medians: Kd (1970-1974, 1977-1979, 1981-1983); TSS (1972, 1973, 1977-1979, 1981-1983); CHLA (1970, 1971, 1973, 1977-1979, 1981-1983); DIP (1970, 1971, 1973, 1977-1983); and DIN (1970, 1971, 1973, 1977-1983). Numbers of SAV habitat requirements with growing season medians are shown above bars when some values were missing.
Sources: Chesapeake Bay Program, 1993a and 1993b.

of this region. *Ruppia maritima* was the only species reported by the survey in recent years. The overall pattern of change in SAV recorded through the ground survey is similar to that documented through the aerial survey (Figures 67 and 69).

The 1990 U.S. Fish and Wildlife Service clam survey found SAV at only 4.3 percent of the 508 sites visited (Jorde et al., 1991). The sites with SAV were primarily those closest to the Choptank River mouth. *Zannichellia palustris* was the only species reported.

Ruppia maritima was the dominant species reported by ground surveys associated with the aerial survey program throughout both the Choptank and Little Choptank rivers. *Zannichellia palustris* and *P. pectinatus* were the only other species reported from these segments. University of Maryland Horn Point Environmental Laboratory scientists had limited success in transplanting *R. maritima* and *P. pectinatus* between 1984 and 1987 (Stevenson et al., 1993). Virginia Institute of Marine Science and Horn Point Environmental Laboratory scientists planted *Z. marina* seeds off Tilghman Island in 1988 and again in 1989, as well as at the mouth of Irish Creek and Brannock Bay in 1989. Although seeds germinated and showed some springtime growth in both years, the plants did not survive a full year (Orth, unpublished data).

Water quality in the lower Choptank and Little Choptank rivers met all five SAV habitat requirements from 1985 to 1988 and in 1991, with four of the five SAV habitat requirements met in 1988 and 1989 (Figure 68). Data from a single station in the middle of the lower Choptank River, combined with data from one station in the middle of the Little Choptank River, were used to characterize water quality conditions from 1984 to 1991 for this segment. As in Eastern Bay, the rapid fluctuation of SAV in this segment, even though the water quality appeared suitable based on the SAV habitat requirements, remains problematic.

Lower Choptank River

Year	Hectares of SAV by Density Category				Segment Total	% of Tier I Restoration Goal	% of Tier III Restoration Goal
	<10%	10-40%	40-70%	70-100%			
'70	-	-	-	-	-	-	-
'71	-	-	-	-	-	-	-
'72	-	-	-	-	-	-	-
'73	-	-	-	-	-	-	-
'74	-	-	-	-	-	-	-
'75	-	-	-	-	-	-	-
'76	-	-	-	-	-	-	-
'77	-	-	-	-	-	-	-
'78	-	-	-	-	1,999	55%	17%
'79	-	-	-	-	-	-	-
'80	-	-	-	-	-	-	-
'81	-	-	-	-	-	-	-
'82	-	-	-	-	-	-	-
'83	-	-	-	-	-	-	-
'84	11	26	32	17	86	2%	<1%
'85	88	497	900	293	1,778	49%	15%
'86	39	140	179	101	459	13%	4%
'87	40	79	125	109	353	10%	3%
'88	-	-	-	-	-	-	-
'89	18	208	552	89	867	24%	7%
'90	2	52	101	33	188	5%	2%
'91	1	78	33	0	112	3%	1%

Table 26. Hectares of SAV by density category and percentage of Tier I SAV restoration goal (3,646 hectares) and Tier III SAV restoration target (11,648 hectares) are listed for 1970 to 1991 for CBP Segment EE2 (Lower Choptank River).
Sources: Anderson and Macomber, 1980; Batiuk et al., 1992; Orth et al., 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Nowak, 1990.

Again, data from the two mid-embayment stations may not be fully representative of water quality in the shoal areas where the shoreline is highly dissected by smaller tidal tributaries. In addition, most if not all SAV beds in this segment are monospecific (*R. maritima*) and fluctuations in abundance may occur regardless of water quality. In the adjacent segment, for the remaining upriver portion of the Choptank River, water quality conditions rarely met two of the five SAV habitat requirements (Figure 70).

Achievement of the Tier I restoration goal and the Tier III restoration target in the lower

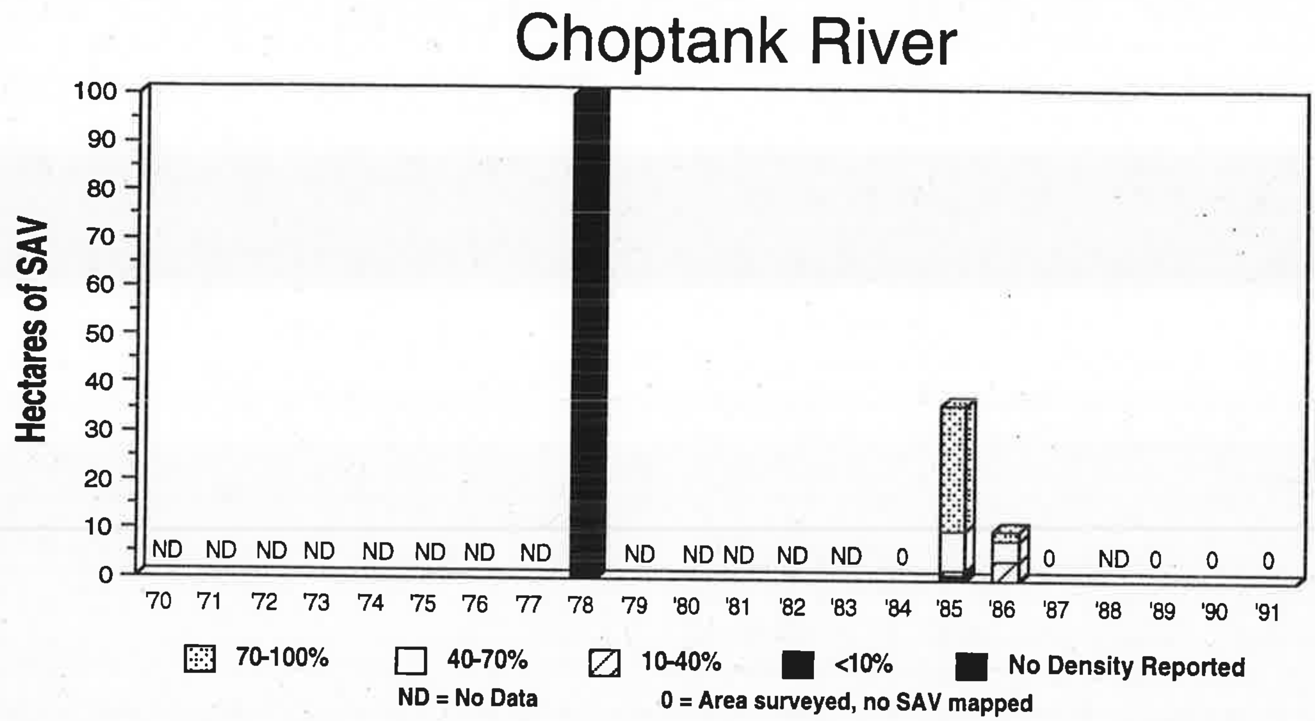


Figure 69. Hectares of SAV by density category for all years for which aerial survey data were available. For CBP Segment ET5 (Choptank River), the Tier I SAV restoration goal is 191 hectares.
Sources: Anderson and Macomber, 1980; Batiuk et al., 1992; Orth et al,. 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Nowak, 1990.

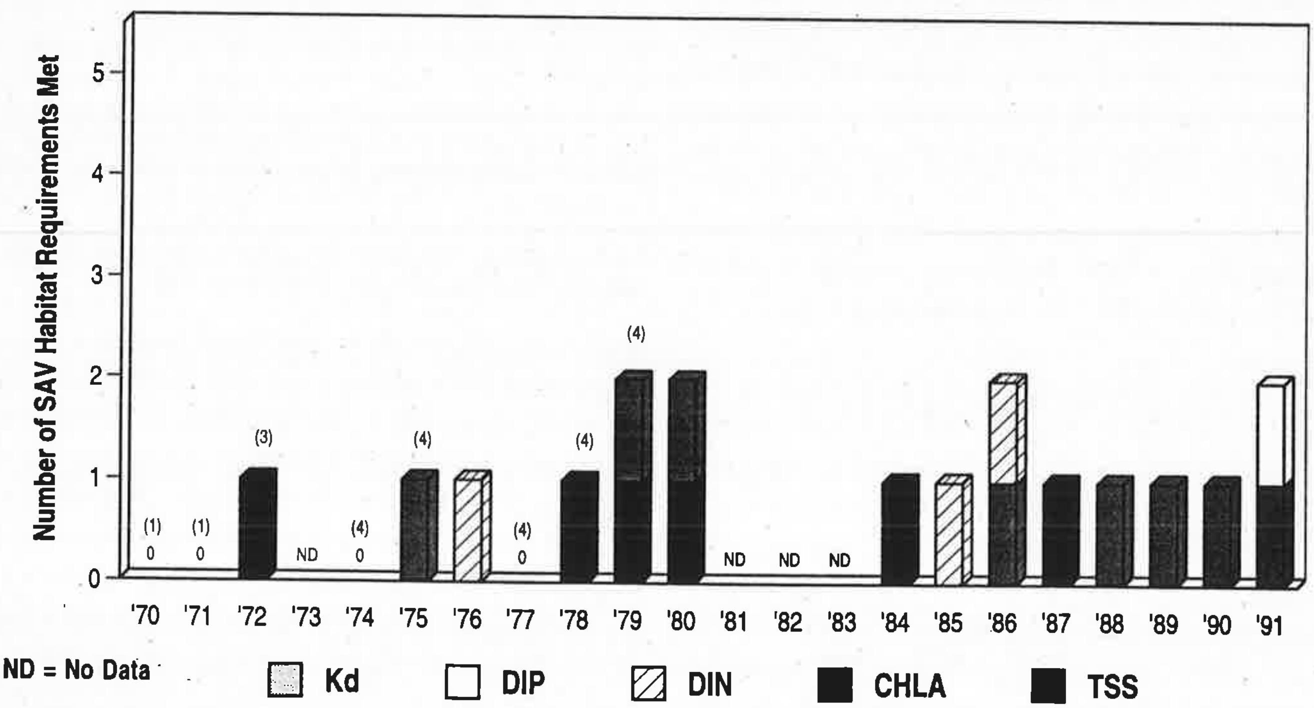


Figure 70. The number of SAV habitat requirements met over the SAV growing season from 1970 to 1991 for CBP Segment ET5 (Choptank River). No SAV habitat requirements met = 0; no water quality data available = ND. Sufficient data for the following parameters were not available to calculate growing season medians: Kd (1970-1975, 1977-1979, 1981-1983); TSS (1973, 1981-1983); CHLA (1970, 1971, 1973, 1981-1983); DIN (1970-73, 1981-1983); and DIP (1970, 1971, 1973, 1981-1983).
Sources: Chesapeake Bay Program, 1993a and 1993b.

Choptank River

Year	Hectares of SAV by Density Category <10%	10-40%	40-70%	70-100%	Segment Total	% of Tier I Restoration Goal	% of Tier III Restoration Goal
'70	-	-	-	-	-	-	-
'71	-	-	-	-	-	-	-
'72	-	-	-	-	-	-	-
'73	-	-	-	-	-	-	-
'74	-	-	-	-	-	-	-
'75	-	-	-	-	-	-	-
'76	-	-	-	-	-	-	-
'77	-	-	-	-	-	-	-
'78	-	-	-	-	100	52%	3%
'79	-	-	-	-	-	-	-
'80	-	-	-	-	-	-	-
'81	-	-	-	-	-	-	-
'82	-	-	-	-	-	-	-
'83	-	-	-	-	-	-	-
'84	0	0	0	0	0	0%	0%
'85	<1	1	8	26	36	19%	1%
'86	0	4	4	2	10	5%	<1%
'87	0	0	0	0	0	0%	0%
'88	-	-	-	-	-	-	-
'89	0	0	0	0	0	0%	0%
'90	0	0	0	0	0	0%	0%
'91	0	0	0	0	0	0%	0%

Table 27. Hectares of SAV by density category and percentage of Tier I (191 hectares) SAV restoration goal and Tier III (3,009 hectares) SAV restoration target are listed for 1970 to 1991 for CBP Segment ET5 (Choptank River). Sources: Anderson and Macomber, 1980; Batiuk et al., 1992; Orth et al., 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Nowak, 1990.

Choptank and Little Choptank rivers was highest in 1978 (55 percent and 15 percent, respectively) and lowest in 1984 (2 percent and <1 percent, respectively) (Table 26). The absence of SAV in the Choptank River, as documented through the aerial survey, has resulted in 0 percent achievement of both the Tier I goal and the Tier III target since 1987 (Table 27).

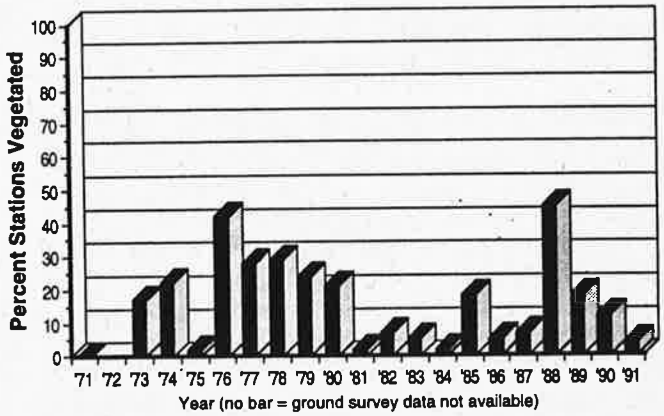


Figure 71. Percentage of Maryland Department of Natural Resources SAV Ground Survey Program stations sampled where SAV was observed for CBP Segment EE2 (Lower Choptank River). Ground survey data were not available for 1971 and 1972.
Source: Chesapeake Bay Program, unpublished data c.

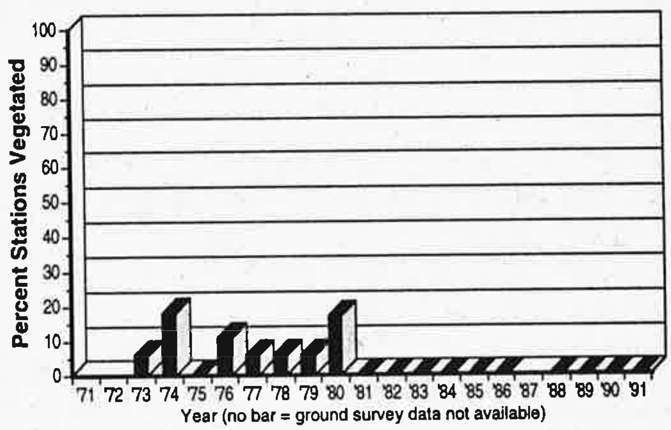
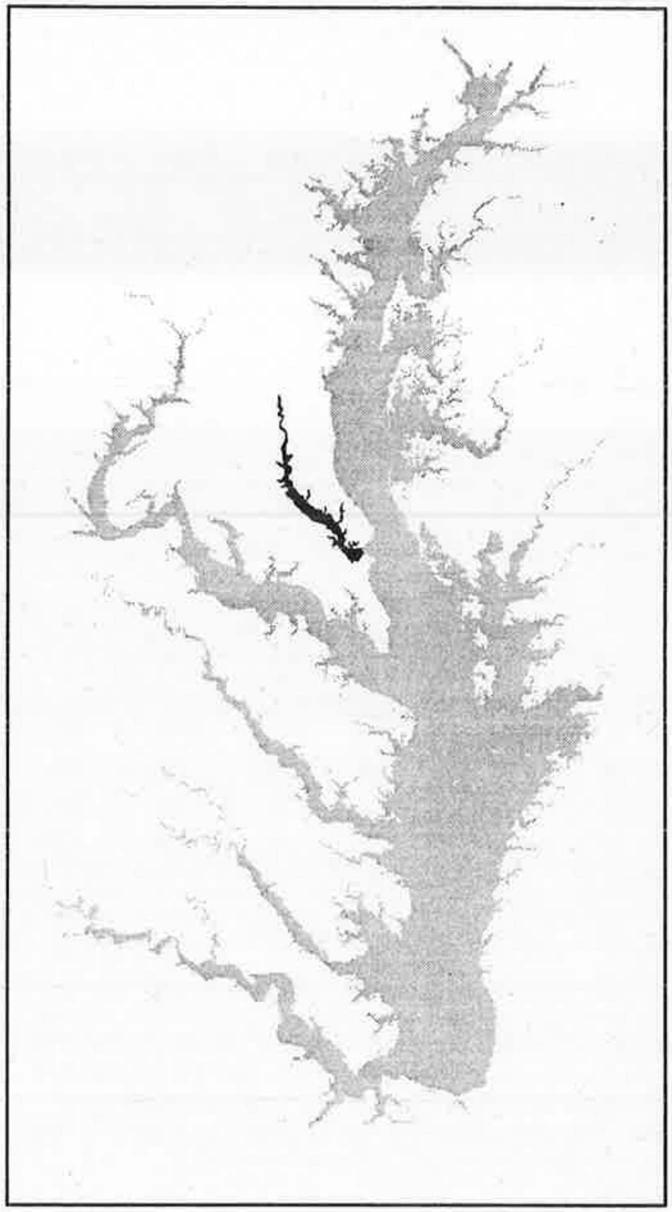


Figure 72. Percentage of Maryland Department of Natural Resources SAV Ground Survey Program stations sampled where SAV was observed for CBP Segment ET5 (Choptank River). Ground survey data were not available for 1971, 1972, and 1987.
Source: Chesapeake Bay Program, unpublished data c.

Patuxent River



Over the last two decades, the Patuxent River has had very limited stands of SAV—documented through the baywide aerial survey and the Maryland Department of Natural Resources ground survey. This situation contrasts with earlier years when ground surveys reported beds of SAV in many sections of the river and historical aerial photographs showed dense stands of SAV in the lower Patuxent River. *Zostera marina* was reported around Solomons Island in the late 1940s (Elser, 1969) and prior to 1971 (Boynton, personal communication). Other species noted during these years by Stewart (1962), Anderson (1969), and Bayley et al. (1978) were *Z. palustris*, *E. canadensis*, *P. perfoliatus*, *P. pectinatus*, *N. flexilis*, and *R. maritima*.

The baywide aerial survey has reported no more than 55 hectares of SAV in any one year throughout the river (Figures 73, 75, and 77; Tables 28, 29, and 30). Submerged aquatic vegetation was concentrated in the lower Patuxent River around Broomes Island in the middle to late 1980s.

The Maryland Department of Natural Resources ground survey reported almost no SAV at 50 stations sampled in the lower and middle Patuxent River and no SAV in the upper Patuxent River between 1971 and 1989 (Figures 79 and 80). These findings confirm the results of the aerial survey, although drift SAV was commonly observed and recorded.

Ruppia maritima, *M. spicatum*, *Z. palustris*, and *P. pectinatus* were the species reported most frequently by ground surveys in the lower and middle sections of the river. The Maryland Capital Parks and Planning Commission and other surveys found numerous species in the upper reaches of the river (above Deep Landing, but primarily above Jug Bay) including *V. americana*, *N. guadalupensis*, *E. canadensis*, *N. minor*, *N. gracillima*, *C. demersum*, *Z. palustris*, *P. perfoliatus*, *P. pectinatus*, *P. crispus*, and *P. pusillus*. Many of these species were observed in numerous small tidal creeks entering the mainstem Patuxent River and cannot be mapped using 1:24,000 scale aerial photography.

In the lower Patuxent River, all SAV habitat requirements were met in 1985, 1990, and 1991 with three to four SAV habitat requirements achieved during the remaining four years since 1985 (Figure 74). Water quality conditions in the middle and upper Patuxent River seldom met more than one SAV habitat requirement (Figures 76 and 78).

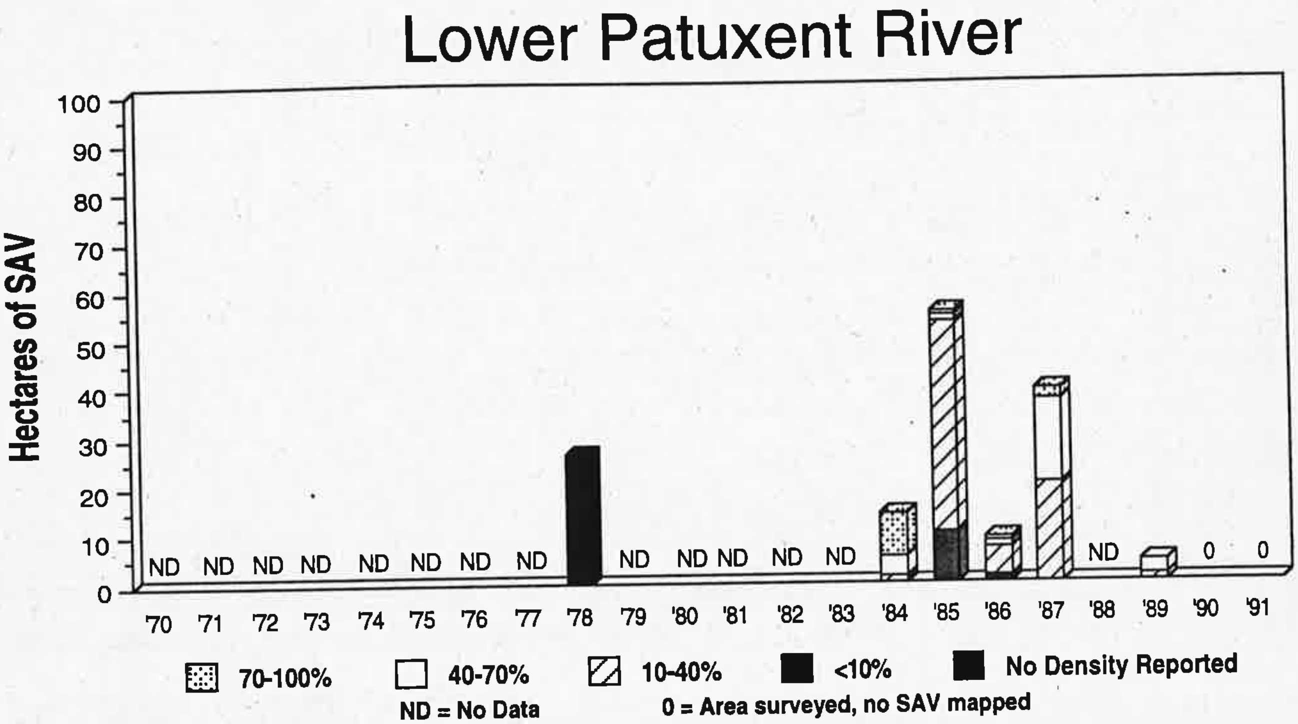


Figure 73. Hectares of SAV by density category for all years for which aerial survey data were available. For CBP Segment LE1 (Lower Patuxent River), the Tier I SAV restoration goal is 132 hectares.
Sources: Anderson and Macomber, 1980; Batiuk et al., 1992; Orth et al., 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Nowak, 1990.

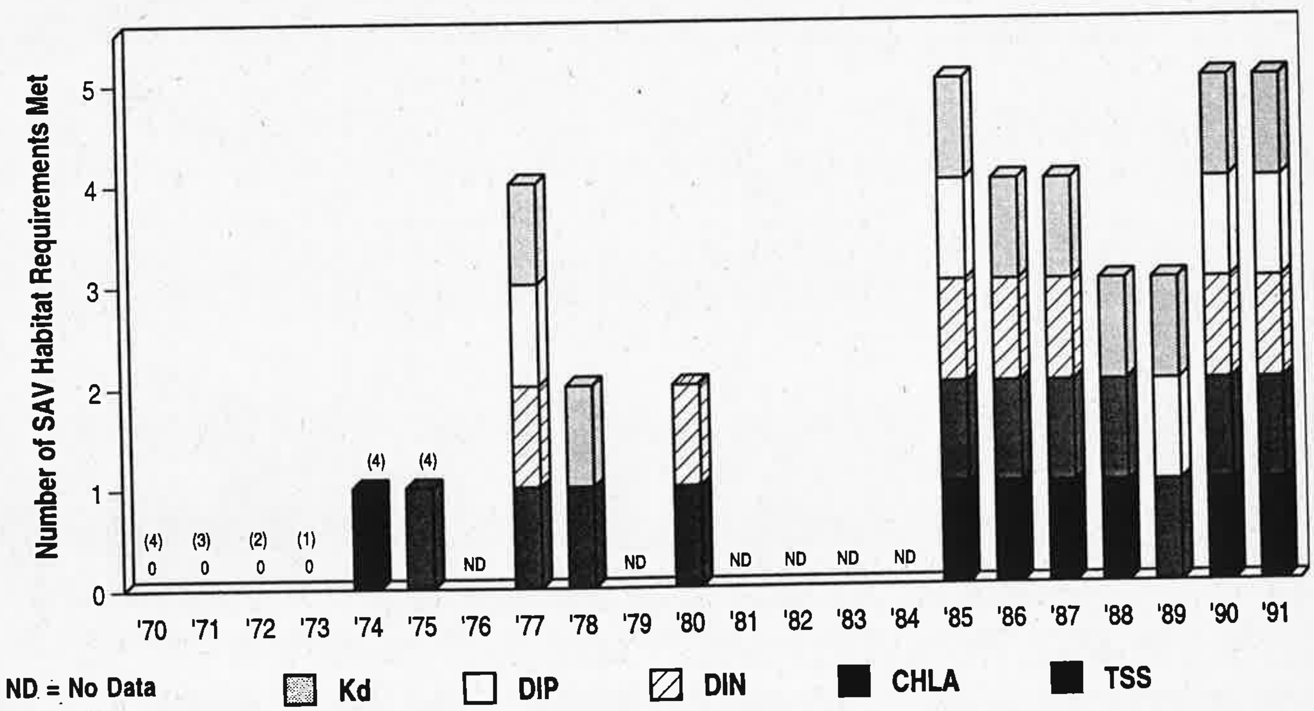


Figure 74. The number of SAV habitat requirements met over the SAV growing season from 1970 to 1991 for CBP Segment LE1 (Lower Patuxent River). No SAV habitat requirements met = 0; no water quality data available = ND. Sufficient data for the following parameters were not available to calculate growing season medians: Kd (1970-1976, 1979, 1981-1984); TSS (1973, 1976, 1979, 1981-1984); CHLA (1971-1973, 1976, 1979, 1981-1984); DIP (1976, 1979, 1981-1984); and DIN (1972, 1973, 1976, 1979, 1981-1984). Numbers of SAV habitat requirements with growing season medians are shown above bars when some values were missing.
Sources: Chesapeake Bay Program, 1993a and 1993b.

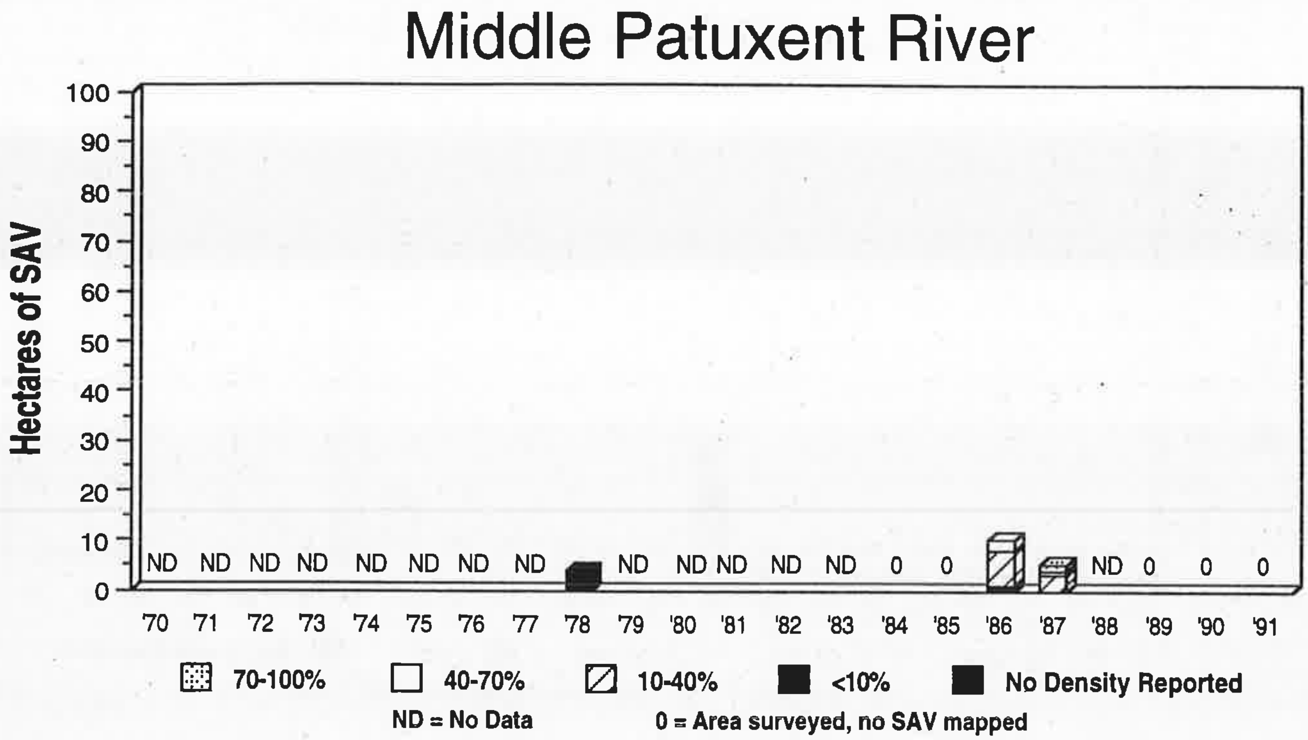


Figure 75. Hectares of SAV by density category for all years for which aerial survey data were available. For CBP Segment RET1 (Middle Patuxent River), the Tier I SAV restoration goal is 16 hectares.
Sources: Anderson and Macomber, 1980; Batiuk et al., 1992; Orth et al., 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Nowak, 1990.

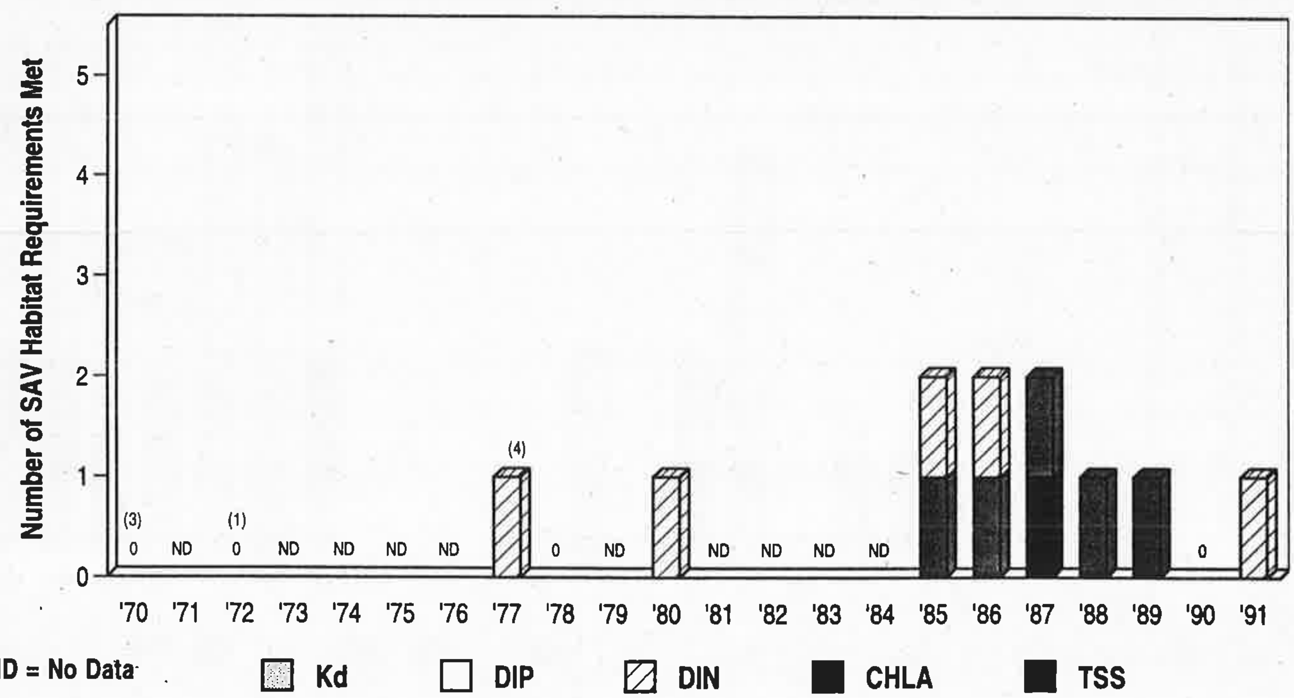


Figure 76. The number of SAV habitat requirements met over the SAV growing season from 1970 to 1991 for CBP Segment RET1 (Middle Patuxent River). No SAV habitat requirements met = 0; no water quality data available = ND. Sufficient data for the following parameters were not available to calculate growing season medians: Kd (1971-1976, 1979, 1981-1984); TSS (1970-1977, 1979, 1981-1984); CHLA (1971-1976, 1979, 1981-1984); DIP (1971, 1973-1976, 1979, 1981-1984); and DIN (1970-1976, 1979, 1981-1984). Numbers of SAV habitat requirements with growing season medians are shown above bars when some values were missing.
Sources: Chesapeake Bay Program, 1993a and 1993b.

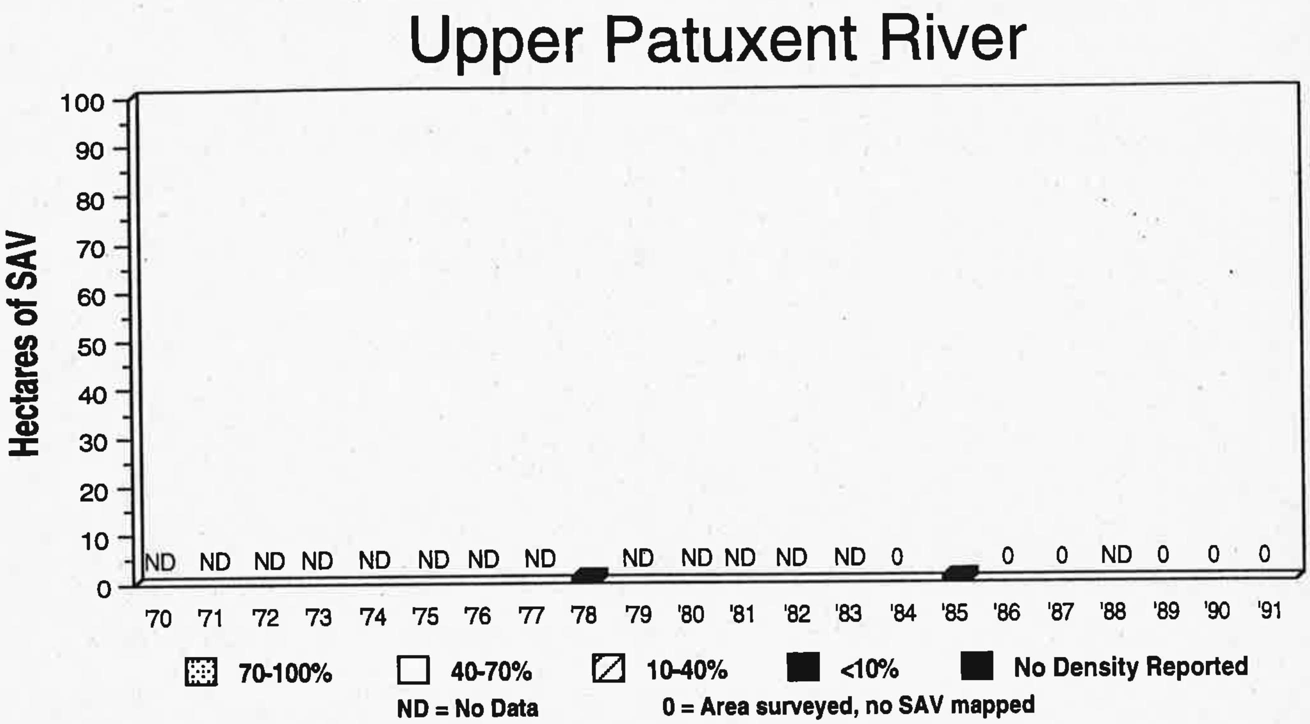


Figure 77. Hectares of SAV by density category for all years for which aerial survey data were available. For CBP Segment TF1 (Upper Patuxent River), the Tier I SAV restoration goal is six hectares.
Sources: Anderson and Macomber, 1980; Batiuk et al., 1992; Orth et al., 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Nowak, 1990.

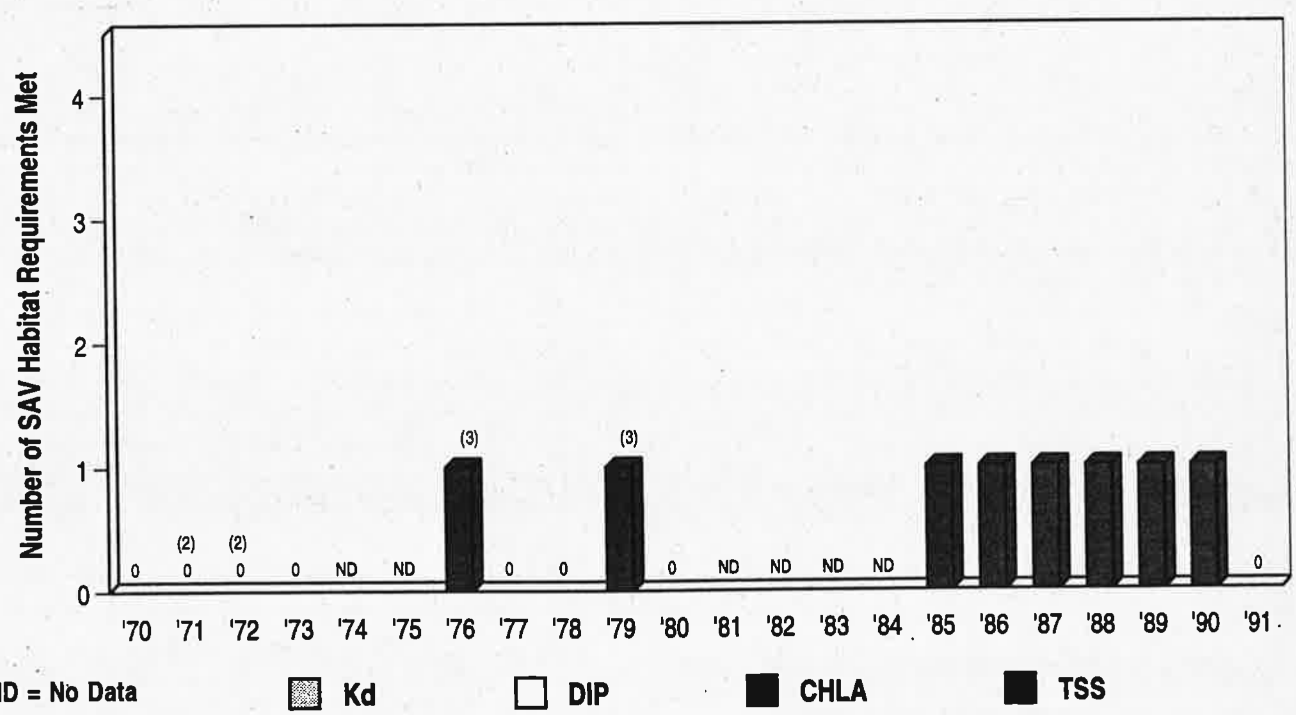


Figure 78. The number of SAV habitat requirements met over the SAV growing season from 1970 to 1991 for CBP Segment TF1 (Upper Patuxent River). No SAV habitat requirements met = 0; no water quality data available = ND. Sufficient data for the following parameters were not available to calculate growing season medians: Kd (1971-1976, 1979, 1981-1984); TSS (1973, 1981-1984); CHLA (1971-1973, 1981-1984); and DIP (1973, 1981-1984). Numbers of SAV habitat requirements with growing season medians are shown above bars when some values were missing.
Sources: Chesapeake Bay Program, 1993a and 1993b.

Lower Patuxent River

Year	Hectares of SAV by Density Category <10%	10-40%	40-70%	70-100%	Segment Total	% of Tier I Restoration Goal	% of Tier III Restoration Goal
'70	-	-	-	-	-	-	-
'71	-	-	-	-	-	-	-
'72	-	-	-	-	-	-	-
'73	-	-	-	-	-	-	-
'74	-	-	-	-	-	-	-
'75	-	-	-	-	-	-	-
'76	-	-	-	-	-	-	-
'77	-	-	-	-	-	-	-
'78	-	-	-	-	26	20%	<1%
'79	-	-	-	-	-	-	-
'80	-	-	-	-	-	-	-
'81	-	-	-	-	-	-	-
'82	-	-	-	-	-	-	-
'83	-	-	-	-	-	-	-
'84	0	1	4	9	14	11%	<1%
'85	10	43	1	<1	55	42%	2%
'86	<1	6	<1	1	9	7%	<1%
'87	0	20	17	2	39	30%	1%
'88	-	-	-	-	-	-	-
'89	0	<1	3	0	4	3%	<1%
'90	0	0	0	0	0	0%	0%
'91	0	0	0	0	0	0%	0%

Table 28. Hectares of SAV by density category and percentage of Tier I SAV restoration goal (132 hectares) and Tier III SAV restoration target (2,653 hectares) are listed for 1970 to 1991 for CBP Segment LE1 (Lower Patuxent River).
Sources: Anderson and Macomber 1980; Batiuk et al., 1992; Orth et al., 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Nowak, 1990.

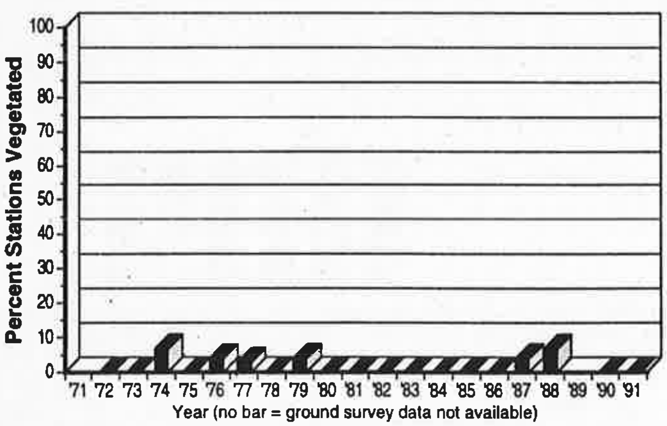


Figure 79. Percentage of Maryland Department of Natural Resources SAV Ground Survey Program stations sampled where SAV was observed for CBP Segment LE1 (Lower Patuxent River). Ground survey data were not available for 1971 and 1989.
Source: Chesapeake Bay Program, unpublished data c.

Middle Patuxent River

Year	Hectares of SAV by Density Category <10%	10-40%	40-70%	70-100%	Segment Total	% of Tier I Restoration Goal	% of Tier III Restoration Goal
'70	-	-	-	-	-	-	-
'71	-	-	-	-	-	-	-
'72	-	-	-	-	-	-	-
'73	-	-	-	-	-	-	-
'74	-	-	-	-	-	-	-
'75	-	-	-	-	-	-	-
'76	-	-	-	-	-	-	-
'77	-	-	-	-	-	-	-
'78	-	-	-	-	4	25%	<1%
'79	-	-	-	-	-	-	-
'80	-	-	-	-	-	-	-
'81	-	-	-	-	-	-	-
'82	-	-	-	-	-	-	-
'83	-	-	-	-	-	-	-
'84	0	0	0	0	0	0%	0%
'85	0	0	0	0	0	0%	0%
'86	<1	7	2	0	10	63%	1%
'87	0	3	<1	<1	5	31%	<1%
'88	-	-	-	-	-	-	-
'89	0	0	0	0	0	0%	0%
'90	0	0	0	0	0	0%	0%
'91	0	0	0	0	0	0%	0%

Table 29. Hectares of SAV by density category and percentage of Tier I SAV restoration goal (16 hectares) and Tier III SAV restoration target (959 hectares) are listed for 1970 to 1991 for CBP Segment RET1 (Middle Patuxent River).
Sources: Anderson and Macomber, 1980; Batiuk et al., 1992; Orth et al., 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Nowak, 1990.

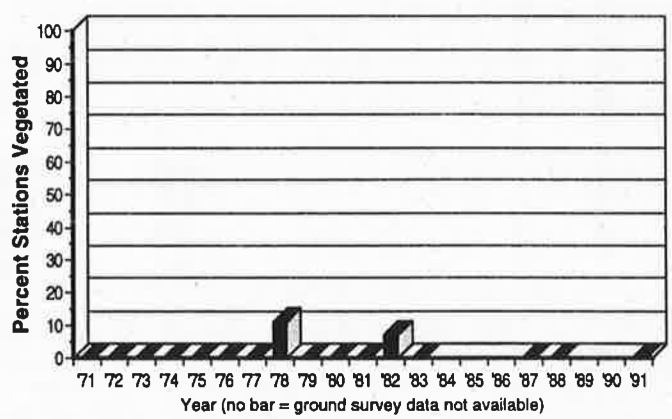


Figure 80. Percentage of Maryland Department of Natural Resources SAV Ground Survey Program stations sampled where SAV was observed for CBP Segment RET1 (Middle Patuxent River). Ground survey data were not available for 1984, 1985, 1986, 1989, and 1990.
Source: Chesapeake Bay Program, unpublished data c.

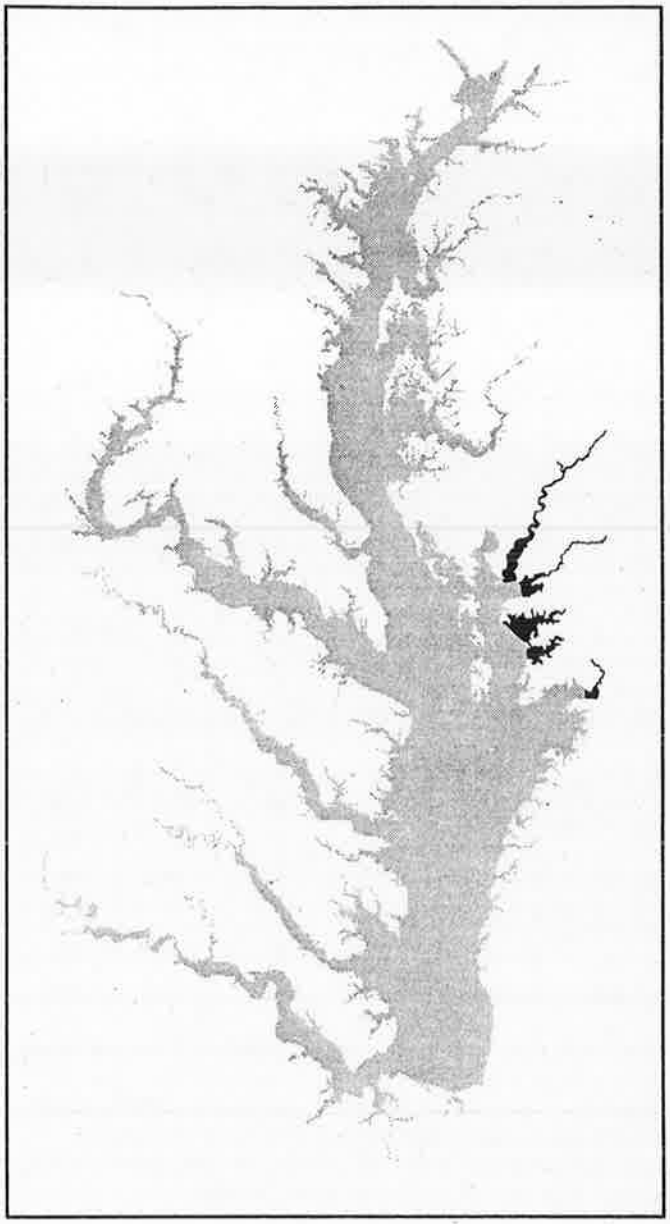
Upper Patuxent River

Year	Hectares of SAV by Density Category <10%	10-40%	40-70%	70-100%	Segment Total	% of Tier I Restoration Goal	% of Tier III Restoration Goal
'70	-	-	-	-	-	-	-
'71	-	-	-	-	-	-	-
'72	-	-	-	-	-	-	-
'73	-	-	-	-	-	-	-
'74	-	-	-	-	-	-	-
'75	-	-	-	-	-	-	-
'76	-	-	-	-	-	-	-
'77	-	-	-	-	-	-	-
'78	-	-	-	-	<1	17%	<1%
'79	-	-	-	-	-	-	-
'80	-	-	-	-	-	-	-
'81	-	-	-	-	-	-	-
'82	-	-	-	-	-	-	-
'83	-	-	-	-	-	-	-
'84	0	0	0	0	0	0%	0%
'85	0	1	0	5	6	100%	<1%
'86	0	0	0	0	0	0%	0%
'87	0	0	0	0	0	0%	0%
'88	-	-	-	-	-	-	-
'89	0	0	0	0	0	0%	0%
'90	0	0	0	0	0	0%	0%
'91	0	0	0	0	0	0%	0%

Table 30. Hectares of SAV by density category and percentage of Tier I SAV restoration goal (6 hectares) and Tier III SAV restoration target (890 hectares) are listed for 1970 to 1991 for CBP Segment TF1 (Upper Patuxent River). Sources: Anderson and Macomber, 1980; Batiuk et al., 1992; Orth et al., 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Nowak, 1990.

Because of the recent scarcity of SAV in this river, achievement of the Tier I restoration goal and the Tier III restoration target has been minimal since the late 1980s (Tables 28, 29, and 30).

Nanticoke, Wicomico, Manokin, Big Annemessex, and Pocomoke Rivers



This region includes the five tributaries entering Chesapeake Bay along the middle Eastern Shore (the Nanticoke, Wicomico, Manokin, Big Annemessex, and Pocomoke rivers). No SAV has been reported from the Nanticoke, Wicomico, and Pocomoke rivers since the first baywide aerial survey in 1978 (Figures 81, 83, and 89; Tables 31, 32, and 35). Submerged aquatic vegetation has been consistently reported from both the Manokin (73-143 hectares) and Big Annemessex (96-197 hectares) rivers (Figures 85 and 87; Tables 33 and 34). The SAV beds were restricted primarily to areas close to the river mouths and in small coves or protected areas.

The Maryland Department of Natural Resources ground survey found no SAV in the Nanticoke and Wicomico rivers since the first survey in 1971. A much greater percentage of vegetated stations was found in both the Manokin and Big Annemessex rivers in the 1970s and late 1980s compared to the period from 1978 through 1983 (Figures 91 and 92). No ground survey stations were located on the Pocomoke River. The patterns of SAV distribution in these tributaries during the 1980s parallel those reported by the aerial surveys.

Four species have been reported from these tributaries in past years. *Zostera marina* and *R. maritima* were the most commonly reported species with *P. pectinatus* and *P. perfoliatus* occasionally found in samples. *Ruppia maritima* and *P. perfoliatus* were found from the late 1960s through 1971 in the Nanticoke and Wicomico rivers but no SAV has been reported since 1971. *Zostera marina* and *R. maritima* were reported in the Manokin and Big Annemessex rivers during the 1960s. In the 1970s, however, both species declined—especially *Z. marina*. Consequently, the Maryland Department of Natural Resources ground survey reported *R. maritima* more frequently in the 1970s and 1980s. Although the ground surveys associated with the baywide aerial survey reported only *R. maritima* in the Manokin River, the Maryland Department of Natural Resources ground survey reported *Z. marina* at two locations. Both species have been reported in the Big Annemessex River with *R. maritima* reported most frequently.

Water quality in the Nanticoke, Wicomico, and Pocomoke rivers has been unsuitable for SAV survival from 1970 to 1991 (Figures 82, 84, and

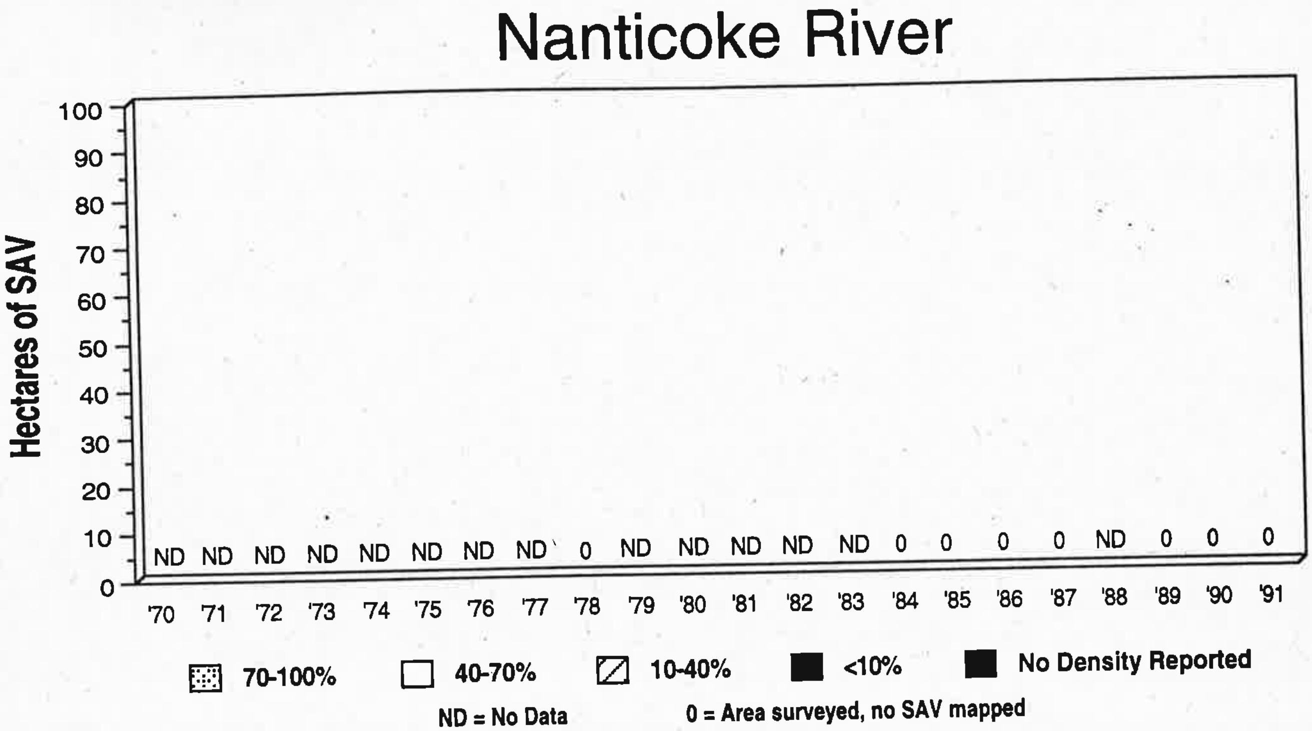


Figure 81. Hectares of SAV by density category for all years for which aerial survey data were available. For CBP Segment ET6 (Nanticoke River), there is no Tier I SAV restoration goal.
Sources: Anderson and Macomber, 1980; Batiuk et al., 1992; Orth et al., 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Nowak, 1990.

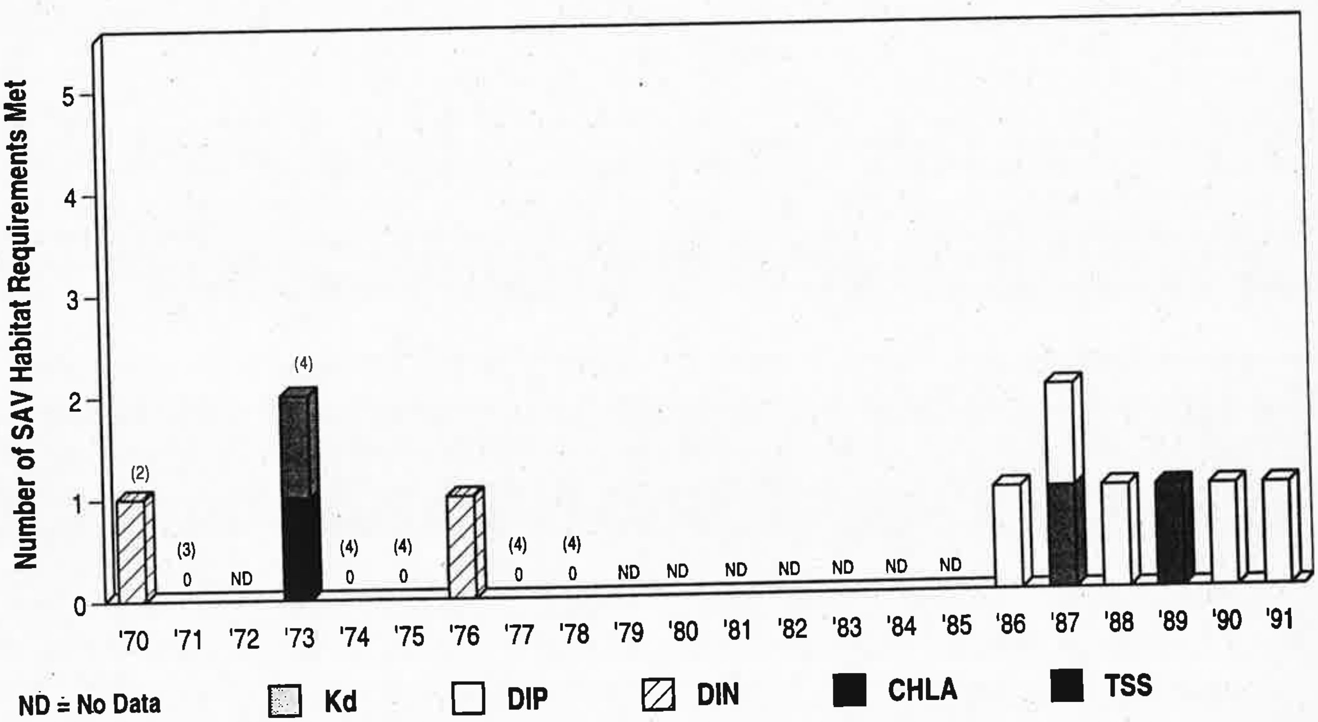


Figure 82. The number of SAV habitat requirements met over the SAV growing season from 1970 to 1991 for CBP Segment ET6 (Nanticoke River). No SAV habitat requirements met = 0; no water quality data available = ND. Sufficient data for the following parameters were not available to calculate growing season medians: Kd (1970-1975, 1977-1985); TSS (1972, 1979-1985); CHLA (1970-1972, 1979-1985); DIP (1970, 1972, 1979-1985); and DIN (1972, 1979-1985). Numbers of SAV habitat requirements with growing season medians are shown above bars when some values were missing.
Sources: Chesapeake Bay Program, 1993a and 1993b.

Nanticoke River

Year	Hectares of SAV by Density Category <10%	10-40%	40-70%	70-100%	Segment Total	% of Tier I Restoration Goal	% of Tier III Restoration Goal
'70	-	-	-	-	-	-	-
'71	-	-	-	-	-	-	-
'72	-	-	-	-	-	-	-
'73	-	-	-	-	-	-	-
'74	-	-	-	-	-	-	-
'75	-	-	-	-	-	-	-
'76	-	-	-	-	-	-	-
'77	-	-	-	-	-	-	-
'78	-	-	-	-	0	-	0%
'79	-	-	-	-	-	-	-
'80	-	-	-	-	-	-	-
'81	-	-	-	-	-	-	-
'82	-	-	-	-	-	-	-
'83	-	-	-	-	-	-	-
'84	0	0	0	0	0	-	0%
'85	0	0	0	0	0	-	0%
'86	0	0	0	0	0	-	0%
'87	0	0	0	0	0	-	0%
'88	-	-	-	-	-	-	-
'89	0	0	0	0	0	-	0%
'90	0	0	0	0	0	-	0%
'91	0	0	0	0	0	-	0%

Table 31. Hectares of SAV by density category and percentage of Tier III SAV restoration target (4,084 hectares) are listed for 1970 to 1991 for CBP Segment ET6 (Nanticoke River). There is no Tier I SAV restoration goal for this segment. Sources: Anderson and Macomber, 1980; Batiuk et al., 1992; Orth et al., 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Nowak, 1990.

Wicomico River

Year	Hectares of SAV by Density Category <10%	10-40%	40-70%	70-100%	Segment Total	% of Tier I Restoration Goal	% of Tier III Restoration Goal
'70	-	-	-	-	-	-	-
'71	-	-	-	-	-	-	-
'72	-	-	-	-	-	-	-
'73	-	-	-	-	-	-	-
'74	-	-	-	-	-	-	-
'75	-	-	-	-	-	-	-
'76	-	-	-	-	-	-	-
'77	-	-	-	-	-	-	-
'78	-	-	-	-	0	-	0%
'79	-	-	-	-	-	-	-
'80	-	-	-	-	-	-	-
'81	-	-	-	-	-	-	-
'82	-	-	-	-	-	-	-
'83	-	-	-	-	-	-	-
'84	0	0	0	0	0	-	0%
'85	0	0	0	0	0	-	0%
'86	0	0	0	0	0	-	0%
'87	0	0	0	0	0	-	0%
'88	-	-	-	-	-	-	-
'89	0	0	0	0	0	-	0%
'90	0	0	0	0	0	-	0%
'91	0	0	0	0	0	-	0%

Table 32. Hectares of SAV by density category and percentage of Tier III SAV restoration target (2,648 hectares) are listed for 1970 to 1991 for CBP Segment ET7 (Wicomico River). There is no Tier I SAV restoration goal for this segment. Sources: Anderson and Macomber, 1980; Batiuk et al., 1992; Orth et al., 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Nowak, 1990.

90). In the Manokin River, the water quality has consistently met three SAV habitat requirements (chlorophyll *a*, dissolved inorganic nitrogen, and dissolved inorganic phosphorus) since 1986 (Figure 86).

Water quality conditions in the Big Annemessex River have declined from all five SAV habitat requirements met from 1986 to 1987 to only three SAV habitat requirements met (chlorophyll *a*, dissolved inorganic nitrogen, and dissolved inorganic phosphorus) since 1990. Higher concentrations of total suspended solids beginning in 1988 most likely contributed to non-achievement of the light attenuation coefficient habitat requirement in 1990 and 1991. Despite decreases in overall bed density, no significant changes in the Big Annemessex River's SAV distribution in response to these water quality changes have occurred.

No progress has been made in the Nanticoke, Wicomico, and Pocomoke rivers towards achievement of the tiered restoration goals and targets since no SAV has grown in these rivers since 1978 (Tables 31, 32, and 35). In the Manokin and Big Annemessex rivers, 42 percent and 48 percent of the Tier I restoration goal, respectively, and 3 percent and 9 percent of Tier III restoration target, respectively, had been achieved as of 1991 (Tables 33 and 34).

Wicomico River

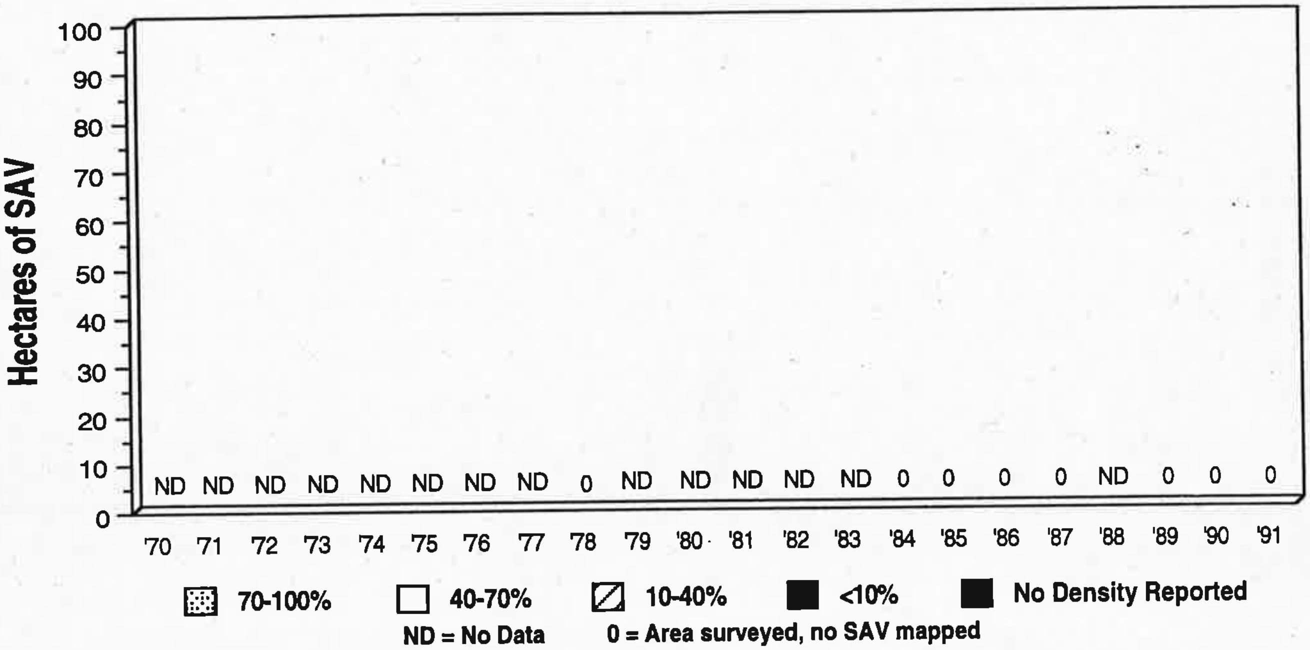


Figure 83. Hectares of SAV by density category for all years for which aerial survey data were available. For CBP Segment ET7 (Wicomico River), there is no Tier I SAV restoration goal.
Sources: Anderson and Macomber, 1980; Batiuk et al., 1992; Orth et al,. 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Nowak, 1990.

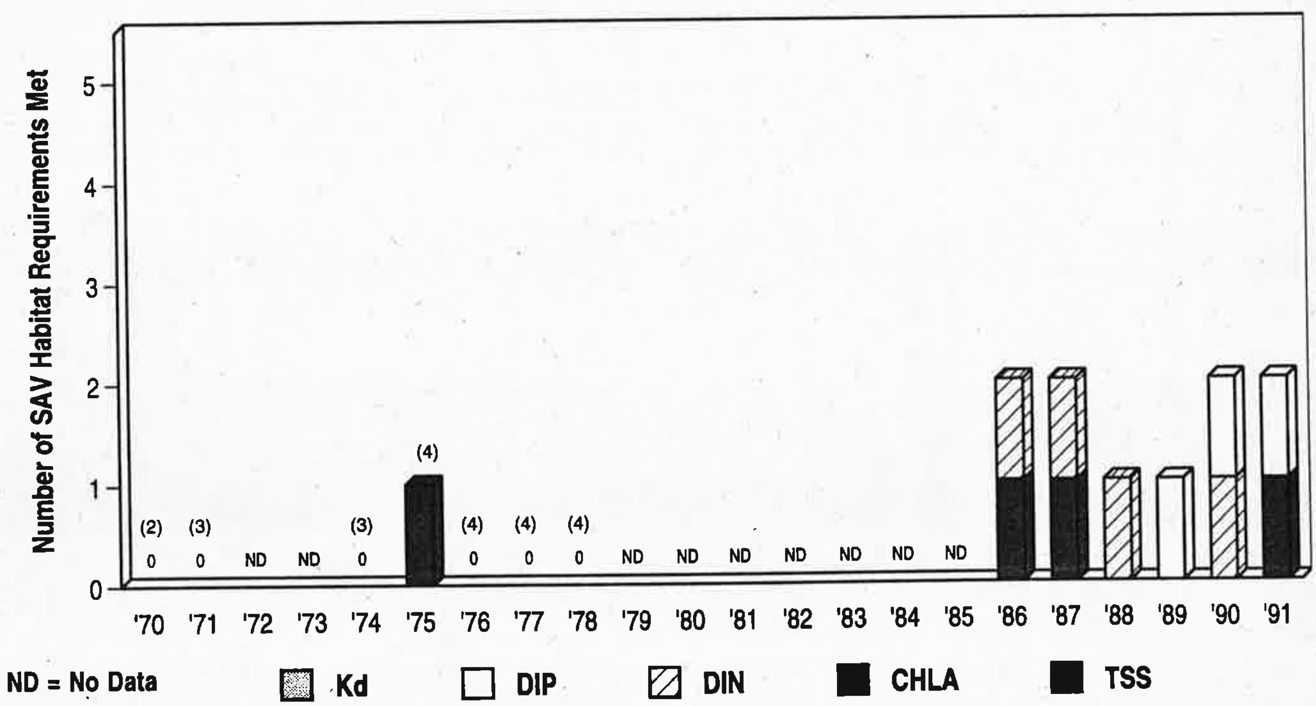


Figure 84. The number of SAV habitat requirements met over the SAV growing season from 1970 to 1991 for CBP Segment ET7 (Wicomico River). No SAV habitat requirements met = 0; no water quality data available = ND. Sufficient data for the following parameters were not available to calculate growing season medians: Kd (1970-1985); TSS (1972, 1973, 1979-1985); CHLA (1970-1973, 1979-1985); DIP (1970, 1972, 1973, 1979-1985); and DIN (1972, 1973, 1979-1985). Numbers of SAV habitat requirements with growing season medians are shown above bars when some values were missing.
Sources: Chesapeake Bay Program, 1993a and 1993b.

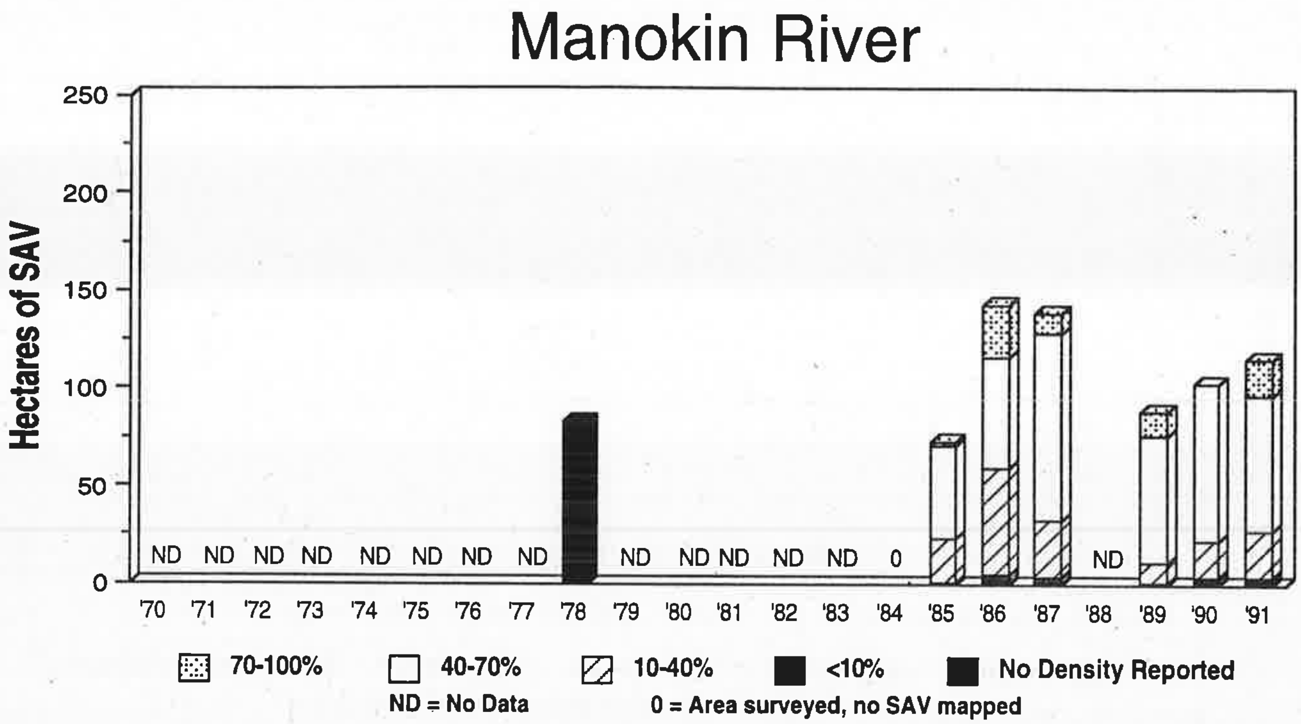


Figure 85. Hectares of SAV by density category for all years for which aerial survey data were available. For CBP Segment ET8 (Manokin River), the Tier I SAV restoration goal is 272 hectares.
Sources: Anderson and Macomber, 1980; Batiuk et al., 1992; Orth et al., 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Nowak, 1990.

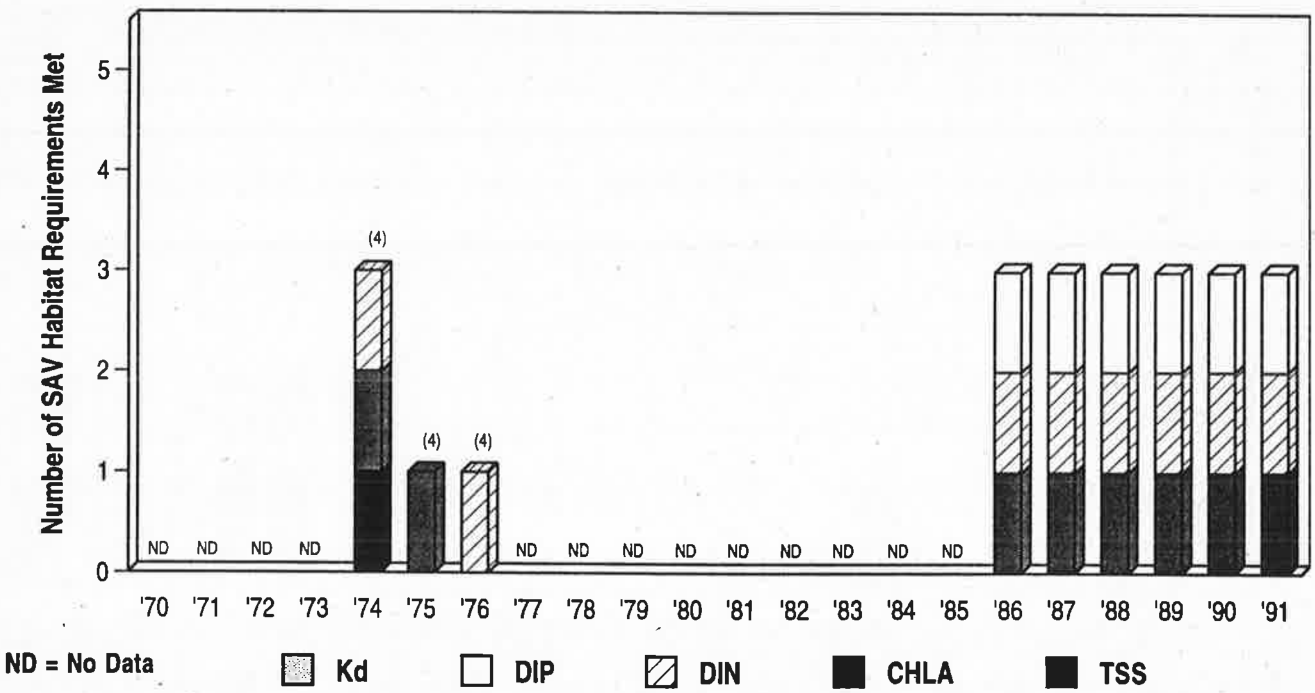


Figure 86. The number of SAV habitat requirements met over the SAV growing season from 1970 to 1991 for CBP Segment ET8 (Manokin River). No SAV habitat requirements met = 0; no water quality data available = ND. Sufficient data for the following parameters were not available to calculate growing season medians: Kd (1970-1975, 1977-1985); TSS (1970-1973, 1976-1985); CHLA (1970-1973, 1977-1985); DIP (1970-1973, 1977-1985); and DIN (1970-1973, 1977-1985). Numbers of SAV habitat requirements with growing season medians are shown above bars when some values were missing.
Sources: Chesapeake Bay Program, 1993a and 1993b.

Manokin River

Year	Hectares of SAV by Density Category <10%	10-40%	40-70%	70-100%	Segment Total	% of Tier I Restoration Goal	% of Tier III Restoration Goal
'70	-	-	-	-	-	-	-
'71	-	-	-	-	-	-	-
'72	-	-	-	-	-	-	-
'73	-	-	-	-	-	-	-
'74	-	-	-	-	-	-	-
'75	-	-	-	-	-	-	-
'76	-	-	-	-	-	-	-
'77	-	-	-	-	-	-	-
'78	-	-	-	-	83	30%	2%
'79	-	-	-	-	-	-	-
'80	-	-	-	-	-	-	-
'81	-	-	-	-	-	-	-
'82	-	-	-	-	-	-	-
'83	-	-	-	-	-	-	-
'84	0	0	0	0	0	0%	0%
'85	<1	22	48	2	73	27%	2%
'86	5	54	57	27	143	52%	4%
'87	4	29	95	11	139	51%	4%
'88	-	-	-	-	-	-	-
'89	1	10	65	12	88	32%	2%
'90	4	18	81	0	103	38%	3%
'91	4	23	69	19	115	42%	3%

Table 33. Hectares of SAV by density category and percentage of Tier I SAV restoration goal (271 hectares) and Tier III SAV restoration target (3,763 hectares) are listed for 1970 to 1991 for CBP Segment ET8 (Manokin River). Sources: Anderson and Macomber, 1980; Batiuk et al., 1992; Orth et al., 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Nowak, 1990.

Big Annemessex River

Year	Hectares of SAV by Density Category <10%	10-40%	40-70%	70-100%	Segment Total	% of Tier I Restoration Goal	% of Tier III Restoration Goal
'70	-	-	-	-	-	-	-
'71	-	-	-	-	-	-	-
'72	-	-	-	-	-	-	-
'73	-	-	-	-	-	-	-
'74	-	-	-	-	-	-	-
'75	-	-	-	-	-	-	-
'76	-	-	-	-	-	-	-
'77	-	-	-	-	-	-	-
'78	-	-	-	-	197	54%	10%
'79	-	-	-	-	-	-	-
'80	-	-	-	-	-	-	-
'81	-	-	-	-	-	-	-
'82	-	-	-	-	-	-	-
'83	-	-	-	-	-	-	-
'84	0	0	0	0	0	0%	0%
'85	3	21	100	29	153	42%	8%
'86	6	52	86	25	169	46%	8%
'87	0	19	75	2	96	26%	5%
'88	-	-	-	-	-	-	-
'89	4	23	23	95	145	40%	7%
'90	10	21	45	53	129	35%	6%
'91	0	61	53	63	177	48%	9%

Table 34. Hectares of SAV by density category and percentage of Tier I SAV restoration goal (363 hectares) and Tier III SAV restoration target (2,044 hectares) are listed for 1970 to 1991 for CBP Segment ET9 (Big Annemessex River). Sources: Anderson and Macomber, 1980; Batiuk et al., 1992; Orth et al., 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Nowak, 1990.

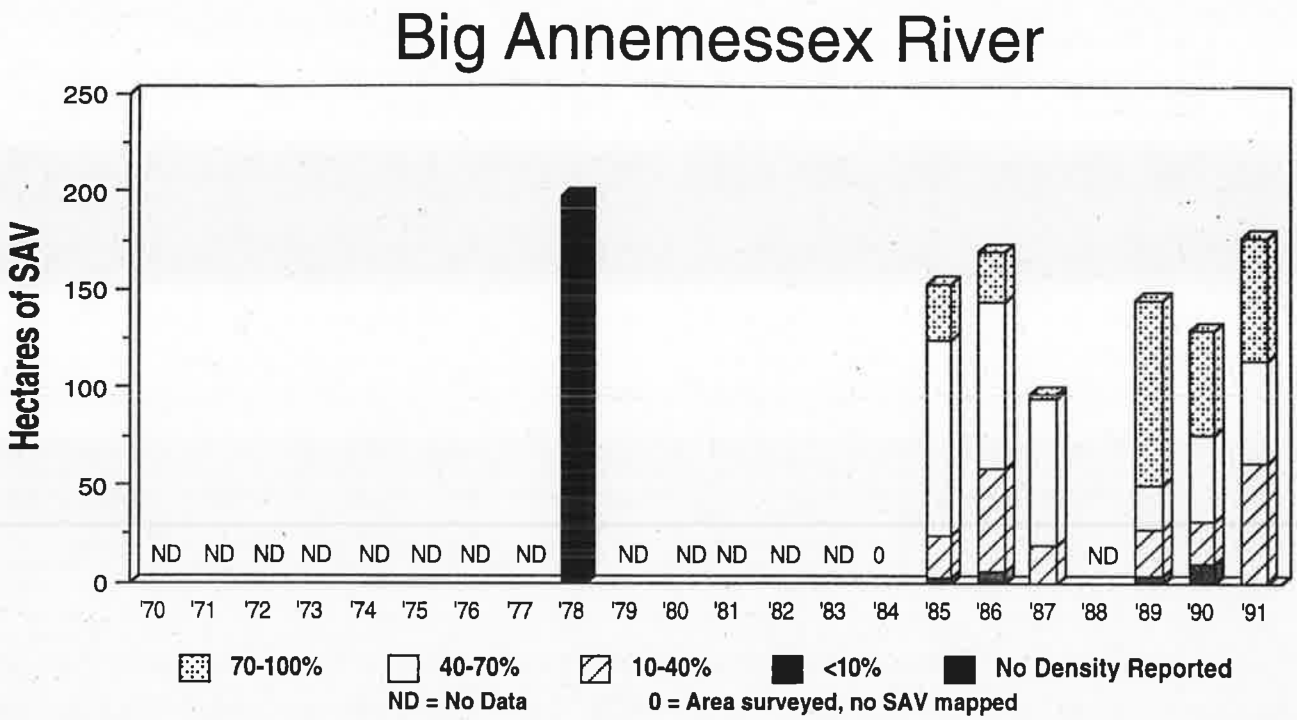


Figure 87. Hectares of SAV by density category for all years for which aerial survey data were available. For CBP Segment ET9 (Big Annemessex River), the Tier I SAV restoration goal is 363 hectares
Sources: Anderson and Macomber, 1980; Batiuk et al., 1992; Orth et al. 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Nowak, 1990.

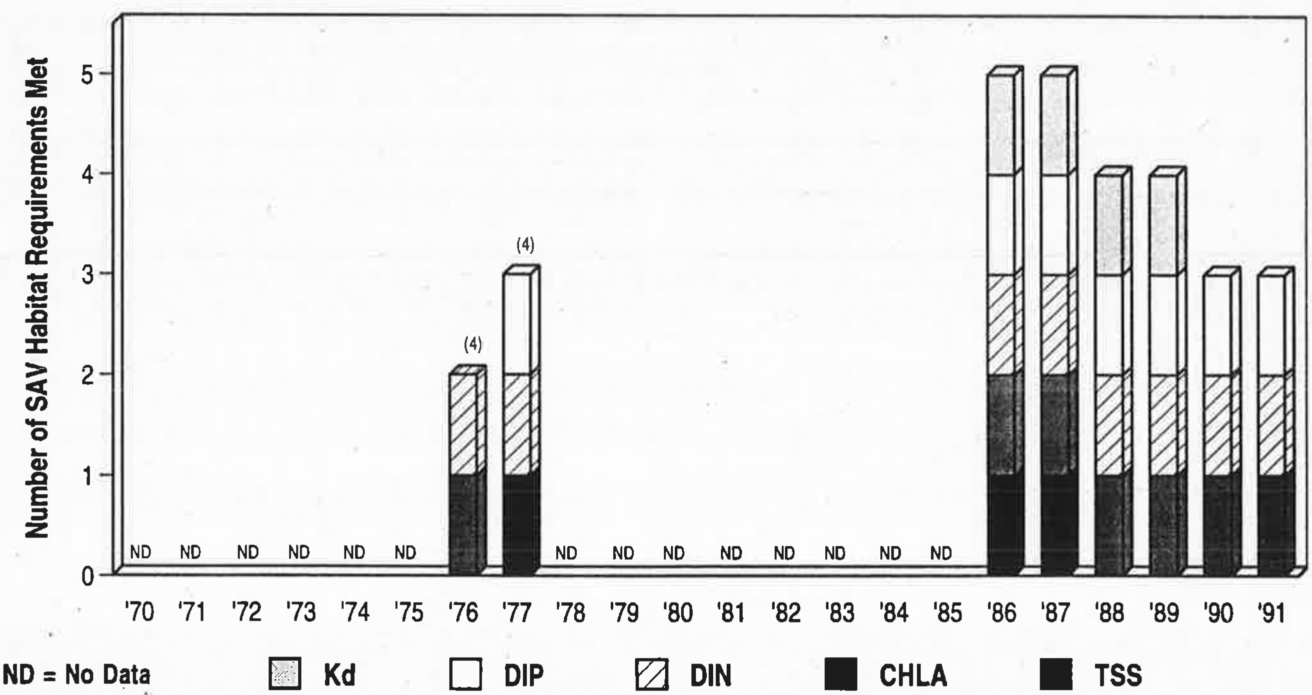


Figure 88. The number of SAV habitat requirements met over the SAV growing season from 1970 to 1991 for CBP Segment ET9 (Big Annemessex River). No SAV habitat requirements met = 0; no water quality data available = ND. Sufficient data for the following parameters were not available to calculate growing season medians: Kd (1970-1975, 1977-1985); TSS (1970-1976, 1978-1985); CHLA (1970-1975, 1978-1985); DIP (1970-1975, 1978-1985); and DIN (1970-1975, 1978-1985). Numbers of SAV habitat requirements with growing season medians are shown above bars when some values were missing.
Sources: Chesapeake Bay Program, 1993a and 1993b.

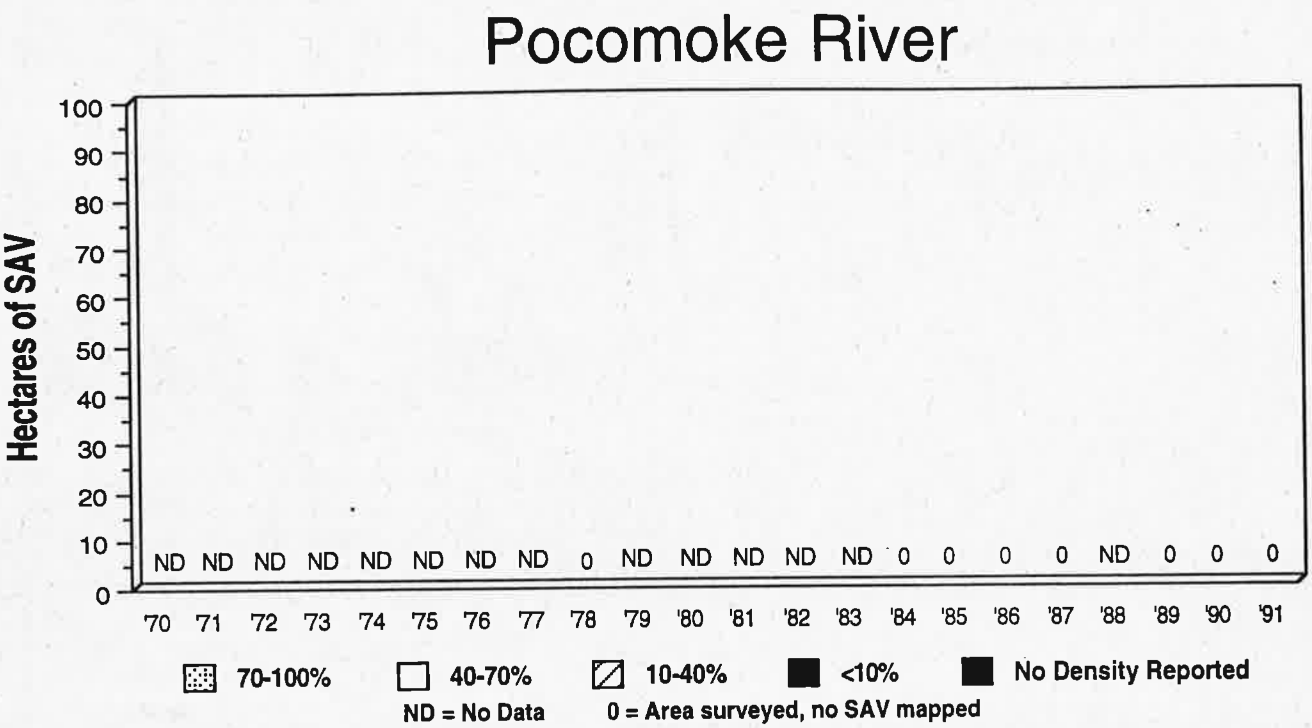


Figure 89. Hectares of SAV by density category for all years for which aerial survey data were available. For CBP Segment ET10 (Pocomoke River), there is no Tier I SAV restoration goal.
Sources: Anderson and Macomber, 1980; Batiuk et al., 1992; Orth et al., 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Nowak, 1990.

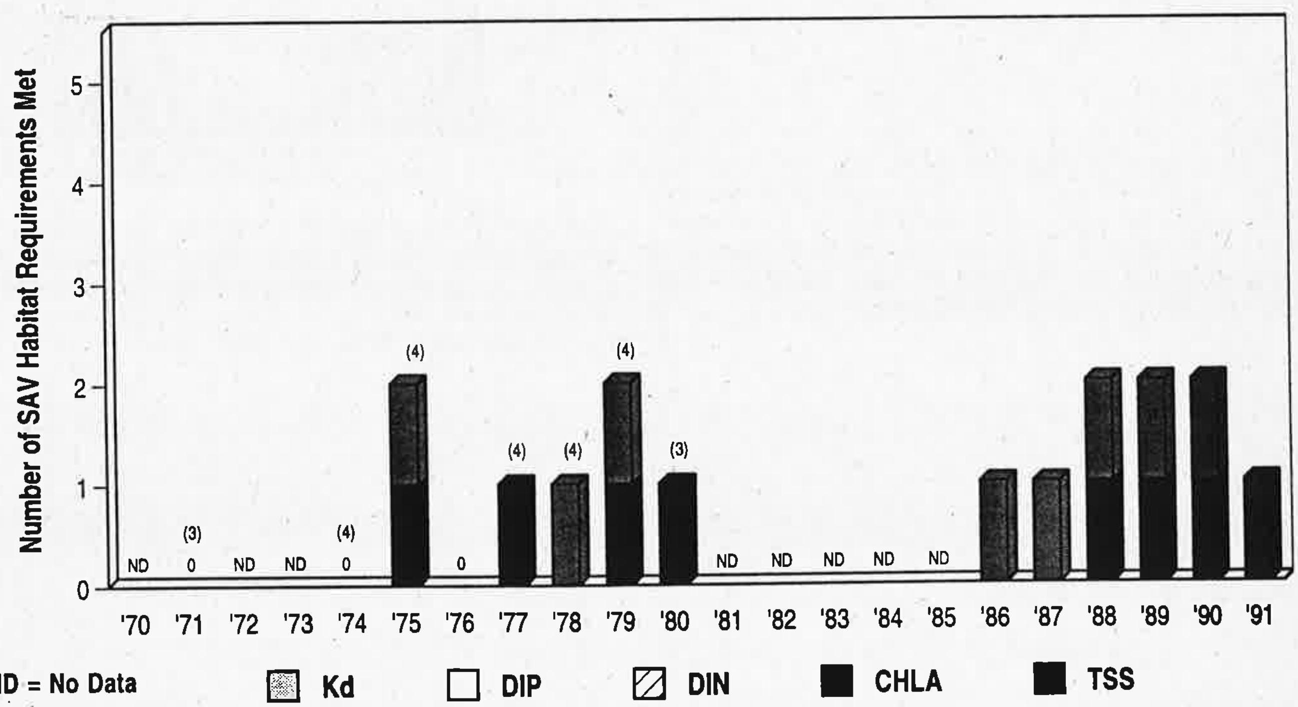


Figure 90. The number of SAV habitat requirements met over the SAV growing season from 1970 to 1991 for CBP Segment ET10 (Pocomoke River). No SAV habitat requirements met = 0; no water quality data available = ND. Sufficient data for the following parameters were not available to calculate growing season medians: Kd (1970-1975, 1977-1985); TSS (1970, 1972, 1973, 1981-1985); CHLA (1970-1973, 1980-1985); DIP (1970-1973, 1981-1985); and DIN (1970, 1972, 1973, 1981-1985). Numbers of SAV habitat requirements with growing season medians are shown above bars when some values were missing.
Sources: Chesapeake Bay Program, 1993a and 1993b.

Pocomoke River

Year	Hectares of SAV by Density Category <10%	10-40%	40-70%	70-100%	Segment Total	% of Tier I Restoration Goal	% of Tier III Restoration Goal
'70	-	-	-	-	-	-	-
'71	-	-	-	-	-	-	-
'72	-	-	-	-	-	-	-
'73	-	-	-	-	-	-	-
'74	-	-	-	-	-	-	-
'75	-	-	-	-	-	-	-
'76	-	-	-	-	-	-	-
'77	-	-	-	-	-	-	-
'78	-	-	-	-	0	-	0%
'79	-	-	-	-	-	-	-
'80	-	-	-	-	-	-	-
'81	-	-	-	-	-	-	-
'82	-	-	-	-	-	-	-
'83	-	-	-	-	-	-	-
'84	0	0	0	0	0	-	0%
'85	0	0	0	0	0	-	0%
'86	0	0	0	0	0	-	0%
'87	0	0	0	0	0	-	0%
'88	-	-	-	-	-	-	-
'89	0	0	0	0	0	-	0%
'90	0	0	0	0	0	-	0%
'91	0	0	0	0	0	-	0%

Table 35. Hectares of SAV by density category and percentage of the Tier III SAV restoration target (495 hectares) are listed for 1970 to 1991 for CBP Segment ET10 (Pocomoke River). There is no Tier I SAV restoration goal for this segment. Sources: Anderson and Macomber, 1980; Batiuk et al., 1992; Orth et al., 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Nowak, 1990.

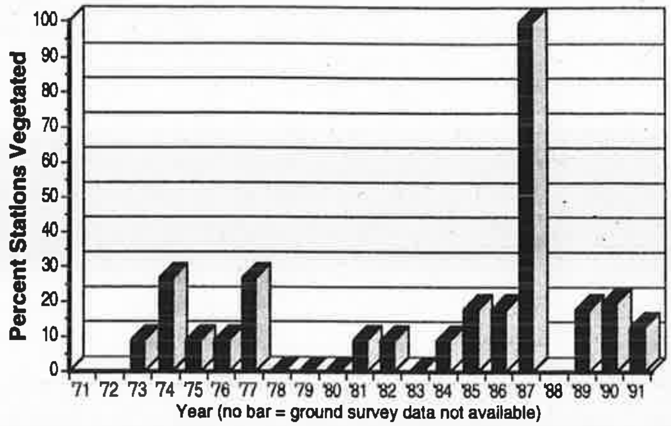


Figure 91. Percentage of Maryland Department of Natural Resources SAV Ground Survey Program stations sampled where SAV was observed for CBP Segment ET8 (Manokin River). Ground survey data were not available for 1971, 1972, and 1988.
Source: Chesapeake Bay Program, unpublished data c.

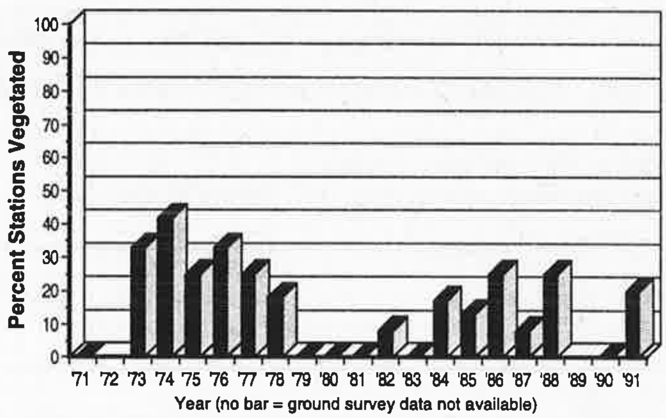
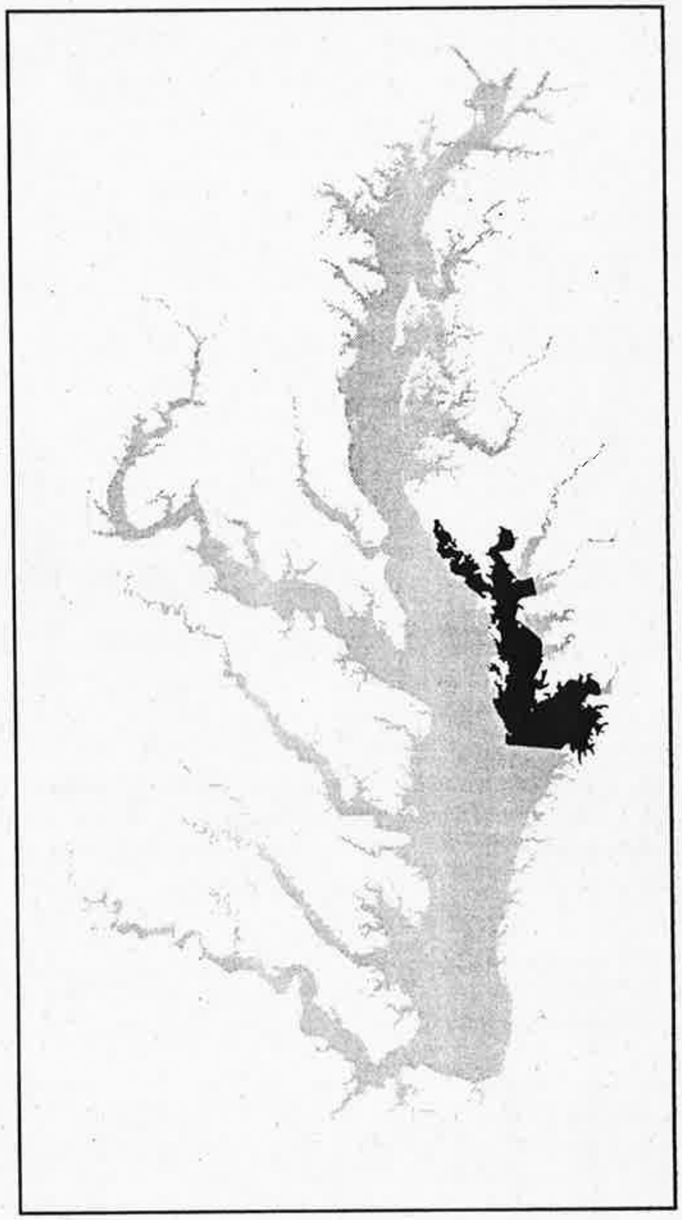


Figure 92. Percentage of Maryland Department of Natural Resources SAV Ground Survey Program stations sampled where SAV was observed for CBP Segment ET9 (Big Annemessex River). Ground survey data were not available for 1972, 1989, and 1990.
Source: Chesapeake Bay Program, unpublished data c.

Tangier Sound



Tangier Sound covers a large area of shallow water habitat that includes the Honga River, Fishing Bay, Bloodsworth, Southmarsh, Smith, Tangier, and Great Fox islands, Little Annemessex River, and Pocomoke Sound. This segment is closely coupled with the Lower Chesapeake Bay; both segments include portions of the same regions (e.g., Bloodsworth and Southmarsh islands).

Prior to 1971, SAV was very abundant in this segment, growing extensively in the expansive shoal areas. Ground survey teams from the Maryland Department of Natural Resources documented the abundance of *Z. marina* and *R. maritima* throughout the segment. Submerged aquatic vegetation was practically eliminated from the entire segment after 1971. The distribution of *Z. marina* changed dramatically during this period. Abundant throughout the segment prior to 1971, this species was sighted only occasionally in the 1970s and 1980s.

The baywide aerial survey has documented a significant increase in the distribution of SAV in this segment over the last 13 years, from 1,645 hectares in 1978 to 5,461 hectares in 1991. This change represents an increase of over 230 percent (Figure 93, Table 36) and is coupled with the large increase reported for the adjacent Lower Chesapeake Bay segment (see below). Almost 60 percent of the SAV in Tangier Sound was classified as dense (70-100 percent coverage) in 1991 compared to less than 1 percent in 1978.

The Maryland Department of Natural Resources ground survey reported vegetation at 100 percent of the stations in 1971. Reported percentages of vegetated stations after 1971 ranged from 22 percent in 1974 to less than 2 percent by 1979. The percentage of vegetated stations remained under 10 percent through 1986, increasing to 38 percent by 1988 and ranging from 14 to 17 percent from 1989 through 1991 (Figure 95).

The 1990 U.S. Fish and Wildlife Service clam survey found SAV at 28 percent of 170 sampled sites in the Honga River (Jorde et al., 1991). It was particularly abundant along the eastern side of the Honga River, although *R. maritima* was the only species reported.

In the Honga River and around Bloodsworth and Southmarsh islands, *R. maritima* was the dominant species reported through ground surveys conducted as part of the aerial survey program. Both *Z. marina* and *R. maritima* were reported from

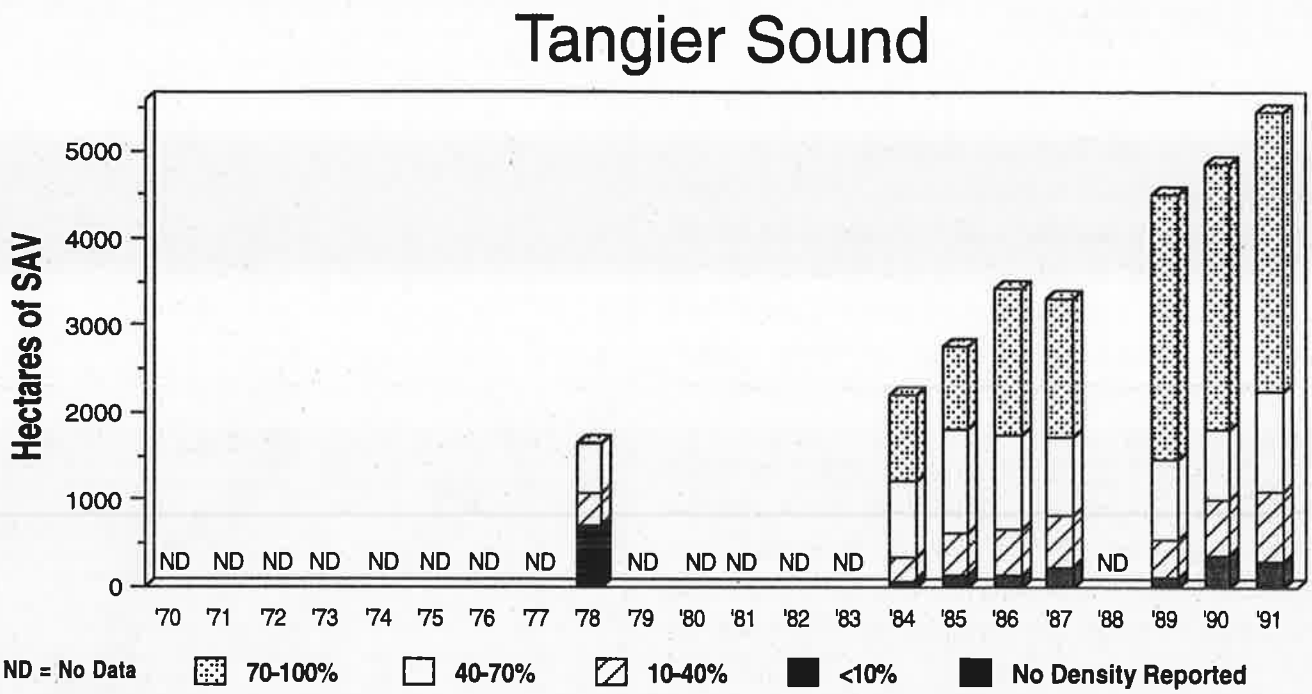


Figure 93. Hectares of SAV by density category for all years for which aerial survey data were available. For CBP Segment EE3 (Tangier Sound), the Tier I SAV restoration goal is 6,345 hectares.
Sources: Anderson and Macomber, 1980; Batiuk et al., 1992; Orth et al., 1979, 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Nowak, 1990.

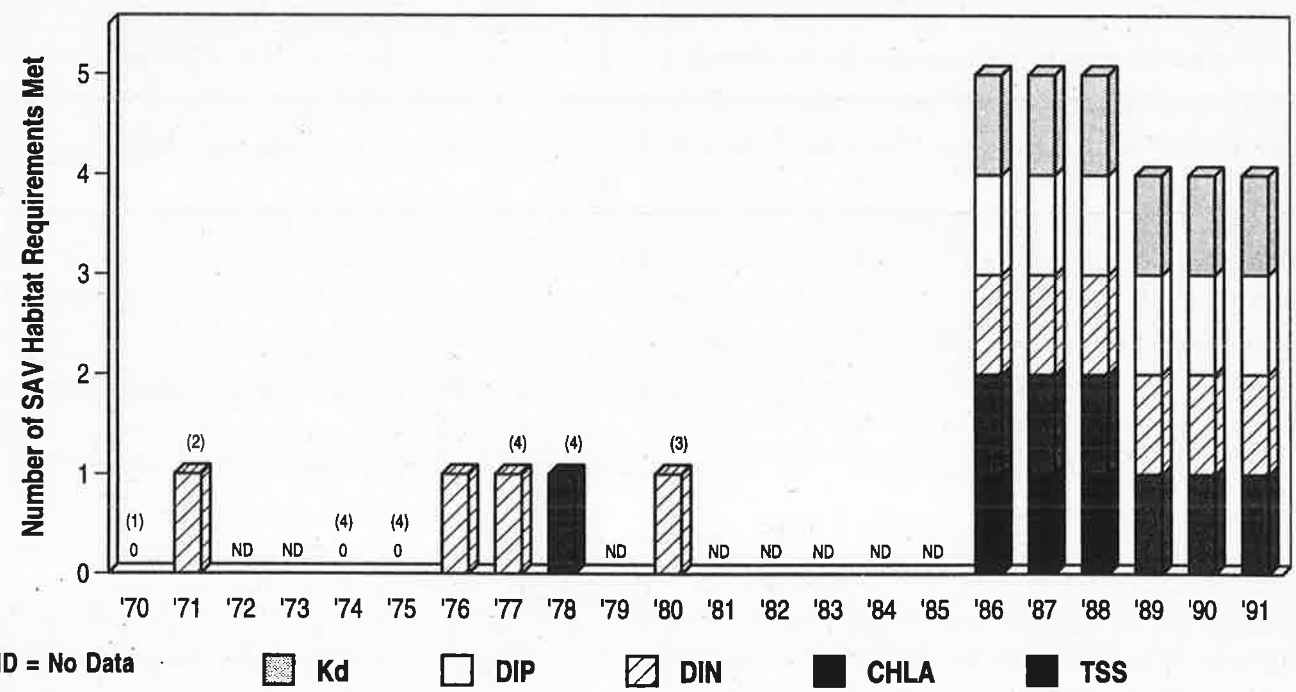


Figure 94. The number of SAV habitat requirements met over the SAV growing season from 1970 to 1991 for CBP Segment EE3 (Tangier Sound). No SAV habitat requirements met = 0; no water quality data available = ND. Sufficient data for the following parameters were not available to calculate growing season medians: Kd (1970-1975, 1977-1985); TSS (1972, 1973, 1979, 1981-1985); CHLA (1970-1973, 1979-1985); DIP (1970-1973, 1979, 1981-1985); and DIN (1970, 1972, 1973, 1979, 1981-1985). Numbers of SAV habitat requirements with growing season medians are shown above bars when some values were missing.
Sources: Chesapeake Bay Program, 1993a and 1993b.

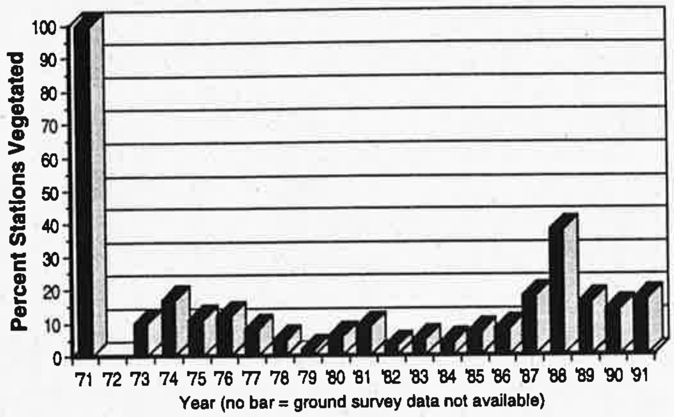


Figure 95. Percentage of Maryland Department of Natural Resources SAV Ground Survey Program stations sampled where SAV was observed for CBP Segment EE3 (Tangier Sound). Ground survey data were not available for 1972. Source: Chesapeake Bay Program, unpublished data c.

around Tangier, Smith, and Great Fox islands and in Big Annemessex River and Pocomoke Sound. The only survey to report *Z. marina* north of Smith Island was the Maryland Department of Natural Resources ground survey. The survey reported this species at several locations in the Honga River in 1991 and around Bloodsworth and Southmarsh islands. The aerial survey shows that Fishing Bay, vegetated with both *R. maritima* and *Z. marina* prior to 1971, currently has only a small amount of SAV.

Water quality conditions in Tangier Sound from 1986 through 1988 met all five SAV habitat requirements. From 1989 to 1991, only the total suspended solids habitat requirement was not achieved (Figure 94). Water quality in Tangier Sound, as well as in the adjacent lower Chesapeake Bay (Figure 106), has generally been suitable for SAV survival and growth.

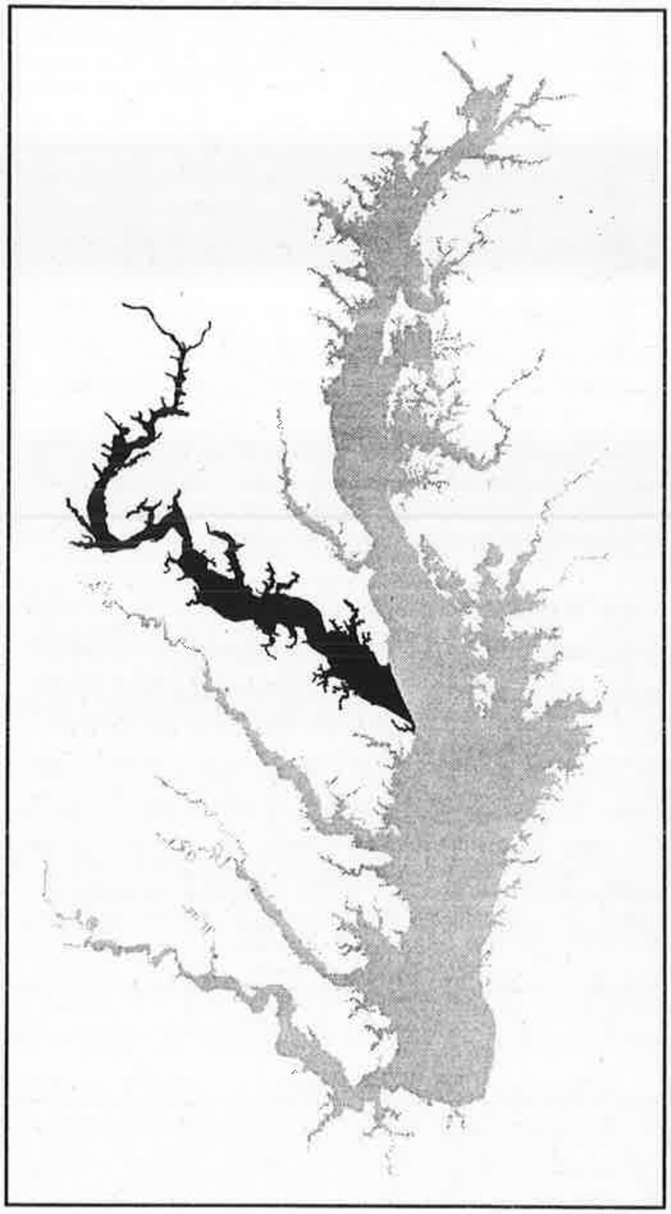
With increases in SAV distribution since 1978, significant progress has been made towards the Tier I restoration goal, increasing from 26 percent to 86 percent by 1991 (Table 36). Achievement of the Tier III restoration target has also increased from 5 percent in 1978 to 15 percent in 1991. Further expansion of SAV distributions beyond one meter in depth will be dependent on further improvements in water quality, particularly decreases in total suspended solids concentrations and light attenuation.

Tangier Sound

	Hectares of SAV by Density Category						
Year	<10%	10-40%	40-70%	70-100%	Segment Total	% of Tier I Restoration Goal	% of Tier III Restoration Goal
'70	-	-	-	-	-	-	-
'71	-	-	-	-	-	-	-
'72	-	-	-	-	-	-	-
'73	-	-	-	-	-	-	-
'74	-	-	-	-	-	-	-
'75	-	-	-	-	-	-	-
'76	-	-	-	-	-	-	-
'77	-	-	-	-	-	-	-
'78	46	375	557	2	1,645	26%	5%
'79	-	-	-	-	-	-	-
'80	-	-	-	-	-	-	-
'81	-	-	-	-	-	-	-
'82	-	-	-	-	-	-	-
'83	-	-	-	-	-	-	-
'84	50	285	879	993	2,207	35%	6%
'85	140	475	1,190	948	2,753	43%	8%
'86	120	548	1,084	1,675	3,427	54%	10%
'87	225	599	895	1,592	3,311	51%	9%
'88	-	-	-	-	-	-	-
'89	105	442	914	3,045	4,506	71%	13%
'90	355	657	790	3,047	4,849	76%	14%
'91	281	819	1,158	3,202	5,461	86%	15%

Table 36. Hectares of SAV by density category and percentage of Tier I SAV restoration goal (6,345 hectares) and Tier III SAV restoration target (35,686 hectares) are listed for 1970 to 1991 for CBP Segment EE3 (Tangier Sound). In 1978, 665 hectares of SAV were mapped for which no density category was reported but were included in the segment totals.
Sources: Anderson and Macomber, 1980; Batiuk et al., 1992; Orth et al., 1979, 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Nowak, 1990.

Potomac River



The Potomac River historically supported dense stands of native SAV along its entire length. In addition, several exotic species have appeared during the past 70 years (Carter et al., 1983; Haramis and Carter, 1983; Orth and Moore, 1984; Stevenson and Confer, 1978; Stevenson and Staver, in press). Today, the Potomac River is the only major western shore tributary with SAV in each of its three major segments, although the vegetation occurs at a somewhat reduced level in the lower Potomac River segment.

One of the earliest accounts of SAV distribution comes from Cumming et al. (1916) who reported dense SAV beds on the margins of the upper Potomac River below Washington, DC in the early 1900s. Much native SAV in the tidal fresh and oligohaline portions was gone by the late 1930s. Many past surveys have shown that SAV in the middle Potomac River, especially in and adjacent to Port Tobacco River and Nanjemoy Creek, had fluctuating abundance levels through the 1970s. *Myriophyllum spicatum*, one exotic that grows in this river, dramatically increased in the late 1950s, declined in the mid-1960s, and occurred only in sporadic locations by the late 1960s. It is now one of the dominant species in the tidal fresh and the oligohaline transition zones of the Potomac River.

The Lower Potomac River, from the Route 301 Bridge south to the river mouth, often contained pockets of SAV in various creeks and rivers. These pockets have fluctuated widely in distribution. Anecdotal information indicated that *Z. marina* was present in several areas of the Lower Potomac River near the river mouth in the 1950s and 1960s but has not been found since then. These observations are based on reports from the many ground surveys conducted in the Lower Potomac River from the 1950s through the early 1980s (Stevenson and Staver, in press).

The U.S. Geological Survey and the U.S. Fish and Wildlife Service have conducted one of the most comprehensive surveys of the entire river (Carter et al., 1983 and 1985a; Haramis and Carter, 1983). The survey found 15 species of SAV, with the greatest concentration in the transition zone (from Quantico, Virginia to the Route 301 Bridge), especially in the Port Tobacco River, Nanjemoy Creek, and adjacent shoreline in the Potomac River. Very little SAV was found in the remainder of the river either above or below the transition zone. Subsequent surveys by the U.S. Geological Survey documented changes in SAV populations, providing important supplementary ground survey information for the aerial survey (Carter et al., 1985b; Rybicki and Schening, 1990; Rybicki et al., 1985, 1986, 1987, and 1988)..

The aerial survey showed very little SAV in the Lower Potomac River (Figure 96, Table 37). Although 107 hectares were mapped in 1978, only 31 hectares were reported in 1987. Submerged aquatic vegetation distribution increased to 84 hectares by 1991—a small increase compared to the Tier III restoration target of approximately 18,000 hectares. This small amount of SAV was found in Machodoc, Rosier, and Cuckold creeks and in Wicomico and St. Mary's rivers. *Ruppia maritima* was the only species found in the St. Mary's River while *M. spicatum* was reported from the other locations.

The Maryland Department of Natural Resources survey reported only two years with vegetated stations (1987 and 1988) since 1971 (Figure 98). The 1990 U.S. Fish and Wildlife Service clam survey found *P. pusillus* in the Wicomico River (Jorde et al., 1991).

In the lower Potomac River, all five SAV habitat requirements have been consistently achieved since 1984 (Figure 97). Re-establishment of SAV in the lower river segment appears to be limited by a complex set of environmental and biological factors that govern which species can become established and grow in this segment. Despite the abundance of SAV in the adjacent segments, downriver spread of some species (e.g., *H. verticillata*) may be prevented by salinities in the lower segment that are above this species' tolerance limit. Other species (e.g., *Z. marina*) may not recover in the lower portion of the lower Potomac River segment because there are no local beds of these species to provide propagules for revegetation. Existing *Z. marina* beds are probably too far removed to provide either seeds or vegetative material.

Lower Potomac River

Year	Hectares of SAV by Density Category <10%	10-40%	40-70%	70-100%	Segment Total	% of Tier I Restoration Goal	% of Tier III Restoration Goal
'70	-	-	-	-	-	-	-
71	-	-	-	-	-	-	-
'72	-	-	-	-	-	-	-
'73	-	-	-	-	-	-	-
'74	-	-	-	-	-	-	-
'75	-	-	-	-	-	-	-
'76	-	-	-	-	-	-	-
'77	-	-	-	-	-	-	-
'78	2	1	3	1	107	38%	<1%
'79	-	-	-	-	-	-	-
'80	-	-	-	-	-	-	-
'81	-	-	-	-	-	-	-
'82	-	-	-	-	-	-	-
'83	-	-	-	-	-	-	-
'84	0	10	37	9	56	20%	<1%
'85	9	23	18	<1	51	18%	<1%
'86	1	20	13	3	37	13%	<1%
'87	2	8	16	5	31	11%	<1%
'88	-	-	-	-	-	-	-
'89	12	7	5	17	41	14%	<1%
'90	22	6	19	5	52	18%	<1%
'91	18	9	25	32	84	30%	<1%

Table 37. Hectares of SAV by density category and percentage of Tier I SAV restoration goal (282 hectares) and Tier III SAV restoration target (18,012 hectares) are listed for 1970 to 1991 for CBP Segment LE2 (Lower Potomac River). In 1978, 100 hectares of SAV were mapped for which no density category was reported but were included in the segment total.
Sources: Anderson and Macomber, 1980; Batiuk et al., 1992; Orth et al., 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Nowak, 1990.

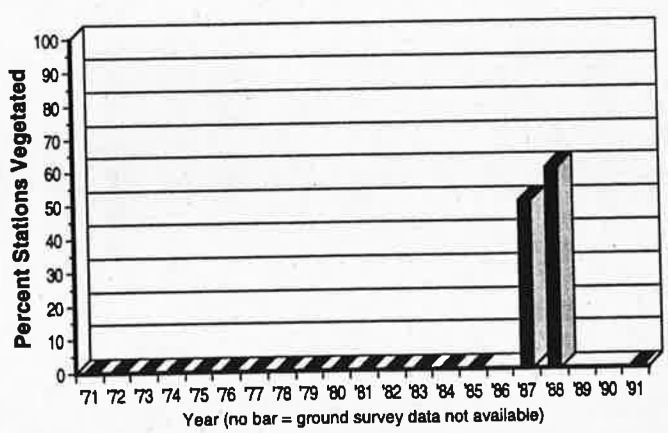


Figure 98. Percentage of Maryland Department of Natural Resources SAV Ground Survey Program stations sampled where SAV was observed for CBP Segment LE2 (Lower Potomac River). Ground survey data were not available for 1986, 1989, and 1990.
Source: Chesapeake Bay Program, unpublished data c.

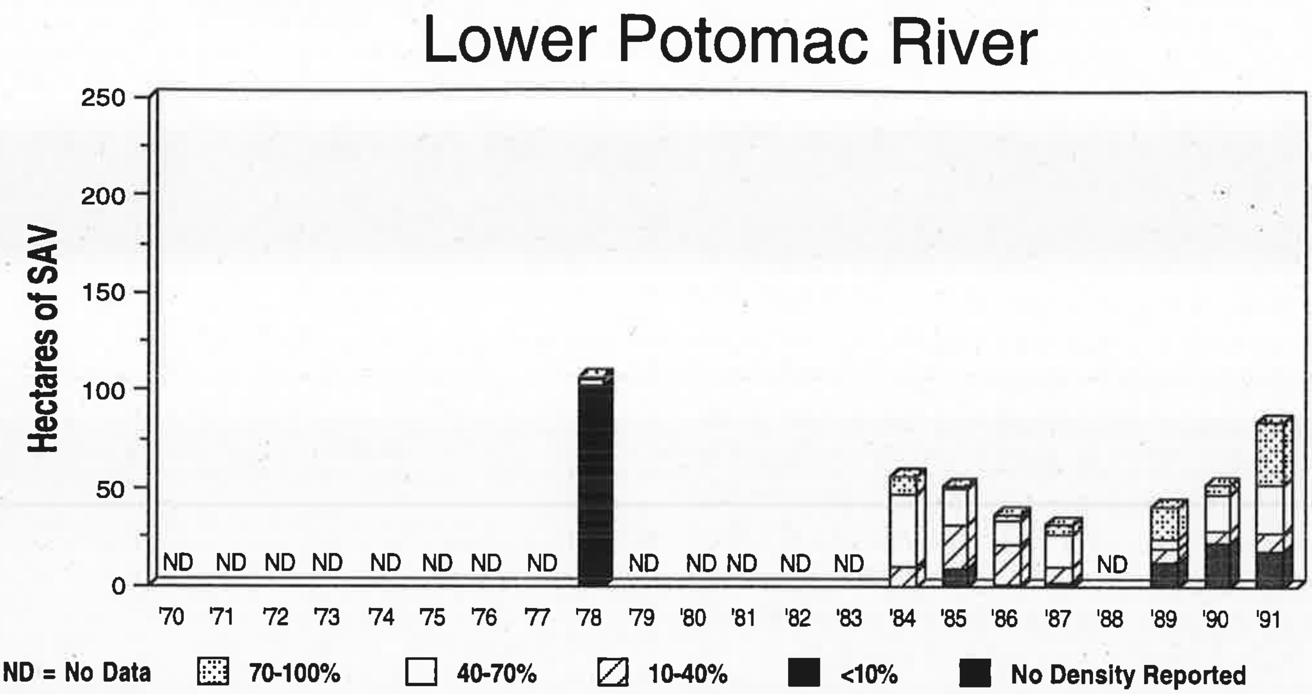


Figure 96. Hectares of SAV by density category for all years for which aerial survey data were available. For CBP Segment LE2 (Lower Potomac River), the Tier I SAV restoration goal is 282 hectares.
Sources: Anderson and Macomber, 1980; Batiuk et al., 1992; Orth et al., 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Nowak, 1990.

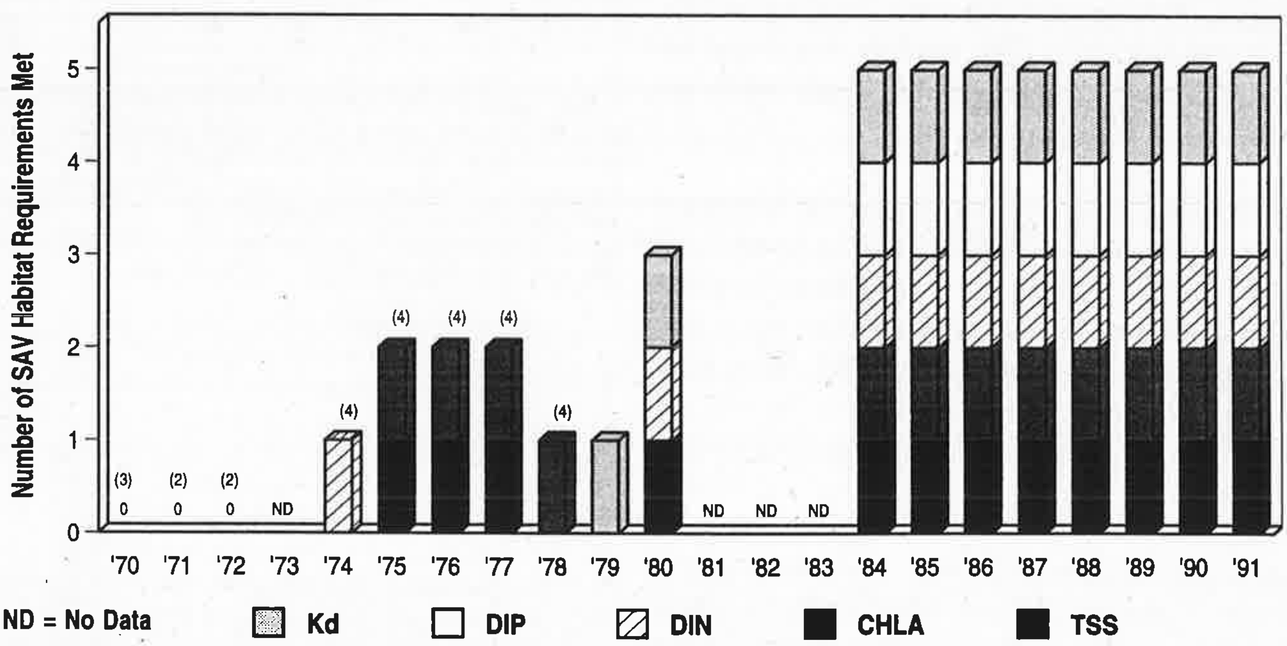


Figure 97. The number of SAV habitat requirements met over the SAV growing season from 1970 to 1991 for CBP Segment LE2 (Lower Potomac River). No SAV habitat requirements met = 0; no water quality data available = ND. Sufficient data for the following parameters were not available to calculate growing season medians: Kd (1970-1978, 1981-1983); TSS (1971-1973, 1981-1983); CHLA (1970-1973, 1981-1983); DIP (1973, 1981-1983); and DIN (1973, 1981-1983). Numbers of SAV habitat requirements with growing season medians are shown above bars when some values were missing.
Sources: Chesapeake Bay Program, 1993a and 1993b.

Submerged aquatic vegetation in the Middle Potomac River, from Quantico to just below the Route 301 bridge, had increased only slightly from 1978 to 1987 (Figure 99, Table 38). It showed a dramatic increase, however, between 1987 and 1989. Abundances remained high through 1991. This large increase was due to the spread of *H. verticillata* downriver to Aquia Creek, although numerous other species have been found with *H. verticillata*, including *V. americana*, *N. guadalupensis*, *E. canadensis*, *N. minor*, *C. demersum*, *M. spicatum*, *Z. palustris*, and *H. dubia*. Submerged aquatic vegetation has been consistently abundant in Port Tobacco River and Nanjemoy Creek, as well as along the shoreline of the Potomac River above and below each of these systems. Along the south side of the river, SAV was abundant adjacent to Mathias Point Neck. Species recorded in this section of the river by ground surveys are *M. spicatum*, *V. americana*, *N. guadalupensis*, *E. canadensis*, *N. minor*, *C. demersum*, *Z. palustris*, *P. perfoliatus*, *P. pectinatus*, and *P. crispus*.

In the Middle Potomac River, the Maryland Department of Natural Resources ground survey reported only two years with vegetated stations (1980 and 1991) since 1971 (Figure 101). The 1990 U.S. Fish and Wildlife Service clam survey found only *V. americana* in the Port Tobacco River and Nanjemoy Creek, although the diversity of SAV is high there (Jorde et al., 1991).

Submerged aquatic vegetation in the Upper Potomac River has shown the most remarkable increase compared to any other segment in Chesapeake Bay (Figure 102, Table 39). The Maryland Department of Natural Resources ground survey reported no SAV between 1972 and 1977 (Figure 104). Although the U.S. Geological Survey reported sparse populations of SAV between 1978 and 1981 (Haramis and Carter, 1983), the aerial survey recorded no SAV in 1978. In 1984, 622 hectares of SAV were mapped in the aerial survey, a result of the rapid spread of *H. verticillata* as well as some other native species downriver from Wash-

Middle Potomac River

Year	Hectares of SAV by Density Category				Segment Total	% of Tier I Restoration Goal	% of Tier III Restoration Goal
	<10%	10-40%	40-70%	70-100%			
'70	-	-	-	-	-	-	-
'71	-	-	-	-	-	-	-
'72	-	-	-	-	-	-	-
'73	-	-	-	-	-	-	-
'74	-	-	-	-	-	-	-
'75	-	-	-	-	-	-	-
'76	-	-	-	-	-	-	-
'77	-	-	-	-	-	-	-
'78	0	281	0	0	281	15%	4%
'79	-	-	-	-	-	-	-
'80	-	-	-	-	-	-	-
'81	-	-	-	-	-	-	-
'82	-	-	-	-	-	-	-
'83	-	-	-	-	-	-	-
'84	25	62	93	42	222	12%	3%
'85	12	70	215	145	442	23%	6%
'86	27	123	117	163	430	23%	6%
'87	18	58	53	378	507	27%	7%
'88	-	-	-	-	-	-	-
'89	69	119	81	1,005	1,274	68%	17%
'90	96	206	242	824	1,368	74%	18%
'91	103	63	153	1,153	1,472	80%	20%

Table 38. Hectares of SAV by density category and percentage of Tier I SAV restoration goal (1,847 hectares) and Tier III SAV restoration target (7,443 hectares) are listed for 1970 to 1991 for CBP Segment RET2 (Middle Potomac River). In 1978, 100 hectares of SAV were mapped for which no density category was reported, but were included in the segment total.
Sources: Anderson and Macomber, 1980; Batiuk et al., 1992; Orth et al., 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Nowak, 1990.

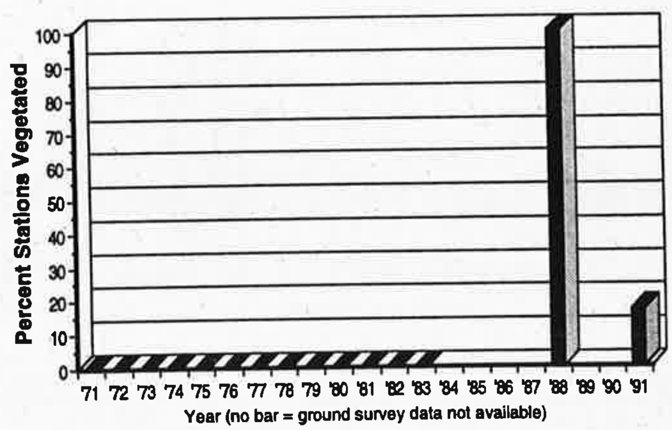


Figure 101. Percentage of Maryland Department of Natural Resources SAV Ground Survey Program stations sampled where SAV was observed for CBP Segment RET2 (Middle Potomac River). Ground survey data were not available for 1984 to 1987, 1989, and 1990.
Source: Chesapeake Bay Program, unpublished data c.

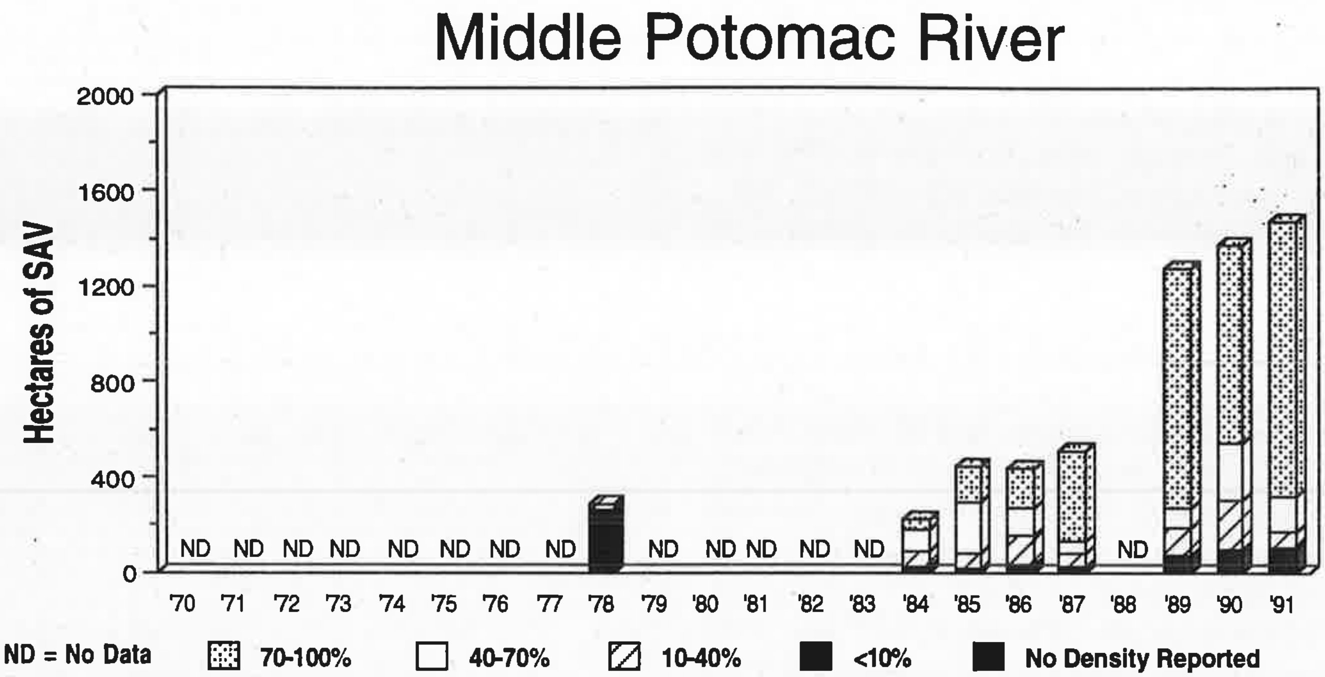


Figure 99. Hectares of SAV by density category for all years for which aerial survey data were available. For CBP Segment RET2 (Middle Potomac River), the Tier I SAV restoration goal is 1,847 hectares.
Sources: Anderson and Macomber, 1980; Batiuk et al., 1992; Orth et al., 1979, 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Nowak, 1990.

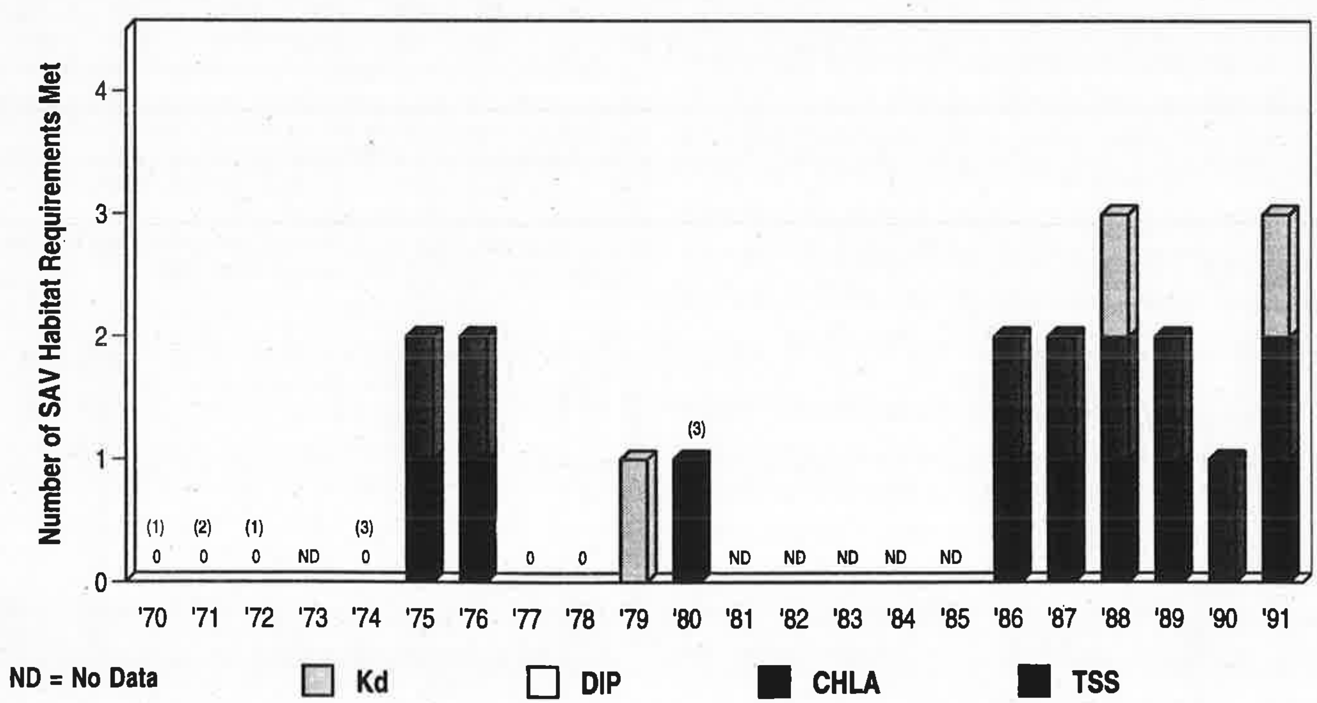


Figure 100. The number of SAV habitat requirements met over the SAV growing season from 1970 to 1991 for CBP Segment RET2 (Middle Potomac River). No SAV habitat requirements met = 0; no water quality data available = ND. Sufficient data for the following parameters were not available to calculate growing season medians: Kd (1970-1974, 1981-1983, 1985); TSS (1970-1973, 1980-1985); CHLA (1970, 1972, 1973, 1981-1985); and DIP (1973, 1981-1985). Numbers of SAV habitat requirements with growing season medians are shown above bars when some values were missing.
Sources: Chesapeake Bay Program, 1993a and 1993b.

Upper Potomac River

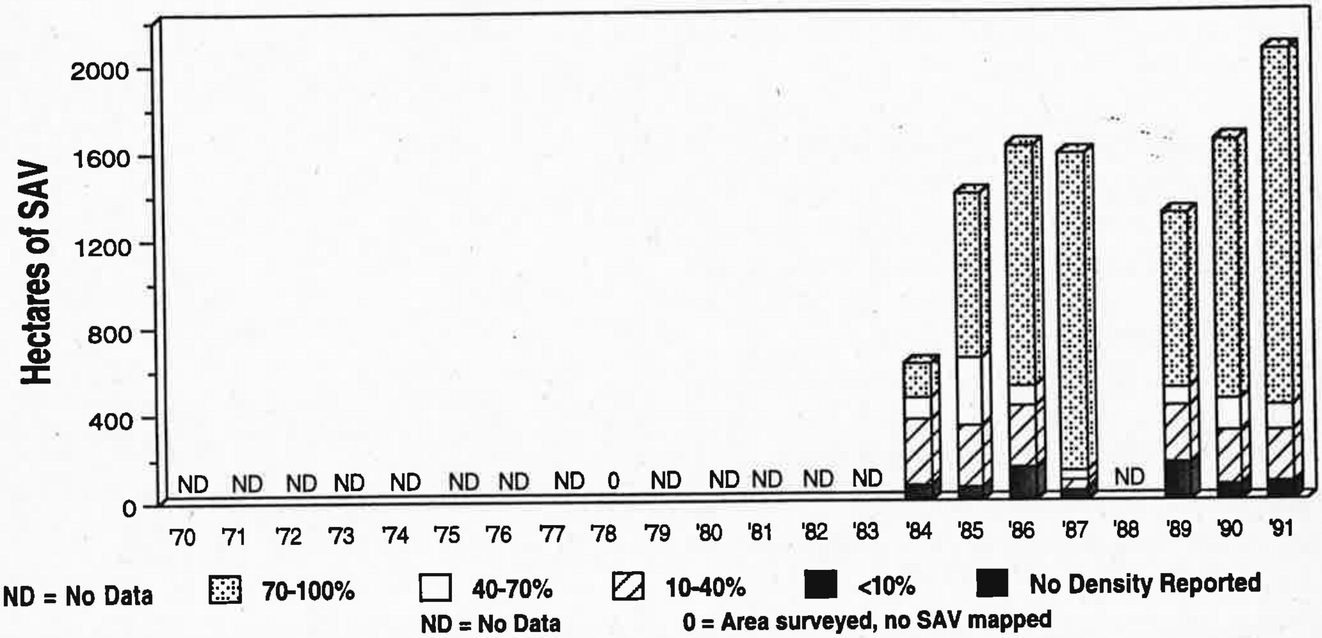


Figure 102. Hectares of SAV by density category for all years for which aerial survey data were available. For CBP Segment TF2 (Upper Potomac River), the Tier I SAV restoration goal is 3,098 hectares. In 1991, 2,049 hectares of SAV were reported.
Sources: Anderson and Macomber, 1980; Batiuk et al., 1992; Orth et al., 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Nowak, 1990.

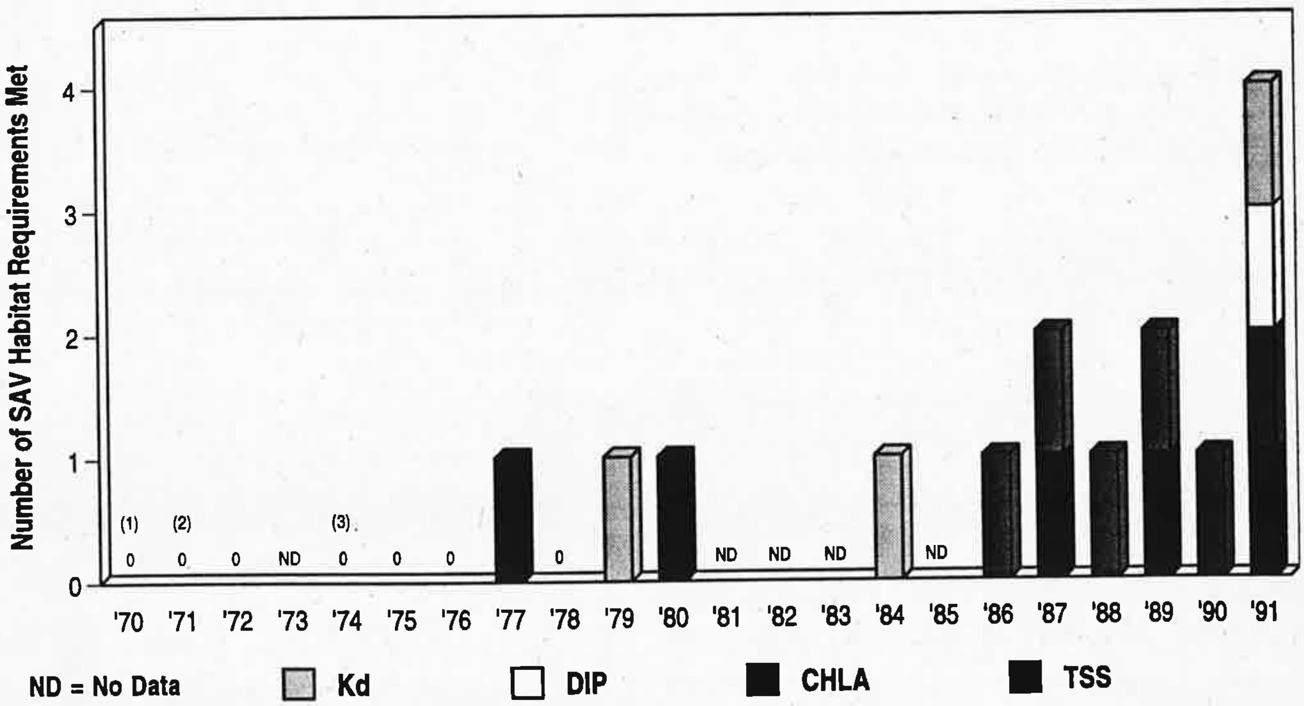


Figure 103. The number of SAV habitat requirements met over the SAV growing season from 1970 to 1991 for CBP Segment TF2 (Upper Potomac River). No SAV habitat requirements met = 0; no water quality data available = ND. Sufficient data for the following parameters were not available to calculate growing season medians: Kd (1970-1974, 1981-1985); TSS (1970-1973, 1981-1985); CHLA (1972, 1973, 1981-1985); and DIP (1970, 1972, 1973, 1981-1985). Numbers of SAV habitat requirements with growing season medians are shown above bars when some values were missing.
Sources: Chesapeake Bay Program, 1993a and 1993b.

ington, DC. *Hydrilla verticillata* was first found in Dyke Marsh in 1982 and had spread rapidly throughout the tidal fresh sections of the river by 1984.

The greatest change occurred between 1984 and 1986 when SAV distribution increased from 622 to 1,618 hectares, occupying most shallow water areas down to Quantico. Some decline occurred by 1989 (1,306 hectares) when *H. verticillata* was no longer found in dense beds in either Piscataway and Broad creeks or along the shoreline across from these creeks. A significant increase took place again between 1989 and 1991; 2,049 hectares were mapped in 1991. The only large areas of shallow water which did not support SAV throughout this period were in Occoquan and Belmont bays, although ground surveys did report *M. spicatum* and *H. verticillata* in Belmont Bay in 1991. The Maryland Department of Natural Resources SAV survey reported vegetated stations only in 1988 and 1991 (Figure 104).

Submerged aquatic vegetation distribution in the Upper Potomac River, from Quantico north to Washington, DC has begun to stabilize in recent years. Most shallow water habitat (one meter or less) is now occupied by SAV. Species recorded in this section of the river by ground surveys were *M. spicatum*, *V. americana*, *H. dubia*, *N. guadalupensis*, *N. gracillima, E. canadensis*, *N. minor*, *C. demersum*, *Z. palustris*, *P. pusillus*, and *P. pectinatus*, with *H. verticillata*, by far, the dominant species.

Increases in SAV in the Upper Potomac River are attributed, in part, to improvements in the Blue Plains Wastewater Treatment Plant in Washington, DC. These improvements have reduced total suspended solids and phosphorus loadings significantly and the plant now uses nitrification. In addition, the dense beds of *H. verticillata* presumably influenced water quality in the shoal areas. Barko (unpublished data) has hypothesized that sediment nutrient changes were factors in the decline. Carter

Upper Potomac River

Year	Hectares of SAV by Density Category				Segment Total	% of Tier I Restoration Goal	% of Tier III Restoration Goal
	<10%	10-40%	40-70%	70-100%			
'70	-	-	-	-	-	-	-
'71	-	-	-	-	-	-	-
'72	-	-	-	-	-	-	-
'73	-	-	-	-	-	-	-
'74	-	-	-	-	-	-	-
'75	-	-	-	-	-	-	-
'76	-	-	-	-	-	-	-
'77	-	-	-	-	-	-	-
'78	-	-	-	-	0	0%	0%
'79	-	-	-	-	-	-	-
'80	-	-	-	-	-	-	-
'81	-	-	-	-	-	-	-
'82	-	-	-	-	-	-	-
'83	-	-	-	-	-	-	-
'84	71	294	105	152	622	20%	7%
'85	62	279	309	748	1,398	45%	17%
'86	147	286	89	1,096	1,618	52%	19%
'87	41	50	44	1,447	1,582	51%	19%
'88	-	-	-	-	-	-	-
'89	165	266	82	793	1,306	42%	16%
'90	72	246	137	1,187	1,642	53%	20%
'91	80	230	120	1,619	2,049	66%	25%

Table 39. Hectares of SAV by density category and percentage of Tier I SAV restoration goal (3,098 hectares) and Tier III SAV restoration target (8,304 hectares) are listed for 1970 to 1991 for CBP Segment TF2 (Upper Potomac River).
Sources: Anderson and Macomber, 1980; Batiuk et al., 1992; Orth et al., 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Nowak, 1990.

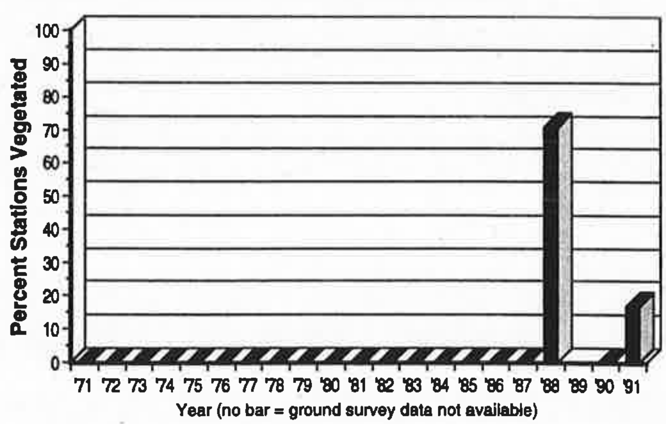


Figure 104. Percentage of Maryland Department of Natural Resources SAV Ground Survey Program stations sampled where SAV was observed for CBP Segment TF2 (Upper Potomac River). Ground survey data were not available for 1989.
Source: Chesapeake Bay Program, unpublished data c.

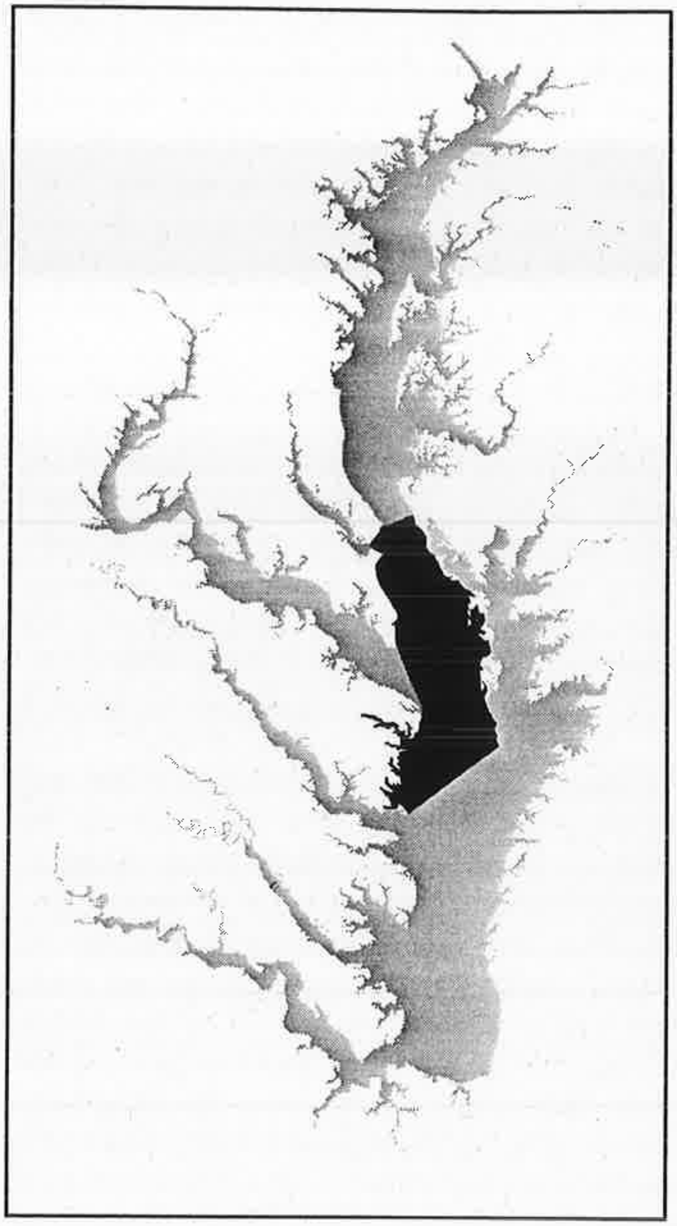
et al. (in press) found increases in plant coverage when the mean Secchi depth was greater than 0.65 meters and decreases in the coverage when the mean Secchi depth dropped below 0.65 meters. The decline of SAV in several sections between 1987 and 1989 resulted from meteorological changes (cool spring temperatures coupled with greater than normal spring rains) and poor water clarity (Carter et al., in press).

Despite the large increases in SAV in the middle and upper Potomac River, mid-channel water quality conditions were not suitable for SAV survival and growth until 1991. In most years, only two of the SAV habitat requirements (generally total suspended solids and chlorophyll *a*) were routinely achieved (Figures 100 and 103).

The discrepancy between increasing SAV distribution and abundance in these segments and the unsuitable water quality conditions can be attributed in part to differences in physiological and morphological adaptations of the various species. *Hydrilla verticillata* is a canopy-forming species with minimum light requirements that are lower than those of other SAV species in Chesapeake Bay (Carter and Rybicki, 1990). Its leaves grow rapidly to the surface and form a canopy that alters local water quality, particularly water clarity. The resultant increased clarity allows other SAV species with higher light requirements to colonize these environments if they can compete with *H. verticillata*. Dense SAV beds can also alter local water quality by taking up nutrients from the water and by baffling the waves and currents that resuspend bottom sediments.

Achievement of the Tier I restoration goal and the Tier III restoration target has been greatest in the Upper and Middle Potomac River, the segments where SAV increased most dramatically. Achievement of the Tier I restoration goal has not exceeded 20 percent, while achievement of the Tier III restoration target has been less than 1 percent in the Lower Potomac River segment from 1984 through 1991 (Table 37). In the middle river segment, achievement of the Tier I restoration goal and Tier III restoration target increased from 12 percent to 80 percent and 3 percent to 38 percent, respectively, during the same period (Table 38). In the upper river segment, achievement of the Tier I restoration goal and the Tier III restoration target increased from 20 percent to 66 percent and 7 percent to 25 percent, respectively (Table 39).

Lower Chesapeake Bay



The Lower Chesapeake Bay segment includes a broad expanse of both the eastern and western shores of the mainstem Bay. It extends southward from just north of the Patuxent River to just above the Rappahannock River mouth and northeast to Tangier Island. This segment contains the third highest amount of potential SAV habitat (Tangier Sound has the largest, followed by the Middle Potomac River segment) based on the Tier III restoration target (Table 5). Along the western shore, most of the potential habitat is located between Smith Point at the mouth of the Potomac River and Windmill Point at the mouth of the Rappahannock River. Along the Eastern Shore, potential SAV habitat includes areas east of the Hooper Islands (the Barren Island area), and portions of Bloodsworth, South Marsh, Smith, and Tangier islands.

Submerged aquatic vegetation abundance has been gradually increasing in the Lower Chesapeake Bay segment, from 2,120 hectares in 1978 to 4,810 hectares in 1991, an increase of over 125 percent (Figure 105; Table 40). Although SAV has increased in all areas of this segment, the most dramatic changes between 1978 and 1991 occurred around Barren (142 to 1,587 hectares), Bloodsworth and Southmarsh islands (2,571 to 4,706 hectares), and Smith and Tangier islands (121 to 1,027 hectares).

The Maryland Department of Natural Resources ground survey reported the percentage of vegetated stations fluctuated between 0 percent and 10 percent between 1971 and 1988, increased from 0 percent to 15 percent from 1988 to 1990, and then declined to 3 percent by 1991 (Figure 107).

Four species have been documented in this segment. *Zostera marina* and *R. maritima* were the most commonly reported species and *P. pectinatus* and *Z. palustris* occurred less frequently. Following the decline of SAV in the 1970s, only *R. maritima* was reported from areas north of Smith Island; it appears that *Z. marina* was completely eliminated from these areas. Only in 1990 did the Maryland Department of Natural Resources ground survey report *Z. marina* from several locations around Bloodsworth Island.

Along the western shore, only two species (*Z. marina* and *R. maritima*) have been reported. This area contained abundant SAV in the late 1960s, although levels declined in the 1970s. The Fleets Bay area just above Windmill Point was examined

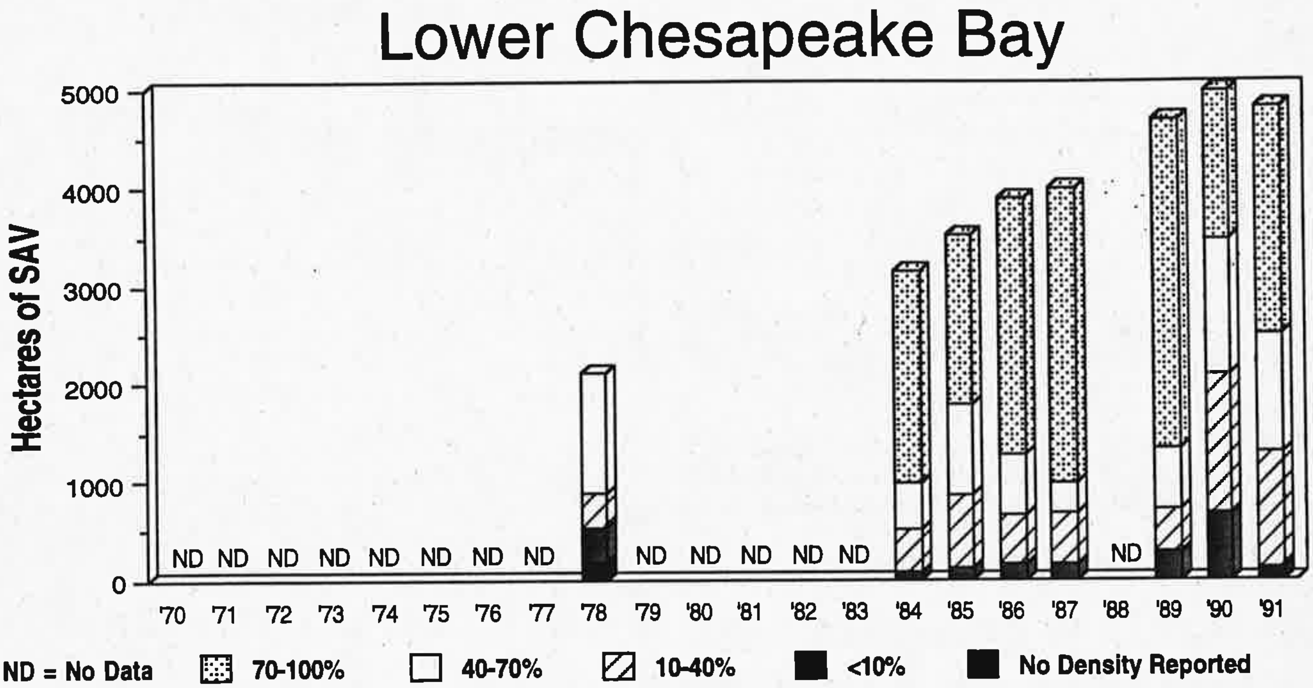


Figure 105. Hectares of SAV by density category for all years for which aerial survey data were available. For CBP Segment CB5 (Lower Chesapeake Bay), the Tier I SAV restoration goal is 6,309 hectares.
Sources: Anderson and Macomber, 1980; Batiuk et al., 1992; Orth et al., 1979, 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Nowak, 1990.

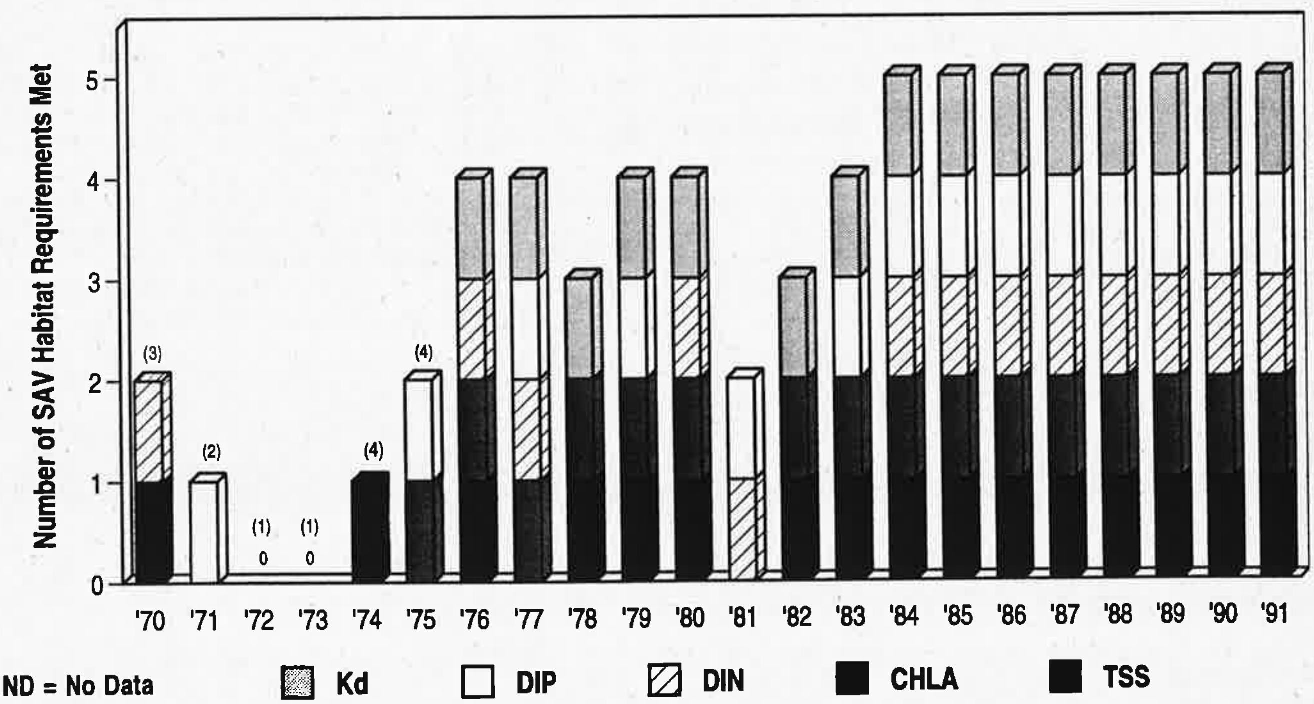


Figure 106. The number of SAV habitat requirements met over the SAV growing season from 1970 to 1991 for CBP Segment CB5 (Lower Chesapeake Bay). No SAV habitat requirements met = 0; no water quality data available = ND. Sufficient data for the following parameters were not available to calculate growing season medians: Kd (1970-1975); TSS (1971-1973); CHLA (1970-1973); and DIP (1972, 1973). Numbers of SAV habitat requirements with growing season medians are shown above bars when some values were missing.
Sources: Chesapeake Bay Program, 1993a and 1993b.

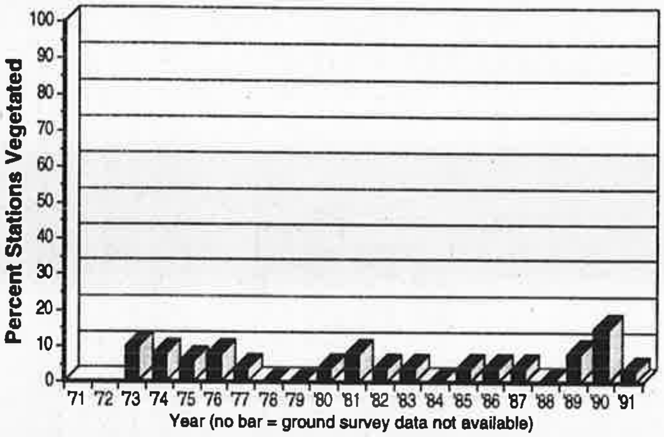


Figure 107. Percentage of Maryland Department of Natural Resources SAV Ground Survey Program stations sampled where SAV was observed for CBP Segment CB5 (Lower Chesapeake Bay). Ground survey data were not available for 1971 and 1972.
Source: Chesapeake Bay Program, unpublished data c.

from 1937 to 1978. Submerged aquatic vegetation increased from 190 hectares in 1937 to 543 hectares in 1969, dropping to 73 hectares in 1978 (Orth et al., 1979). Submerged aquatic vegetation in the section from Windmill Point at the mouth of the Rappahannock River to Smith Point at the mouth of the Potomac River has been generally increasing—from 363 hectares in 1978 to 635 hectares in 1991. In addition, a small but expanding bed (2.2 hectares in 1991) of *Z. marina* and *R. maritima* in Fleets Bay is notable because it is situated in relatively deep (two meters at mean low water) water.

Four of the five SAV habitat requirements were generally met after 1975 until 1984. The improving water quality of the late 1970s and early 1980s (towards the meeting of all five SAV habitat requirements) parallels the increasing trend of SAV distribution for this region of the mainstem Bay. Water quality in this segment has been suitable for SAV survival and growth since 1984 when all five SAV habitat requirements were met (Figure 106).

With the large increase in SAV from 1978 to 1991, the percent achievement of the Tier I restoration goal and the Tier III restoration target has increased from 34 percent to 76 percent and from 14 percent to 32 percent, respectively (Table 40).

Lower Chesapeake Bay

	Hectares of SAV by Density Category						
Year	<10%	10-40%	40-70%	70-100%	Segment Total	% of Tier I Restoration Goal	% of Tier III Restoration Goal
70	-	-	-	-	-	-	-
'71	-	-	-	-	-	-	-
'72	-	-	-	-	-	-	-
'73	-	-	-	-	-	-	-
'74	-	-	-	-	-	-	-
'75	-	-	-	-	-	-	-
'76	-	-	-	-	-	-	-
'77	-	-	-	-	-	-	-
'78	352	352	1,248	0	2,120	34%	14%
'79	-	-	-	-	-	-	-
'80	-	-	-	-	-	-	-
'81	-	-	-	-	-	-	
'82	-	-	-	-	-	-	-
'83	-	-	-	-	-	-	-
'84	67	444	476	2,144	3,131	50%	21%
'85	112	751	925	1,723	3,511	56%	23%
'86	161	496	610	2,610	3,877	61%	26%
'87	160	515	299	3,008	3,982	63%	26%
'88	-	-	-	-	-	-	-
'89	279	439	619	3,356	4,693	52%	22%
'90	669	1,431	1,368	1,,512	4,980	79%	33%
'91	118	1,168	1,211	2,313	4,810	76%	32%

Table 40. Hectares of SAV by density category and percentage of Tier I SAV restoration goal (6,309 hectares) and Tier III SAV restoration target (15,083 hectares) are listed for 1970 to 1991 for CBP Segment CB5 (Lower Chesapeake Bay). In 1978, 168 hectares of SAV were mapped for which no density category was reported but were included in the segment total.
Sources: Anderson and Macomber, 1980; Batiuk et al., 1992; Orth et al., 1979, 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Nowak, 1990.

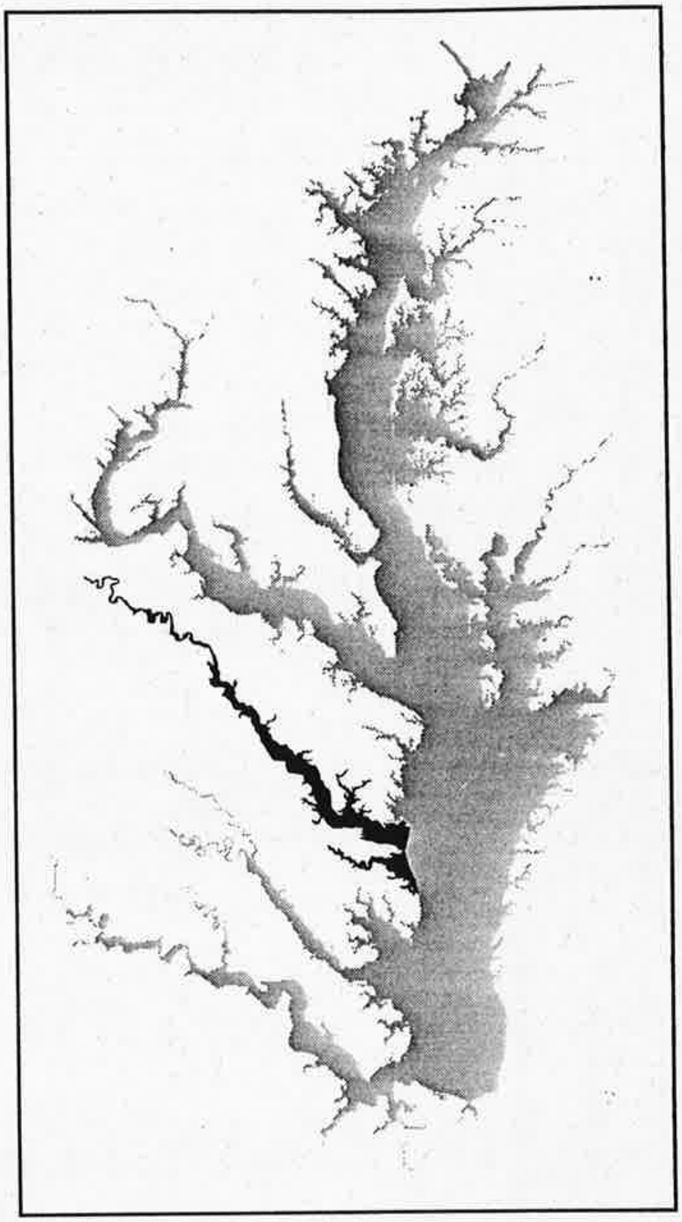
Rappahannock River

This region includes the Rappahannock and Piankatank rivers and a small portion of Milford Haven. Submerged aquatic vegetation was present primarily in the lower Rappahannock and Piankatank rivers in 1971 (1,123 hectares), with beds consisting of both *Z. marina* and *R. maritima* (Figure 108, Table 41). By 1974, however, only 33 hectares were reported. No more than 75 hectares were reported in the Lower Rappahannock River segment until after 1986. From 184 hectares in 1987, SAV distribution increased to 612 hectares in 1989 and then declined to 316 hectares by 1991.

No SAV has been reported from the aerial survey in the Middle and Upper Rappahannock River segments over the last 20 years (Figures 110 and 112; Tables 42 and 43). A ground survey conducted in 1978, however, found several species in many small creeks at 27 locations (Orth et al., 1979). *Potamogeton crispus*, *Z. palustris*, *V. americana*, *E. canadensis*, *C. demersum*, *N. guadalupensis*, *N. minor*, and *R. maritima* were reported as occasional to abundant in many of these areas.

Prior to 1971, historical analyses indicated the continued presence of SAV from 1937 to 1971 in one area (Parrott Island) on the south shore of the lower Rappahannock River (Orth et al., 1979). The 350 hectares of SAV reported in 1960 had declined to less than five hectares by 1974.

In the middle 1980s, portions of the lower Rappahannock River and Piankatank River became colonized with *R. maritima*. Although some declines of this species occurred through 1991, large monospecific stands still exist along the north shore of the Rappahannock River from Towles Point at the mouth of the Corrotoman River to Carters Creek in the Corrotoman River and along the north end of Gwynn Island at the mouth of the Piankatank River.



Some areas of the lower Rappahannock and Piankatank rivers are also being colonized by *Z. marina*, both naturally and with transplants. Since 1984, the Virginia Institute of Marine Science scientists have transplanted both whole plants and seeds to several locations in both rivers (Orth, unpublished data). The scientists have observed transplant success just south of Carters Creek in the Rappahannock River where *Z. marina* seeds were broadcast into an area containing dense *R. maritima* in 1987. This 13-hectare bed now consists of both species. In the Piankatank River, whole plants of *Z. marina* were placed in an unvegetated area off

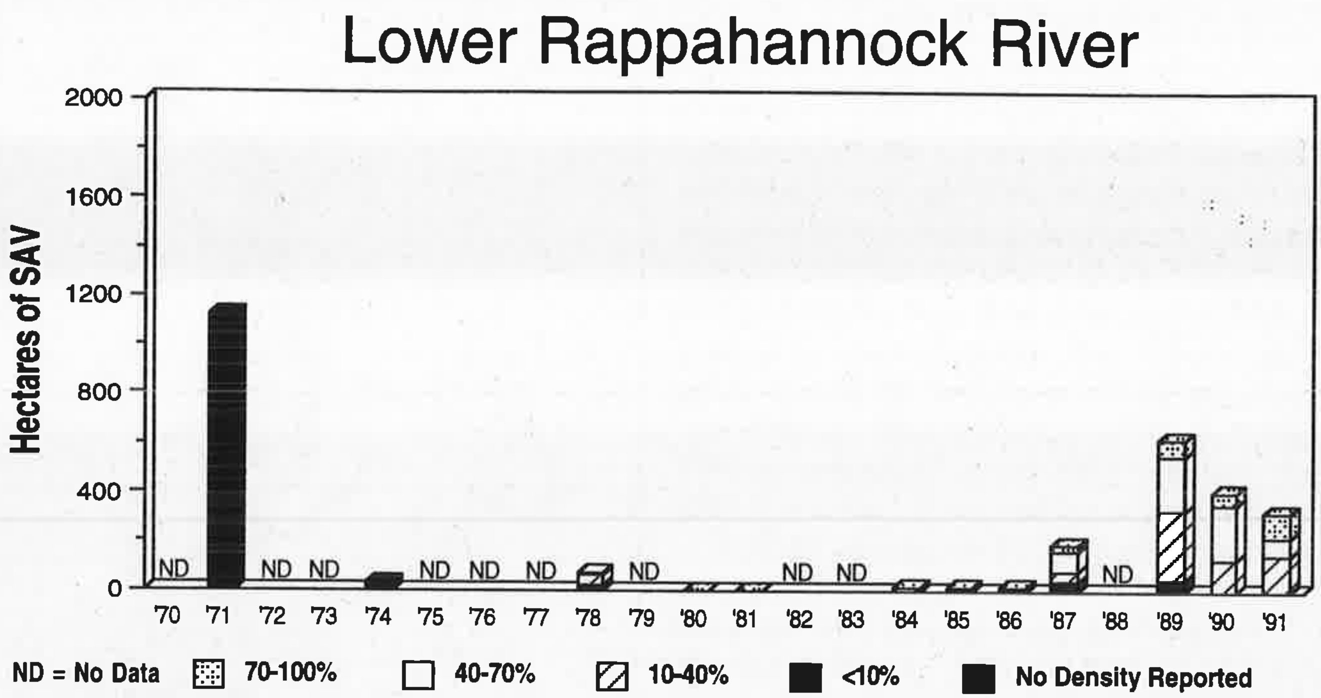


Figure 108. Hectares of SAV by density category for all years for which aerial survey data were available. For CBP Segment LE3 (Lower Rappahannock River), the Tier I SAV restoration goal is 1,714 hectares.
Sources: Batiuk et al., 1992; Chesapeake Bay Program, unpublished data b; Orth et al., 1979, 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Gordon, 1975; Orth and Nowak, 1990.

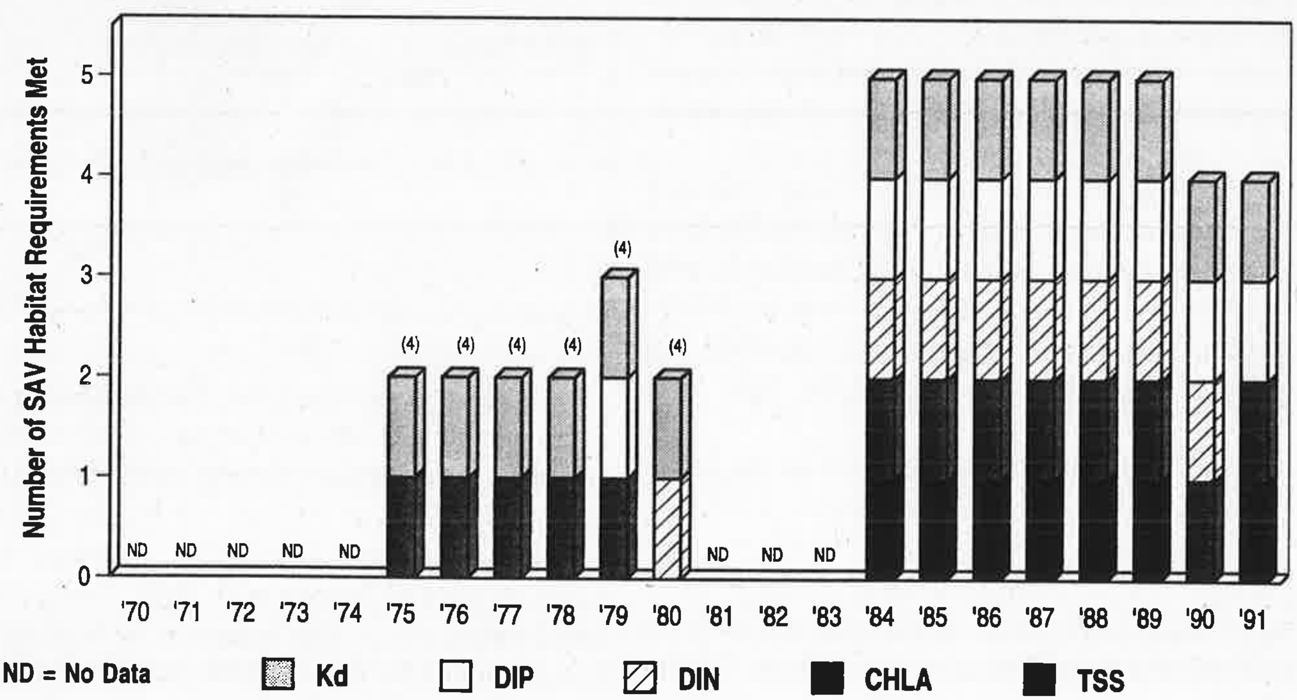


Figure 109. The number of SAV habitat requirements met over the SAV growing season from 1970 to 1991 for CBP Segment LE3 (Lower Rappahannock River). No SAV habitat requirements met = 0; no water quality data available = ND. Sufficient data for the following parameters were not available to calculate growing season medians: Kd (1970-1974, 1981-1983); TSS (1970-1979, 1981-1983); CHLA (1970-1974, 1980-1983); DIP (1970-1974, 1981-1983); and DIN (1970-1974, 1981-1983). Numbers of SAV habitat requirements with growing season medians are shown above bars when some values were missing.
Sources: Chesapeake Bay Program, 1993a and 1993b.

Burtons Point—at the mouth of the river—between 1984 and 1986. By 1991, this SAV bed had expanded to 15 hectares and also had been colonized naturally with *R. maritima*. Transplants at two other locations in the Rappahannock River (Parrott Island and Belle Isle) and one site in the Piankatank River (Healy Creek) have not survived for more than two years.

Several areas have revegetated naturally with *Z. marina*, most notably along the north shore of the Rappahannock River at Windmill Point. Part of the bed at Windmill Point is in the western Lower Chesapeake Bay segment. This bed, which also contains *R. maritima*, had expanded to 13 hectares by 1991.

Water quality conditions in the lower Rappahannock and Piankatank rivers have been generally suitable for SAV survival and growth since 1984, with all five SAV habitat requirements met from 1984 to 1989 (Figure 109). Between 1975 and 1980, only the light attenuation coefficient and chlorophyll *a* habitat requirements were consistently met.

In the Middle Rappahannock River, only the chlorophyll *a*, dissolved inorganic nitrogen, and dissolved inorganic phosphorus SAV habitat requirements were generally met between 1984 and 1991 (Figure 111). No more than three SAV habitat requirements were met during any one year. Prior to 1983, two or fewer SAV habitat requirements were met during any one year, with only the chlorophyll *a* habitat requirement met consistently from 1975 to 1979.

Water quality conditions were unsuitable for SAV survival in the Upper Rappahannock River over the 15-year data record (Figure 113). From 1975 to 1979, only the chlorophyll *a* habitat requirement was consistently met. Between 1986 to 1991, chlorophyll *a* and dissolved inorganic phosphorus were the only requirements achieved.

Lower Rappahannock River

Year	Hectares of SAV by Density Category: <10%	10-40%	40-70%	70-100%	Segment Total	% of Tier I Restoration Goal	% of Tier III Restoration Goal
'70	-	-	-	-	-	-	-
'71	-	-	-	-	1,123	65%	12%
'72	-	-	-	-	-	-	-
'73	-	-	-	-	-	-	-
'74	-	-	-	-	33	2%	<1%
'75	-	-	-	-	-	-	-
'76	-	-	-	-	-	-	-
'77	-	-	-	-	-	-	-
'78	24	38	13	0	75	4%	<1%
'79	-	-	-	-	-	-	-
'80	0	0	0	<1	<1	<1%	<1%
'81	0	0	0	1	1	<1%	<1%
'82	-	-	-	-	-	-	-
'83	-	-	-	-	-	-	-
'84	<1	13	2	1	17	<1%	<1%
'85	8	<1	<1	2	12	<1%	<1%
'86	0	<1	8	3	12	<1%	<1%
'87	35	44	80	25	184	11%	2%
'88	-	-	-	-	-	-	-
'89	47	278	226	61	612	35%	7%
'90	<1	125	225	50	401	23%	4%
'91	<1	141	79	96	316	18%	3%

Table 41. Hectares of SAV by density category and percentage of Tier I SAV restoration goal (1,714 hectares) and Tier III SAV restoration target (9,342 hectares) are listed for 1970 to 1991 for CBP Segment LE3 (Lower Rappahannock River).
Sources: Batiuk et al., 1992; Chesapeake Bay Program, unpublished data b; Orth et al., 1979, 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Nowak, 1990.

Submerged aquatic vegetation has not been reported through the baywide aerial survey in the Middle and Upper Rappahannock River segments where there has been no progress in achieving the tiered restoration goals and targets (Tables 42 and 43). With the recent increases in SAV in the lower Rappahannock and Piankatank rivers, however, the percent achievement of the Tier I restoration goal and the Tier III restoration target has increased from less than 1 percent to 18 percent and from less than 1 percent to 3 percent, respectively, from 1984 to 1991 (Table 41).

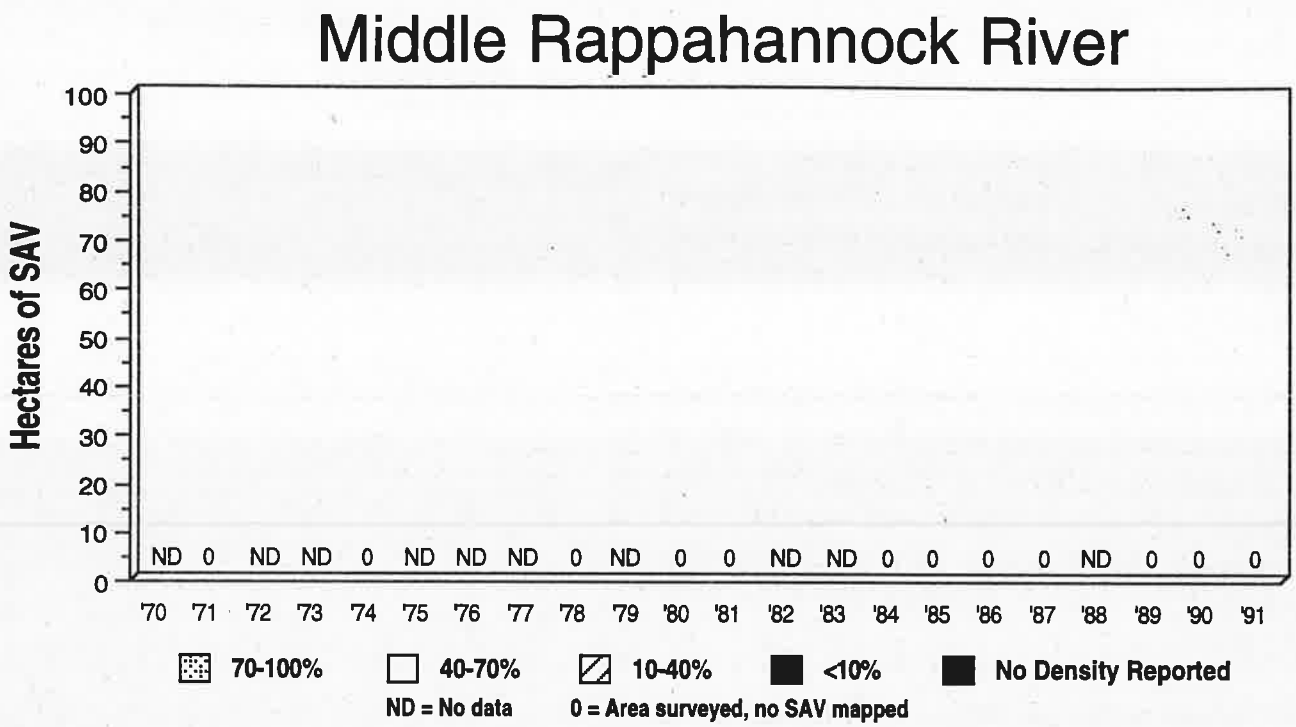


Figure 110. Hectares of SAV by density category for all years for which aerial survey data were available. For CBP Segment RET3 (Middle Rappahannock River), there is no Tier I SAV restoration goal.
Sources: Batiuk et al., 1992; Chesapeake Bay Program, unpublished data b; Orth et al., 1979, 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Gordon, 1975; Orth and Nowak, 1990.

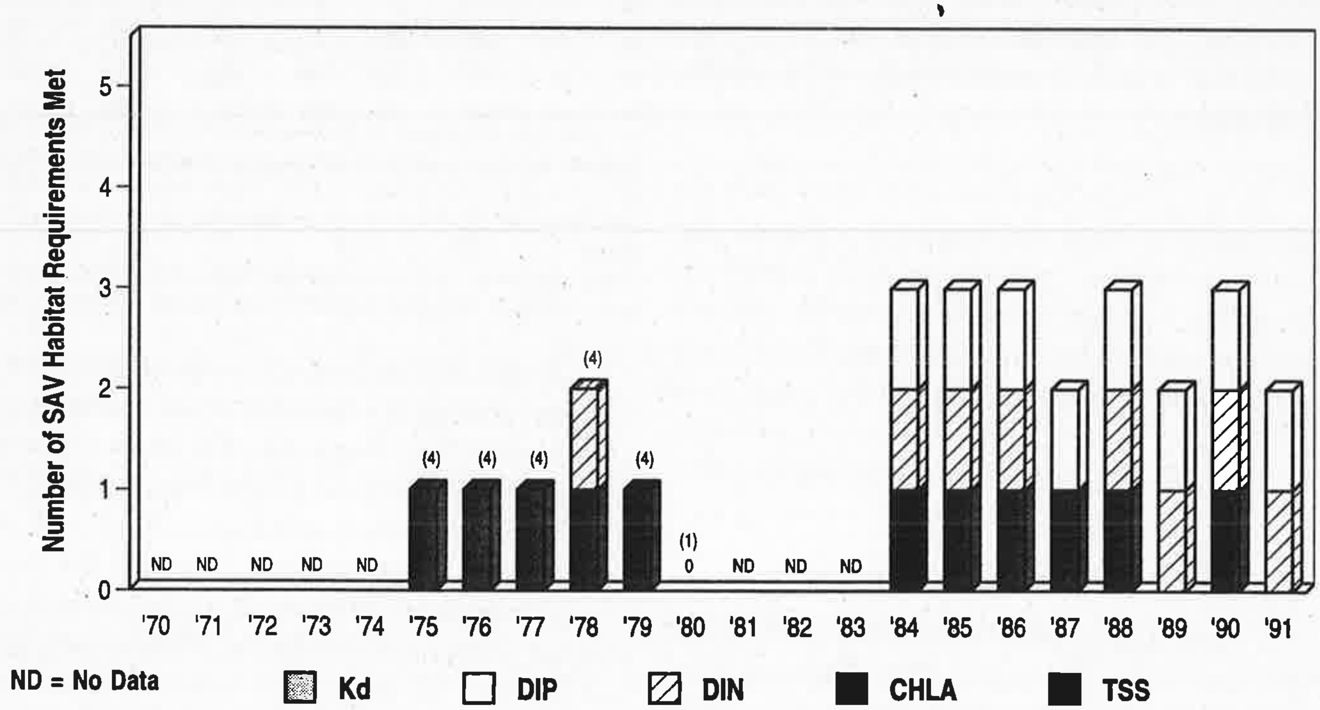


Figure 111. The number of SAV habitat requirements met over the SAV growing season from 1970 to 1991 for CBP Segment RET3 (Middle Rappahannock River). No SAV habitat requirements met = 0; no water quality data available = ND. Sufficient data for the following parameters were not available to calculate growing season medians: Kd (1970-1974, 1981-1983); TSS (1970-1983); CHLA (1970-1974, 1980-1984); DIP (1970-1974, 1980-1983); and DIN (1970-1974, 1980-1983). Numbers of SAV habitat requirements with growing season medians are shown above bars when some values were missing.
Sources: Chesapeake Bay Program, 1993a and 1993b.

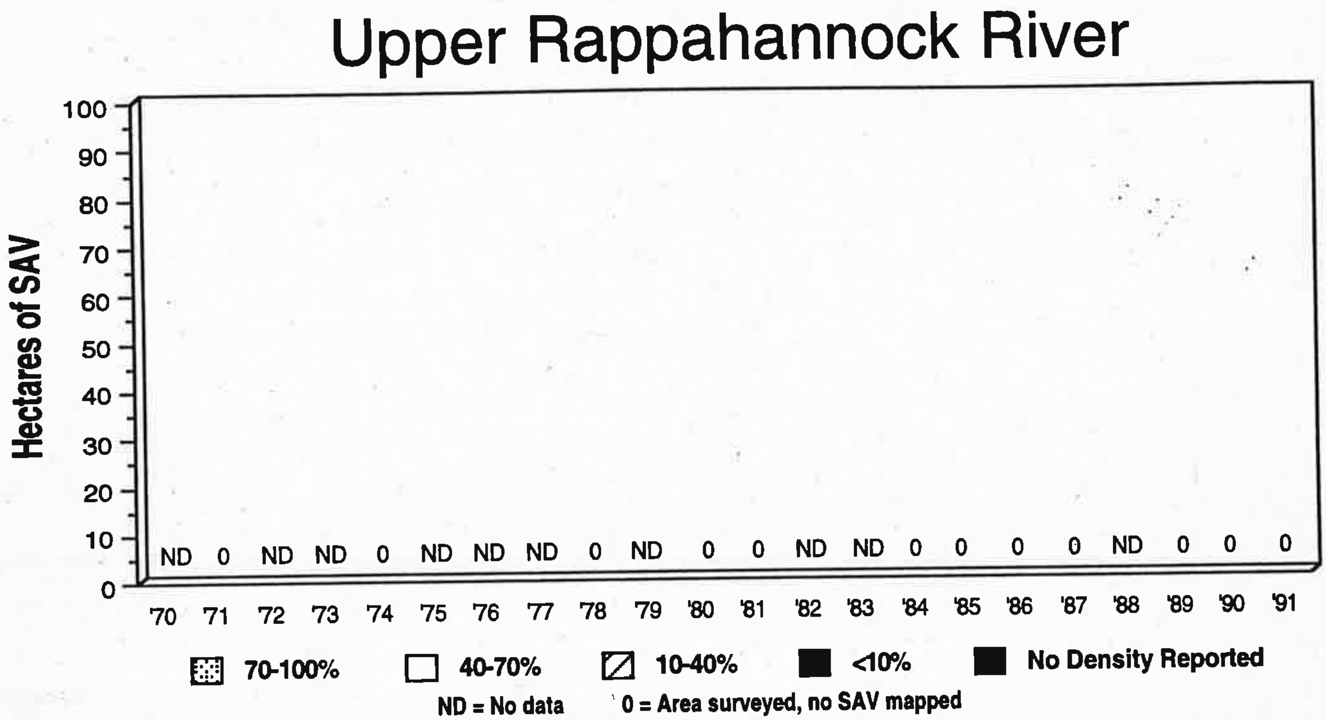


Figure 112. Hectares of SAV by density category for all years for which aerial survey data were available. For CBP Segment TF3 (Upper Rappahannock River), there is no Tier I SAV restoration goal.
Sources: Batiuk et al., 1992; Chesapeake Bay Program, unpublished data b; Orth et al., 1979, 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Gordon, 1975; Orth and Nowak, 1990.

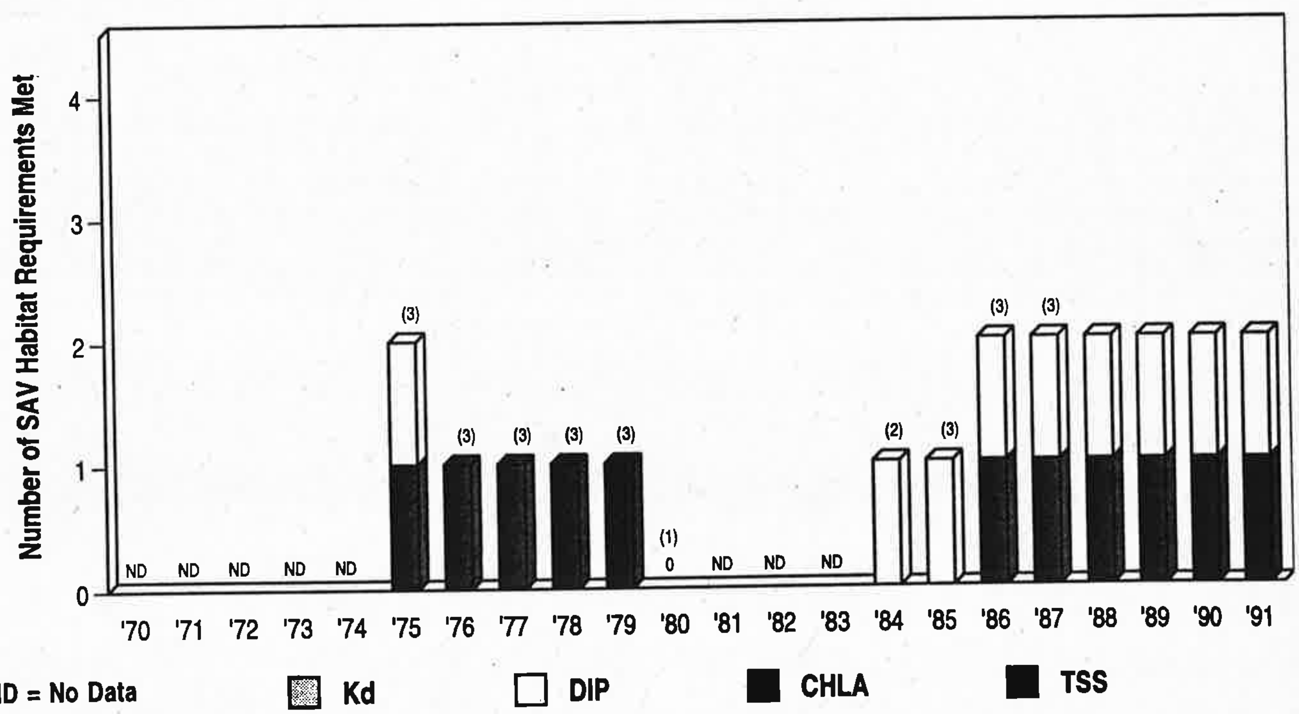


Figure 113. The number of SAV habitat requirements met over the SAV growing season from 1970 to 1991 for CBP Segment TF3 (Upper Rappahannock River). No SAV habitat requirements met = 0; no water quality data available = ND. Sufficient data for the following parameters were not available to calculate growing season medians: Kd (1970-1974, 1981-1983); TSS (1970-1987); CHLA (1970-1974, 1980-1984); and DIP (1970-1974, 1980-1983). Numbers of SAV habitat requirements with growing season medians are shown above bars when some values were missing.
Sources: Chesapeake Bay Program, 1993a and 1993b.

Middle Rappahannock River

Year	Hectares of SAV by Density Category				Segment Total	% of Tier I Restoration Goal	% of Tier III Restoration Goal
	<10%	10-40%	40-70%	70-100%			
'70	-	-	-	-	-	-	-
'71	-	-	-	-	0	-	0%
'72	-	-	-	-	-	-	-
'73	-	-	-	-	-	-	-
'74	-	-	-	-	0	-	0%
'75	-	-	-	-	-	-	-
'76	-	-	-	-	-	-	-
'77	-	-	-	-	-	-	-
'78	0	0	0	0	0	-	0%
'79	-	-	-	-	-	-	-
'80	0	0	0	0	0	-	0%
'81	0	0	0	0	0	-	0%
'82	-	-	-	-	-	-	-
'83	-	-	-	-	-	-	-
'84	0	0	0	0	0	-	0%
'85	0	0	0	0	0	-	0%
'86	0	0	0	0	0	-	0%
'87	0	0	0	0	0	-	0%
'88	-	-	-	-	-	-	-
'89	0	0	0	0	0	-	0%
'90	0	0	0	0	0	-	0%
'91	0	0	0	0	0	-	0%

Table 42. Hectares of SAV by density category and percentage of Tier III SAV restoration target (5,928 hectares) are listed for 1970 to 1991 for CBP Segment RET3 (Middle Rappahannock River). There is no SAV Tier I SAV restoration goal for this segment.

Sources: Batiuk et al., 1992; Chesapeake Bay Program, unpublished data b; Orth et al., 1979, 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Nowak, 1990.

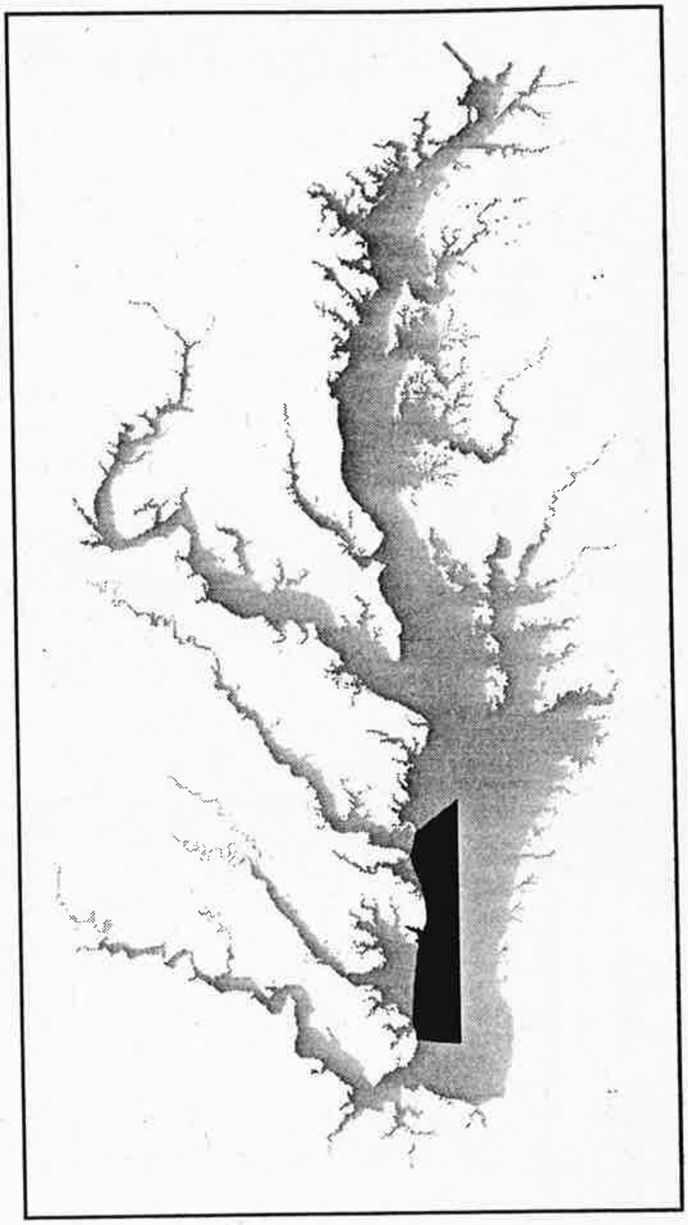
Upper Rappahannock River

Year	Hectares of SAV by Density Category				Segment Total	% of Tier I Restoration Goal	% of Tier III Restoration Goal
	<10%	10-40%	40-70%	70-100%			
'70	-	-	-	-	-	-	-
'71	-	-	-	-	0	-	0%
'72	-	-	-	-	-	-	-
'73	-	-	-	-	-	-	-
'74	0	0	0	0	0	-	0%
'75	-	-	-	-	-	-	-
'76	-	-	-	-	-	-	-
'77	-	-	-	-	-	-	-
'78	0	0	0	0	0	-	0%
'79	-	-	-	-	-	-	-
'80	0	0	0	0	0	-	0%
'81	0	0	0	0	0	-	0%
'82	-	-	-	-	-	-	-
'83	-	-	-	-	-	-	-
'84	0	0	0	0	0	-	0%
'85	0	0	0	0	0	-	0%
'86	0	0	0	0	0	-	0%
'87	0	0	0	0	0	-	0%
'88	-	-	-	-	-	-	-
'89	0	0	0	0	0	-	0%
'90	0	0	0	0	0	-	0%
'91	0	0	0	0	0	-	0%

Table 43. Hectares of SAV by density category and percentage of Tier III SAV restoration target (3,293 hectares) are listed for 1970 to 1991 for CBP Segment TF3 (Upper Rappahannock River). There is no Tier I SAV restoration goal for this segment.

Sources: Batiuk et al., 1992; Chesapeake Bay Program, unpublished data b; Orth et al., 1979, 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Gordon, 1975; Orth and Nowak, 1990.

Western Lower Chesapeake Bay



This segment covers a portion of the mainstem Chesapeake Bay along the western shore from the mouth of the Rappahannock River to the mouth of the Back River. It includes a portion of both Windmill Point, at the mouth of the Rappahannock River, Milford Haven, and the Horn Harbor area, just north of New Point Comfort which is at the entrance to Mobjack Bay.

Both *Z. marina* and *R. maritima* have grown in this segment throughout the last two decades, steadily increasing from 1980 through 1991 from 180 to 555 hectares (Figure 114; Table 44). Over the same period, the area of SAV categorized as dense (70-100 percent) has continued to increase.

Two areas of interest are Windmill Point (discussed above) and Milford Haven. Like many areas, SAV was very abundant throughout Milford Haven in the 1960s. Submerged aquatic vegetation declined in the 1970s and occurred only in small scattered patches. Virginia Institute of Marine Science scientists transplanted submerged aquatic vegetation to Milford Haven in 1986 by using whole plants of *Z. marina*. These transplants took hold and grew through 1991. At the same time, a rapid, natural expansion of the existing SAV beds occurred along with the appearance of naturally colonizing SAV in previously unvegetated areas.

Since 1984, all five SAV habitat requirements have been met in the Western Lower Chesapeake Bay (Figure 115). The success of the transplants since 1991 in Milford Haven, and natural expansion of existing SAV (off Windmill Point and in Milford Haven), likely result from the long period of water quality that was suitable for SAV survival and growth.

The growth of SAV from 1980 to 1991 has resulted in the percent achievement of the Tier I restoration goal increasing from 23 percent to 71 percent and the percent achievement of the Tier III restoration target increasing from 6 percent to 19 percent (Table 44).

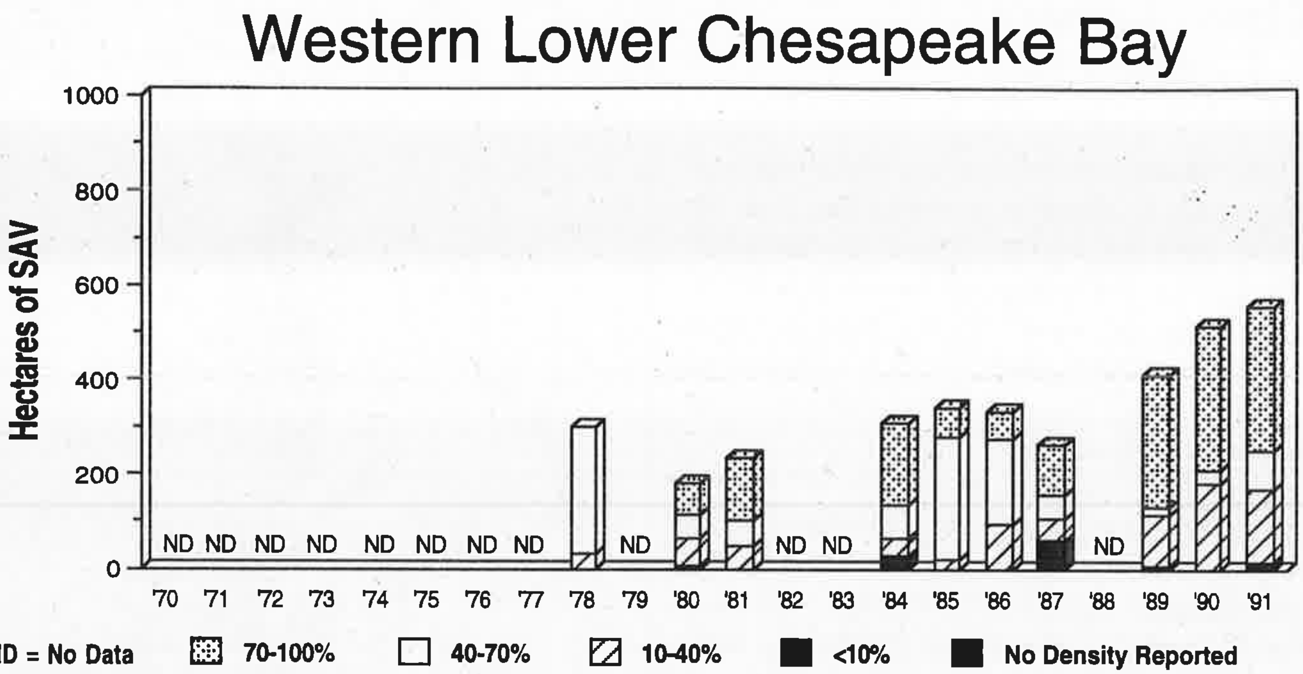


Figure 114. Hectares of SAV by density category for all years for which aerial survey data were available. For CBP Segment CB6 (Western Lower Chesapeake Bay), the Tier I SAV restoration goal is 783 hectares.
Sources: Batiuk et al., 1992; Chesapeake Bay Program, unpublished data b; Orth et al., 1979, 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Gordon, 1975; Orth and Nowak, 1990.

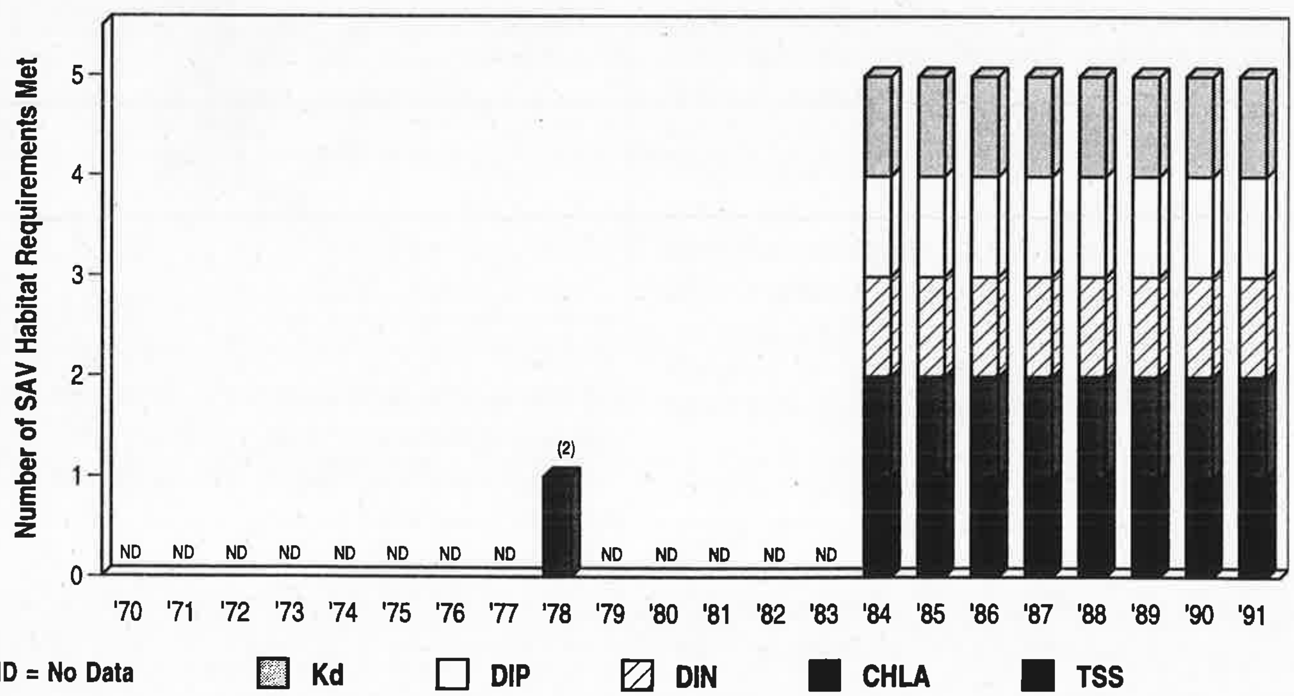


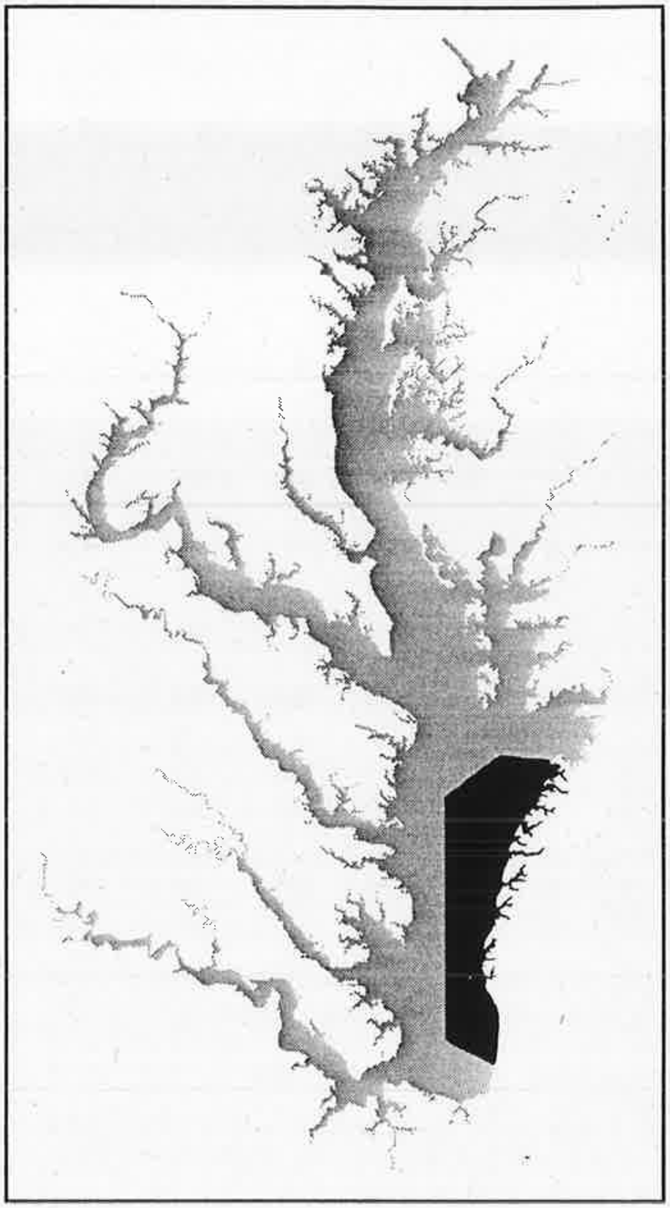
Figure 115. The number of SAV habitat requirements met over the SAV growing season from 1970 to 1991 for CBP Segment CB6 (Western Lower Chesapeake Bay). No SAV habitat requirements met = 0; no water quality data available = ND. Sufficient data for the following parameters were not available to calculate growing season medians: Kd (1970-1983); TSS (1970-1983); CHLA (1970-1977, 1979-1983); DIP (1970-1983); and DIN (1970-1977, 1979-1983). Numbers of SAV habitat requirements with growing season medians are shown above bars when some values were missing.
Sources: Chesapeake Bay Program, 1993a and 1993b.

Western Lower Chesapeake Bay

Year	Hectares of SAV by Density Category <10%	10-40%	40-70%	70-100%	Segment Total	% of Tier I Restoration Goal	% of Tier III Restoration Goal
'70	-	-	-	-	-	-	-
'71	-	-	-	-	-	-	-
'72	-	-	-	-	-	-	-
'73	-	-	-	-	-	-	-
'74	-	-	-	-	-	-	-
'75	-	-	-	-	-	-	-
'76	-	-	-	-	-	-	-
'77	-	-	-	-	-	-	-
'78	0	31	269	0	300	38%	10%
'79	-	-	-	-	-	-	-
'80	6	57	48	68	179	23%	6%
'81	0	46	57	128	231	29%	8%
'82	-	-	-	-	-	-	-
'83	-	-	-	-	-	-	-
'84	27	38	70	174	309	40%	11%
'85	0	18	260	60	338	43%	12%
'86	0	95	181	54	330	42%	11%
'87	59	48	49	107	263	34%	9%
'88	-	-	-	-	-	-	-
'89	8	106	16	278	408	52%	14%
'90	0	178	31	303	512	65%	18%
'91	14	152	81	308	554	71%	19%

Table 44. Hectares of SAV by density category and percentage of Tier I SAV restoration goal (783 hectares) and Tier III SAV restoration target (2,923 hectares) are listed for 1970 to 1991 for CBP Segment CB6 (Western Lower Chesapeake Bay).
Sources: Batiuk et al., 1992; Chesapeake Bay Program, unpublished data b; Orth et al., 1979, 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Nowak, 1990.

Eastern Lower Chesapeake Bay



This mainstem Bay segment covers the lower Eastern Shore from the mouth of Chesapeake Bay north to, but not including, Tangier Island and Pocomoke Sound. The Eastern Lower Chesapeake Bay segment includes many small tributaries that enter the lower Bay, notably Cherrystone, Mattawoman, Hungars, Nassawadox, Occohanock, Nandua, Pungoteague, Onancock, and Chesconessex creeks.

Submerged aquatic vegetation has gradually increased in the Eastern Lower Chesapeake Bay segment, from 1,630 hectares in 1980 to 3,743 hectares in 1991, a 130 percent increase (Figure 116; Table 45). Over the same time period, the area of SAV categorized as dense (70-100 percent) has continued to increase from 19 percent to 41 percent of the total SAV coverage. The predominant species reported are *Z. marina* and *R. maritima*, although *Z. palustris* has been reported occasionally.

Extensive research and monitoring of SAV has been conducted in the Vaucluse Shores area at the mouth of Hungars and Mattawoman creeks since 1976, particularly between 1978 and 1981, as part of the research phase of the Chesapeake Bay Program. Although no segment-wide distributional patterns were available until 1978, the distribution of historical SAV was examined at Vaucluse Shores from 1937 to 1978 (Orth et al., 1979).

Large dense beds of SAV grew at Vaucluse Shores in 1937, only four years after the worldwide eelgrass demise. The beds were relatively stable until 1972, although some reduction in total coverage had occurred (Orth et al., 1979). Some losses took place between 1972 and 1978, probably related to the baywide decline. Historical documentation has revealed large shifts in sand bars and sand spits over the past 40 years, which led to changes in SAV distribution. Some beds appeared to be covered with sand, as bars and spits migrated, while some new SAV habitat opened in areas formerly occupied by these landforms.

Since 1985, all five SAV habitat requirements have been consistently met (Figure 117). Over the historical water quality data record (pre-1984, with the exception of 1979), the SAV habitat requirements were met for all parameters for which data were available.

The increase in SAV from 1980 to 1991 has resulted in the percent achievement of the Tier I restoration goal increasing from 35 percent to 81

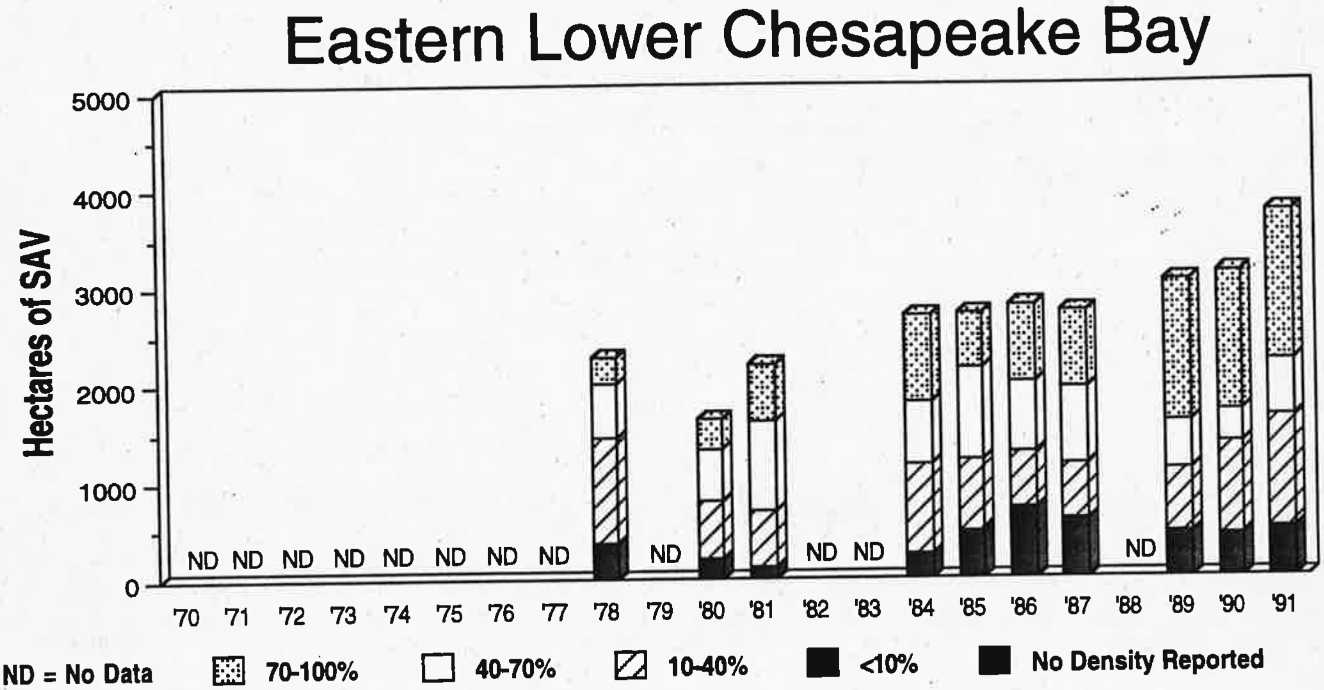


Figure 116. Hectares of SAV by density category for all years for which aerial survey data were available. For CBP Segment CB7 (Eastern Lower Chesapeake Bay), the Tier I SAV restoration goal is 4,624 hectares.
Sources: Batiuk et al., 1992; Chesapeake Bay Program, unpublished data b; Orth et al., 1979, 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Nowak, 1990.

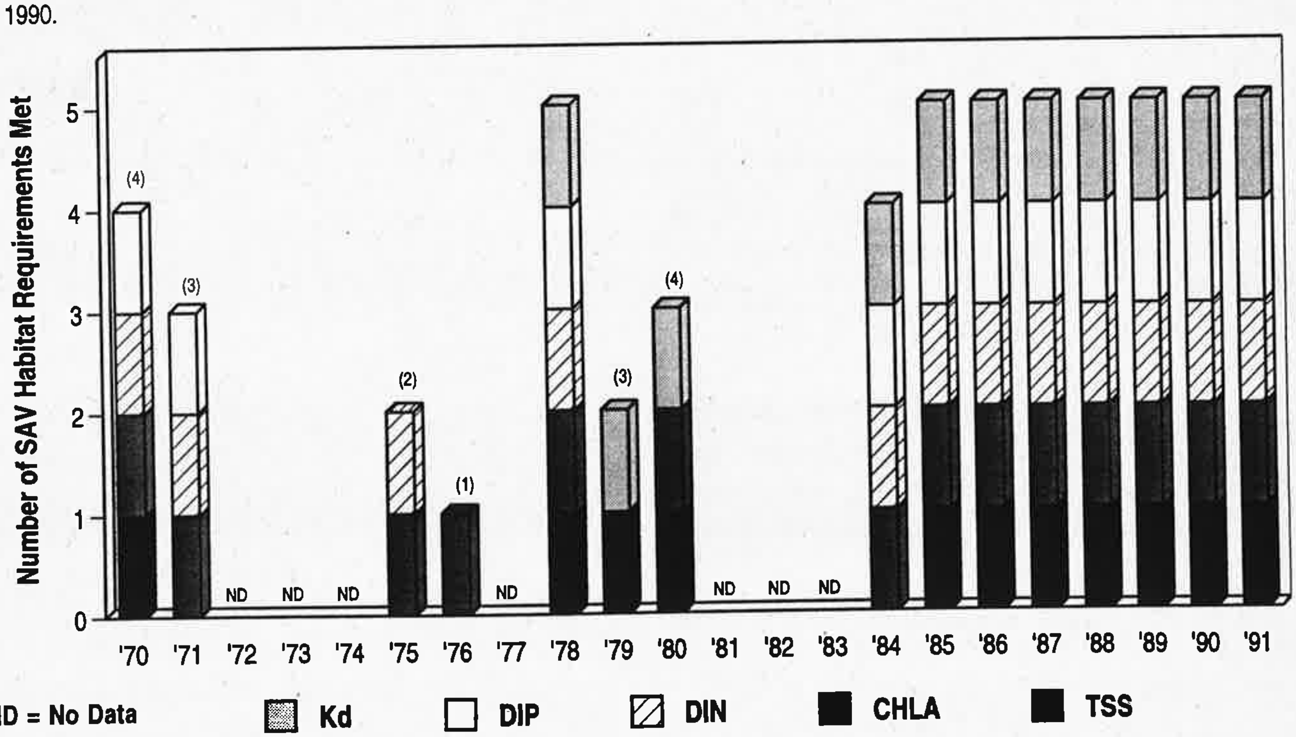


Figure 117. The number of SAV habitat requirements met over the SAV growing season from 1970 to 1991 for CBP Segment CB7 (Eastern Lower Chesapeake Bay). No SAV habitat requirements met = 0; no water quality data available = ND. Sufficient data for the following parameters were not available to calculate growing season medians: Kd (1970-1977, 1981-1983); TSS (1971-1977, 1981-1983); CHLA (1972-1974, 1977, 1981-1983); DIP (1972-1977, 1979, 1981-1983); and DIN (1972-1974, 1976, 1977, 1979, 1980-1983). Numbers of SAV habitat requirements with growing season medians are shown above bars when some values were missing.
Sources: Chesapeake Bay Program, 1993a and 1993b.

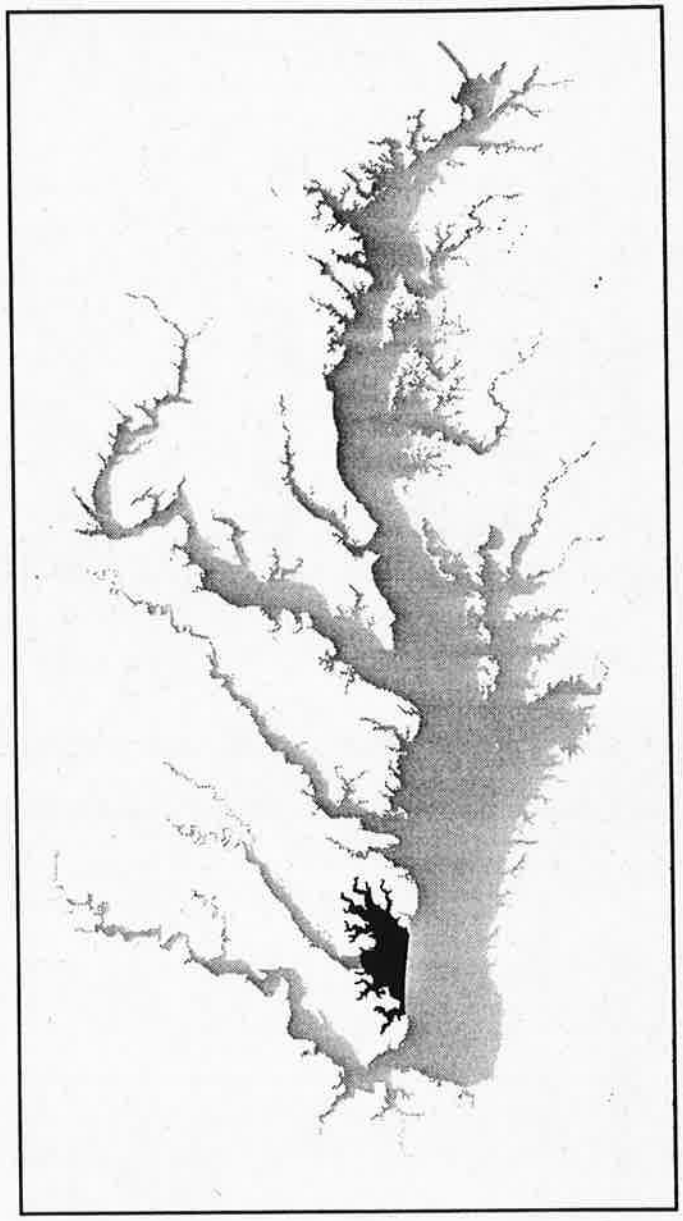
Eastern Lower Chesapeake Bay

Year	Hectares of SAV by Density Category <10%	10-40%	40-70%	70-100%	Segment Total	% of Tier I Restoration Goal	% of Tier III Restoration Goal
'70	-	-	-	-	-	-	-
'71	-	-	-	-	-	-	-
'72	-	-	-	-	-	-	-
'73	-	-	-	-	-	-	-
'74	-	-	-	-	-	-	-
'75	-	-	-	-	-	-	-
'76	-	-	-	-	-	-	-
'77	-	-	-	-	-	-	-
'78	371	1,072	567	272	2,282	49%	19%
'79	-	-	-	-	-	-	-
'80	195	603	525	307	1,630	35%	14%
'81	117	572	933	573	2,195	47%	19%
'82	-	-	-	-	-	-	-
'83	-	-	-	-	-	-	-
'84	234	937	623	892	2,686	58%	23%
'85	464	739	953	552	2,708	58%	23%
'86	718	565	734	779	2,796	60%	24%
'87	593	574	781	771	2,719	59%	23%
'88	-	-	-	-	-	-	-
'89	451	660	490	1,439	3,040	66%	26%
'90	422	946	331	1,412	3,111	67%	26%
'91	491	1,151	564	1,538	3,743	81%	32%

Table 45. Hectares of SAV by density category and percentage of Tier I (4,624 hectares) SAV restoration goal and Tier III (11,803 hectares) SAV restoration target are listed for 1970 to 1991 for CBP Segment CB7 (Eastern Lower Chesapeake Bay).
Sources: Batiuk et al., 1992; Chesapeake Bay Program, unpublished data b; Orth et al., 1979, 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Nowak, 1990.

percent, and that of the Tier III restoration target increasing from 19 percent to 32 percent (Table 45). The continued natural expansion of existing SAV is likely a result of the long period of suitable water quality conditions.

Mobjack Bay



This segment includes Mobjack Bay (starting at New Point Comfort) and its four tidal tributaries (East, North, Ware, and Severn rivers), the Guinea Marsh and Goodwin Island area at the mouth of the York River, the Poquoson and Back rivers, the area adjacent to Plum Tree Island, and Drum Island Flats. *Zostera marina* and *R. maritima* are the dominant species in this segment.

These areas are some of the most heavily vegetated in Chesapeake Bay, both historically and currently. Although some losses of SAV were evident in the 1970s, they were not as extensive as those in many other areas of the Bay. Large, dense stands still occur in the above-mentioned sections. Extensive quantitative data have been collected on the distributional patterns of SAV in this segment over the last two decades (Orth et al., 1979; Orth and Moore, 1988).

Submerged aquatic vegetation declined from 1971 (3,197 hectares) to 1980 (2,457 hectares), gradually increasing to 4,505 hectares by 1991—the highest level recorded over the last two decades (Figure 118; Table 46). In 1980, only 21 percent of SAV was classified as dense (70-100 percent), while 54 percent was in this category by 1991. The most significant increases have occurred along the York River sides of Guinea Marsh and Goodwin Island.

Water quality conditions since 1984 have generally been suitable for SAV survival and growth, meeting all five SAV habitat requirements in five of the last seven years (the total suspended solids habitat requirement was not met in 1988 or 1989) (Figure 119). These conditions represent an improvement from the mid-1970s to 1980 when water quality conditions never met all five SAV habitat requirements.

This segment has one of the highest percentage achievements of the Tier I restoration goal and the Tier III restoration target of all segments in Chesapeake Bay—76 percent and 36 percent, respectively, in 1991. These numbers represent an increase from the respective 1980 levels of 42 percent and 20 percent (Table 46).

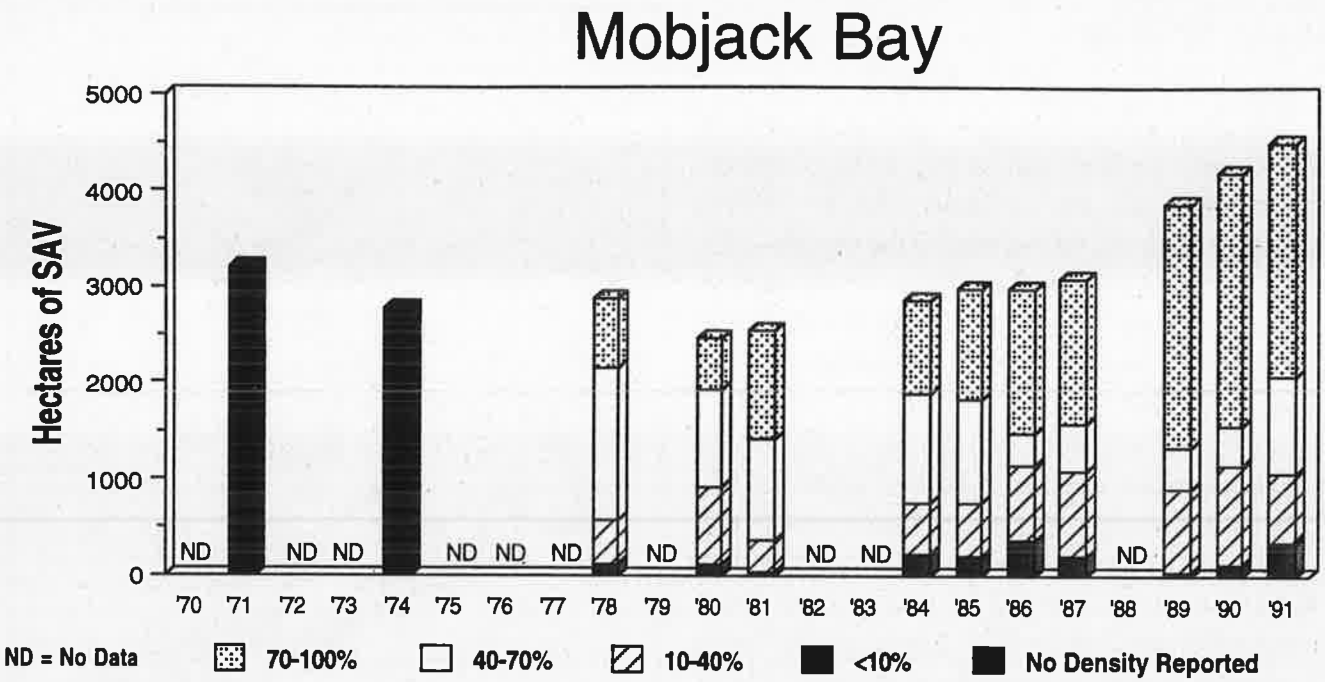


Figure 118. Hectares of SAV by density category for all years for which aerial survey data were available. For CBP Segment WE4 (Mobjack Bay), the Tier I SAV restoration goal is 5,902 hectares.
Sources: Batiuk et al., 1992; Chesapeake Bay Program, unpublished data b; Orth et al., 1979, 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Gordon, 1975; Orth and Nowak, 1990.

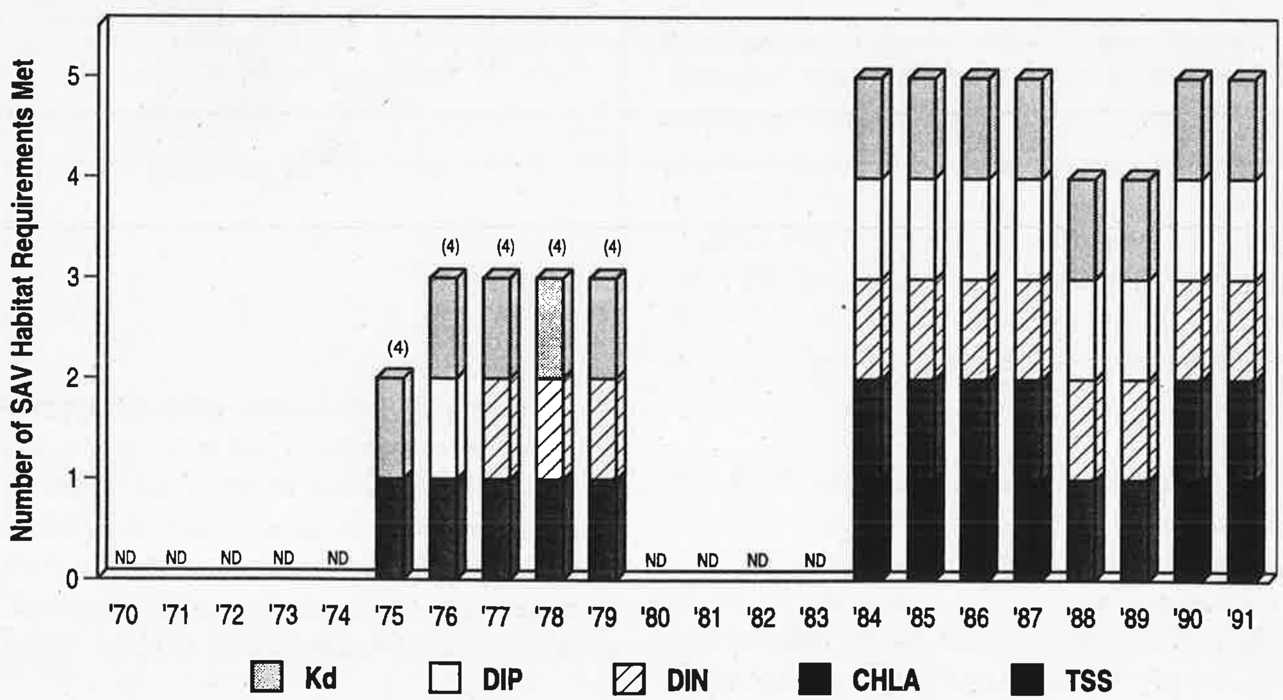


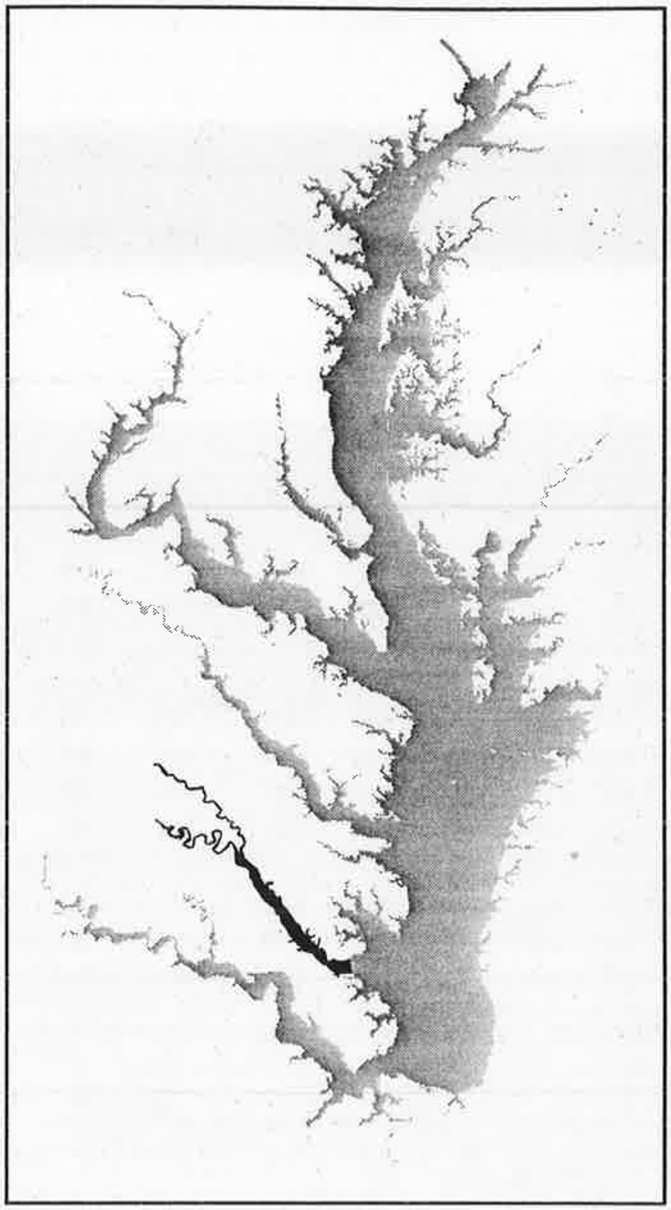
Figure 119. The number of SAV habitat requirements met over the SAV growing season from 1970 to 1991 for CBP Segment WE4 (Mobjack Bay). No SAV habitat requirements met = 0; no water quality data available = ND. Sufficient data for the following parameters were not available to calculate growing season medians: Kd (1970-1974, 1980-1983); TSS (1970-1983); CHLA (1970-1974, 1980-1983); DIP (1970-1974, 1980-1983); and DIN (1970-1974, 1980-1983). Numbers of SAV habitat requirements with growing season medians are shown above bars when some values were missing.
Sources: Chesapeake Bay Program, 1993a and 1993b.

Mobjack Bay

Year	Hectares of SAV by Density Category <10%	10-40%	40-70%	70-100%	Segment Total	% of Tier I Restoration Goal	% of Tier III Restoration Goal
'70	-	-	-	-	-	-	-
'71	-	-	-	-	3,197	54%	26%
'72	-	-	-	-	-	-	-
'73	-	-	-	-	-	-	-
'74	-	-	-	-	2,777	47%	22%
'75	-	-	-	-	-	-	-
'76	-	-	-	-	-	-	-
'77	-	-	-	-	-	-	-
'78	109	467	1,569	735	2,880	49%	23%
'79	-	-	-	-	-	-	-
'80	122	799	1,013	523	2,457	42%	20%
'81	38	320	1,052	1,130	2,540	43%	20%
'82	-	-	-	-	-	-	-
'83	-	-	-	-	-	-	-
'84	210	536	1,149	964	2,859	48%	23%
'85	194	600	1,062	1,147	3,003	51%	24%
'86	355	795	325	1,499	2,974	50%	24%
'87	205	877	498	1,491	3,071	52%	25%
'88	-	-	-	-	-	-	-
'89	29	865	440	2,529	3,863	65%	31%
'90	116	1,038	403	2,635	4,192	71%	33%
'91	341	714	1,020	2,430	4,505	76%	36%

Table 46. Hectares of SAV by density category and percentage of Tier I SAV restoration goal (5,902 hectares) and Tier III SAV restoration target (12,529 hectares) are listed for 1970 to 1991 for CBP Segment WE4 (Mobjack Bay). Sources: Batiuk et al., 1992; Chesapeake Bay Program, unpublished data b; Orth et al., 1979, 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Gordon, 1975; Orth and Nowak, 1990.

York River



The York River historically supported dense stands of SAV (*Z. marina* and *R. maritima*) primarily in the lower 25 kilometers of the river's mainstem (Orth, 1976; Orth et al., 1979). An earlier decline of *Z. marina* occurred in the 1930s and was related to the worldwide decline of this species (Rasmussen, 1973 and 1977). An analysis of photographs of two sites in the lower York River (the Mumfort Islands and Jenkins Neck) taken between 1937 and 1971 showed SAV increasing at both sites from 1937 to 1960, with some decline between 1960 and 1971.

Despite concerns over the large losses of *Z. marina* elsewhere in the world, this species was not totally eliminated, with scattered beds of this plant still present throughout the river. The expansion of *Z. marina* from these refuge populations probably contributed to its rapid return, unlike other localities which have not been recolonized (e.g., the shallow lagoons behind the barrier islands of the Delmarva Peninsula).

Some of the decline of SAV along the south shore in the Lower York River in the 1960s may have been related to construction of an oil refinery and electric power plant. Dense stands of SAV visible in photographs taken prior to construction have either disappeared or were reduced in coverage during the construction phase (Orth, 1976). Some of the losses were due to channel dredging and spoil disposal for the intake and outflow canals from the power plant.

Almost nothing is known about the historical distributions of SAV in the tidal fresh and transition zones, particularly in the broad shoal area along the mainstem York River. No SAV has been mapped in these Upper and Middle York River segments over the last two decades. Submerged aquatic vegetation does exist as small fringing beds in many of the brackish and tidal fresh marshes throughout the area. Examination of marsh creeks at eleven sites in the transition and tidal freshwater zone in 1978 revealed that SAV was present at all locations. Species recorded were *Z. palustris*, *C. demersum*, *E. canadensis*, *P. crispus*, *N. guadalupensis*, *V. americana*, and *N. minor* (Orth et al., 1979).

The more recent decline of SAV in the 1970s resulted in reduced coverage at or near the York River mouth (Figure 120, Table 47) and its total elimination from the middle and upper river segments (Figures 122 and 124; Tables 48 and 49). By

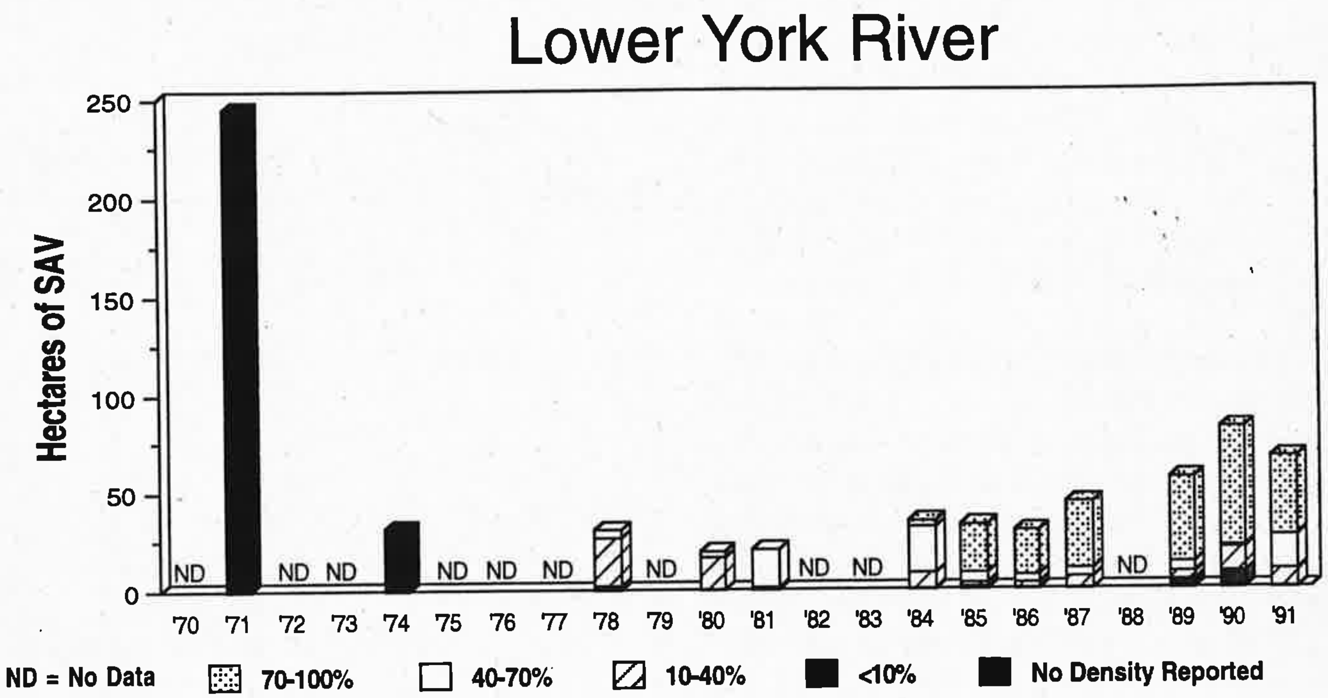


Figure 120. Hectares of SAV by density category for all years for which aerial survey data were available. For CBP Segment LE4 (Lower York River), the Tier I SAV restoration goal is 309 hectares.
Sources: Batiuk et al., 1992; Chesapeake Bay Program, unpublished data b; Orth et al., 1979, 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Gordon, 1975; Orth and Nowak, 1990.

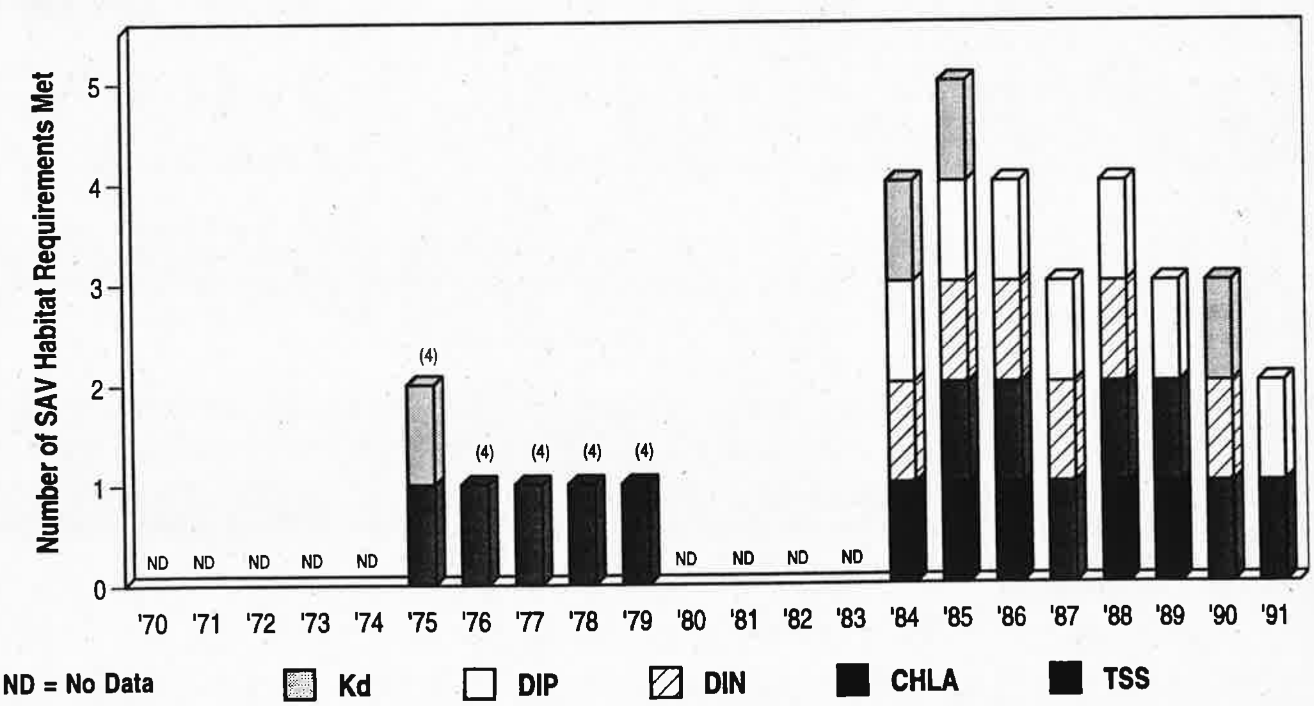


Figure 121. The number of SAV habitat requirements met over the SAV growing season from 1970 to 1991 for CBP Segment LE4 (Lower York River). No SAV habitat requirements met = 0; no water quality data available = ND. Sufficient data for the following parameters were not available to calculate growing season medians: Kd (1970-1974, 1980-1983); TSS (1970-1983); CHLA (1970-1974, 1980-1984); DIP (1970-1974, 1980-1983); and DIN (1970-1974, 1980-1983). Numbers of SAV habitat requirements with growing season medians are shown above bars when some values were missing.
Sources: Chesapeake Bay Program, 1993a and 1993.

1974, only 30 hectares of SAV were mapped in the Lower York River. The distribution further declined to 19 hectares by 1980. From 1980 to 1991, submerged aquatic vegetation rebounded in the Lower York River, from a low of 19 hectares to 66 hectares, with increases primarily in the region from Gloucester Point to the river mouth.

The results of restoration efforts in the York River parallel natural patterns of revegetation. Restoration work with whole plants and seeds has not been successful upriver from Gloucester Point, suggesting that water quality rather than a lack of sufficient propagules is preventing their re-establishment (Batiuk et al., 1992; Moore, unpublished data). Natural revegetation and transplant survival have been greatest downriver where existing beds have rapidly expanded.

Water quality conditions in the Lower York River have varied widely; all five SAV habitat requirements were met in 1985 and only two were met in 1991 (Figure 121). Available historical water quality data indicate that conditions from 1975 to 1979 were unsuitable for SAV survival, with only the chlorophyll *a* habitat requirement consistently achieved.

In the Middle York River, water quality conditions have generally met two or fewer SAV habitat requirements, with only chlorophyll *a* consistently met (Figure 123). Water quality conditions in the Upper York River (Mattaponi and Pumunkey rivers) have met all four SAV habitat requirements since 1988 although conditions were generally unsuitable for SAV survival in previous years (Figure 125).

The increase in SAV in the Lower York River segment from 1980 to 1991 has resulted in an increase in the percent achievement of the Tier I restoration goal from 6 percent to 21 percent and the percent achievement of the Tier III restoration target increasing from under 1 percent to 1 percent (Table 47). As SAV was not reported in the past 20 years in the Middle and Upper York River, no progress has been made towards the tiered restoration goals and targets in these segments (Tables 48 and 49).

Lower York River

	Hectares of SAV by Density Category						
Year	<10%	10-40%	40-70%	70-100%	Segment Total	% of Tier I Restoration Goal	% of Tier III Restoration Goal
'70	-	-	-	-	-	-	-
'71	-	-	-	-	245	79%	5%
'72	-	-	-	-	-	-	-
'73	-	-	-	-	-	-	-
'74	-	-	-	-	31	10%	<1%
'75	-	-	-	-	-	-	-
'76	-	-	-	-	-	-	-
'77	-	-	-	-	-	-	-
'78	2	24	4	0	30	10%	<1%
'79	-	-	-	-	-	-	-
'80	0	16	3	0	19	6%	<1%
'81	0	1	19	0	20	6%	<1%
'82	-	-	-	-	-	-	-
'83	-	-	-	-	-	-	-
'84	0	8	23	3	34	11%	<1%
'85	<1	2	5	24	32	10%	<1%
'86	0	3	4	22	29	9%	<1%
'87	0	6	4	33	43	14%	<1%
'88	-	-	-	-	-	-	-
'89	4	4	5	43	56	18%	1%
'90	8	12	<1	60	79	26%	2%
'91	<1	9	17	40	66	21%	1%

Table 47. Hectares of SAV by density category and percentage of Tier I SAV restoration goal (309 hectares) and Tier III SAV restoration target (4,822 hectares) are listed for 1970 to 1991 for CBP Segment LE4 (Lower York River). Sources: Batiuk et al., 1992; Chesapeake Bay Program, unpublished data b; Orth et al., 1979, 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Gordon, 1975; Orth and Nowak, 1990.

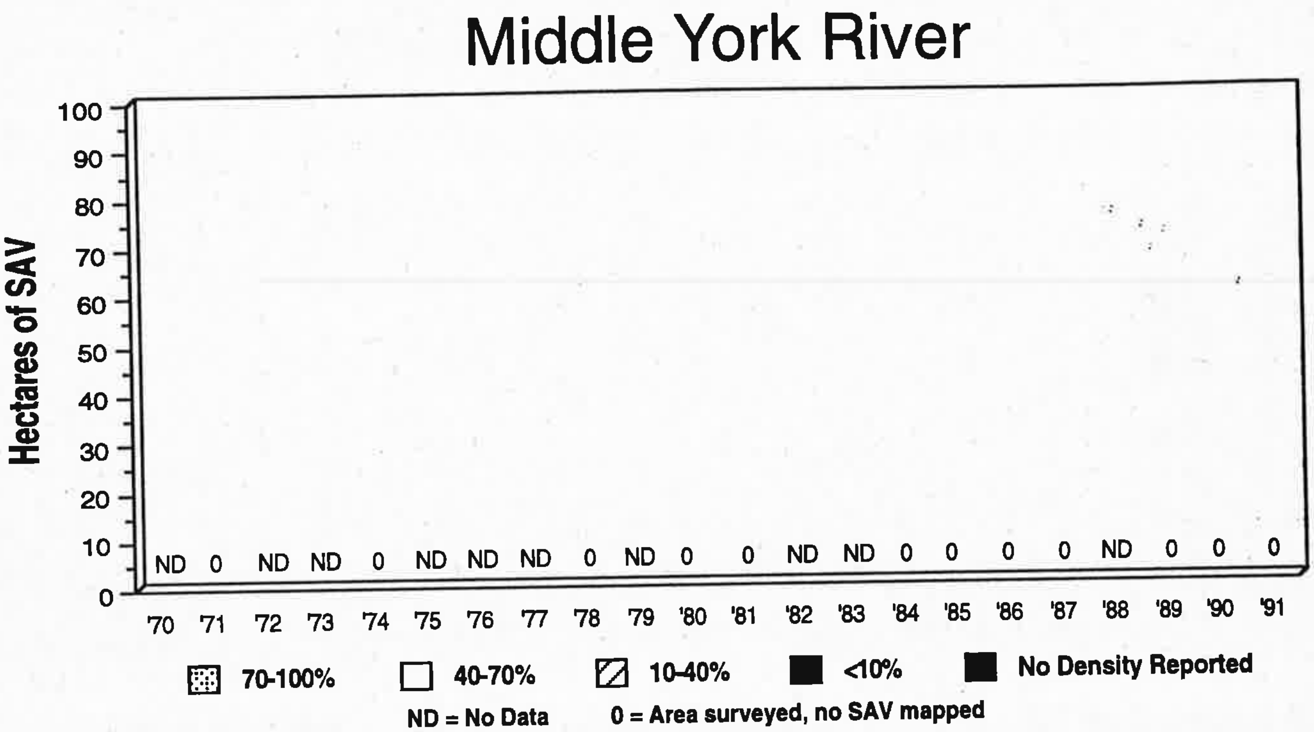


Figure 122. Hectares of SAV by density category for all years for which aerial survey data were available. For CBP Segment RET4 (Middle York River), there is no Tier I SAV restoration goal.
Sources: Batiuk et al., 1992; Chesapeake Bay Program, unpublished data b; Orth et al., 1979, 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Gordon, 1975; Orth and Nowak, 1990.

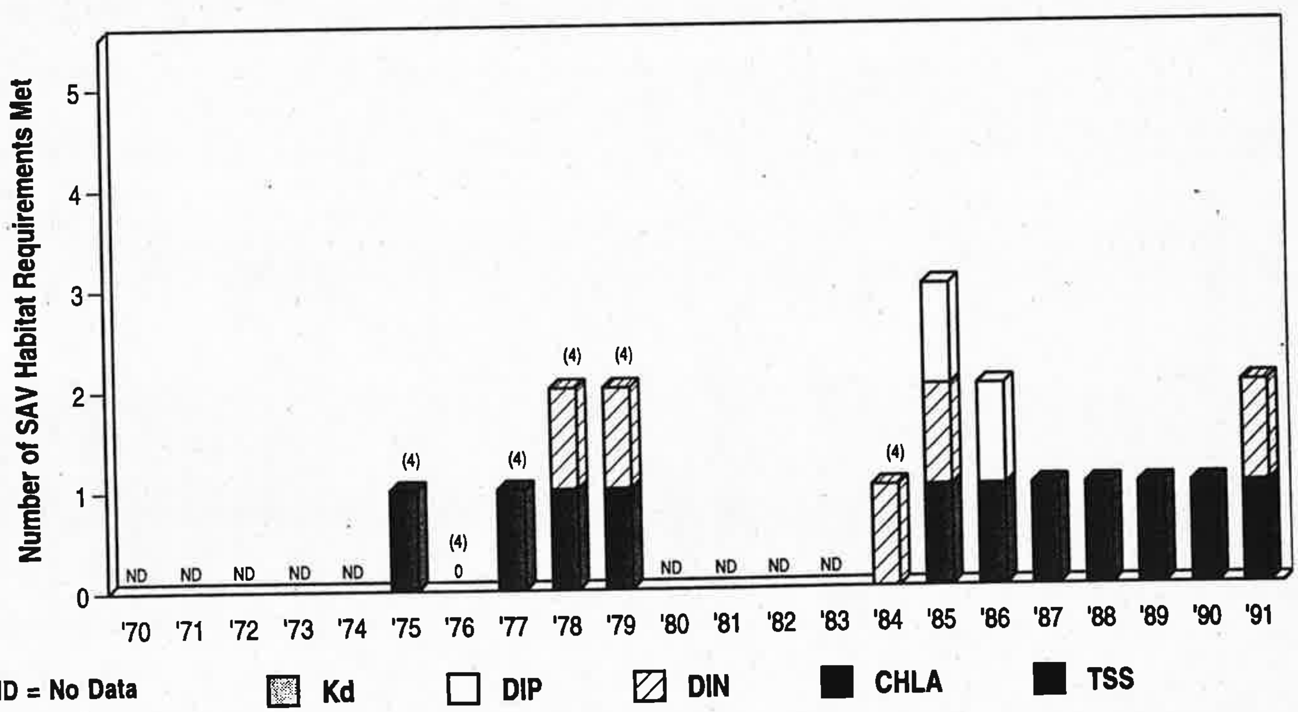


Figure 123. The number of SAV habitat requirements met over the SAV growing season from 1970 to 1991 for CBP Segment RET4 (Middle York River). No SAV habitat requirements met = 0; no water quality data available = ND. Sufficient data for the following parameters were not available to calculate growing season medians: Kd (1970-1974, 1981-1983); TSS (1970-1983); CHLA (1970-1974, 1980-1984); DIP (1970-1974, 1980-1983); and DIN (1970-1974, 1980-1983). Numbers of SAV habitat requirements with growing season medians are shown above bars when some values were missing.
Sources: Chesapeake Bay Program, 1993a and 1993b.

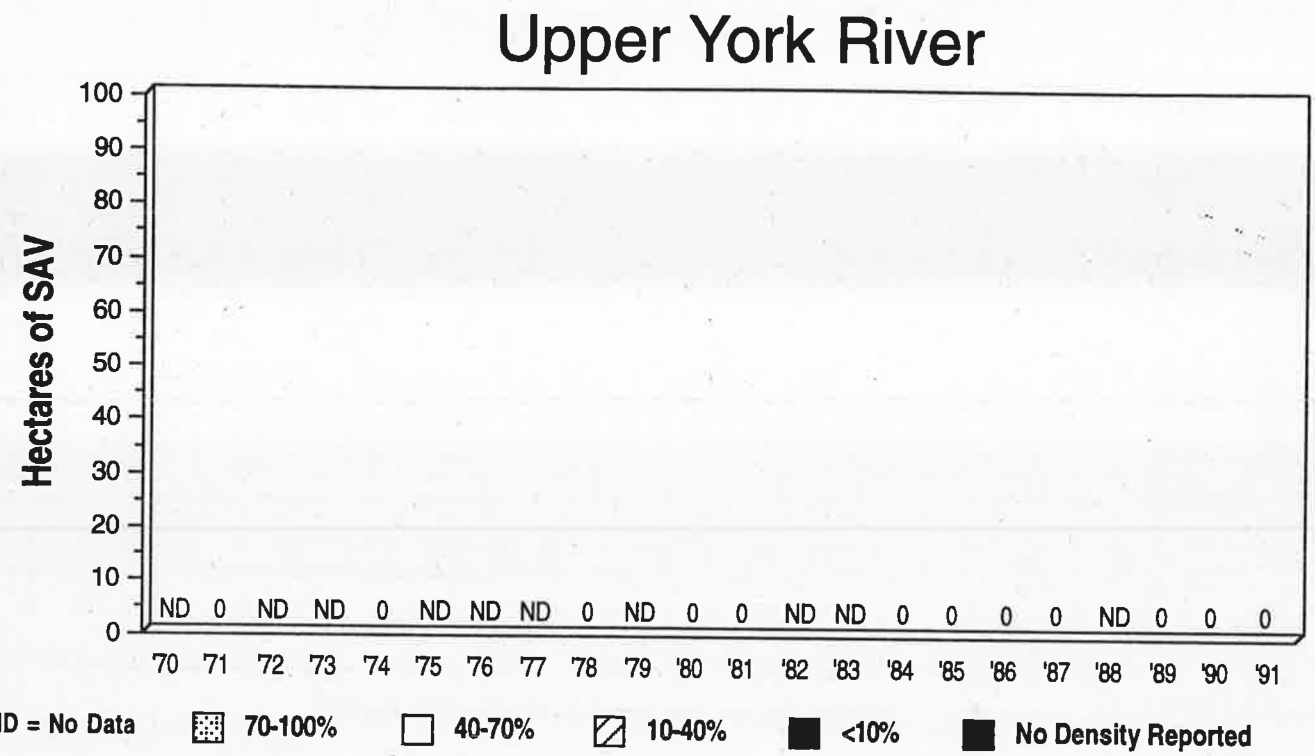


Figure 124. Hectares of SAV by density category for all years for which aerial survey data were available. For CBP Segment TF4 (Upper York River), there is no Tier I SAV restoration goal.
Sources: Batiuk et al., 1992; Chesapeake Bay Program, unpublished data b; Orth et al., 1979, 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Gordon, 1975; Orth and Nowak, 1990.

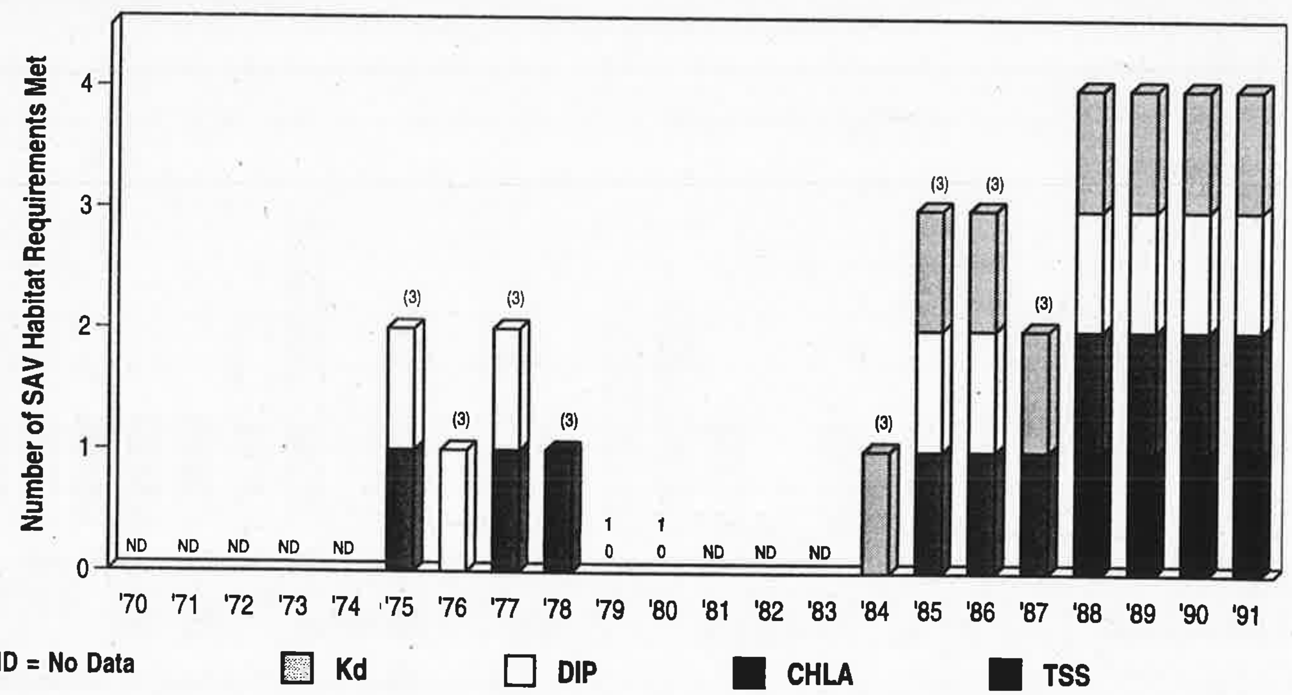


Figure 125. The number of SAV habitat requirements met over the SAV growing season from 1970 to 1991 for CBP Segment TF4 (Upper York River). No SAV habitat requirements met = 0; no water quality data available = ND. Sufficient data for the following parameters were not available to calculate growing season medians: Kd (1970-1974, 1981-1983); TSS (1970-1987); CHLA (1970-1974, 1979-1984); and DIP (1970-1974, 1979-1983). Numbers of SAV habitat requirements with growing season medians are shown above bars when some values were missing.
Sources: Chesapeake Bay Program, 1993a and 1993b.

Middle York River

Year	Hectares of SAV by Density Category <10%	10-40%	40-70%	70-100%	Segment Total	% of Tier I Restoration Goal	% of Tier III Restoration Goal
'70	-	-	-	-	-	-	-
'71	-	-	-	-	0	-	0%
'72	-	-	-	-	-	-	-
'73	-	-	-	-	-	-	-
'74	-	-	-	-	0	-	0%
'75	-	-	-	-	-	-	-
'76	-	-	-	-	-	-	-
'77	-	-	-	-	-	-	-
'78	0	0	0	0	0	-	0%
'79	-	-	-	-	-	-	-
'80	0	0	0	0	0	-	0%
'81	0	0	0	0	0	-	0%
'82	-	-	-	-	-	-	-
'83	-	-	-	-	-	-	-
'84	0	0	0	0	0	-	0%
'85	0	0	0	0	0	-	0%
'86	0	0	0	0	0	-	0%
'87	0	0	0	0	0	-	0%
'88	-	-	-	-	-	-	-
'89	0	0	0	0	0	-	0%
'90	0	0	0	0	0	-	0%
'91	0	0	0	0	0	-	0%

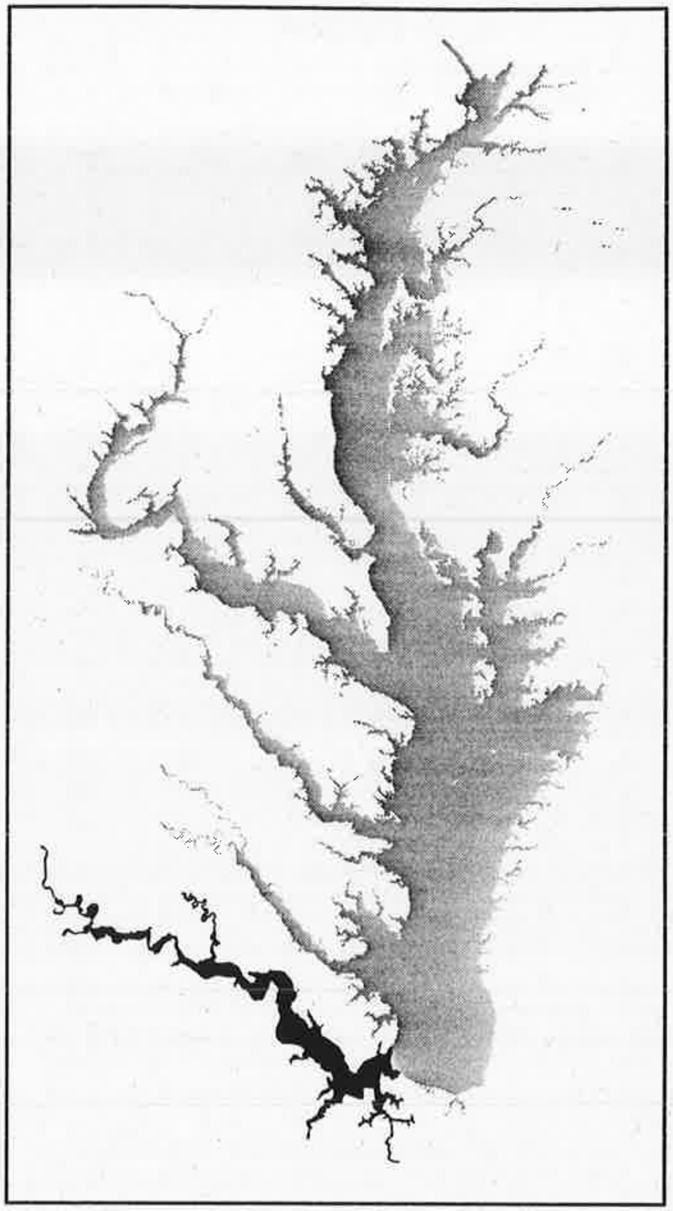
Table 48. Hectares of SAV by density category and percentage of Tier III SAV restoration target (2,915 hectares) are listed for 1970 to 1991 for CBP Segment RET4 (Middle York River). There is no Tier I SAV restoration goal for this segment.
Sources: Batiuk et al., 1992; Chesapeake Bay Program, unpublished data b; Orth et al., 1979, 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Gordon, 1975; Orth and Nowak, 1990.

Upper York River

Year	Hectares of SAV by Density Category <10%	10-40%	40-70%	70-100%	Segment Total	% of Tier I Restoration Goal	% of Tier III Restoration Goal
'70	-	-	-	-	-	-	-
'71	-	-	-	-	0	-	0%
'72	-	-	-	-	-	-	-
'73	-	-	-	-	-	-	-
'74	-	-	-	-	0	-	0%
'75	-	-	-	-	-	-	-
'76	-	-	-	-	-	-	-
'77	-	-	-	-	-	-	-
'78	0	0	0	0	0	-	0%
'79	-	-	-	-	-	-	-
'80	0	0	0	0	0	-	0%
'81	0	0	0	0	0	-	0%
'82	-	-	-	-	-	-	-
'83	-	-	-	-	-	-	-
'84	0	0	0	0	0	-	0%
'85	0	0	0	0	0	-	0%
'86	0	0	0	0	0	-	0%
'87	0	0	0	0	0	-	0%
'88	-	-	-	-	-	-	-
'89	0	0	0	0	0	-	0%
'90	0	0	0	0	0	-	0%
'91	0	0	0	0	0	-	0%

Table 49. Hectares of SAV by density category and percentage of the Tier III SAV restoration target (1,614 hectares) are listed for 1970 to 1991 for CBP Segment TF4 (Upper York River). There is no Tier I SAV restoration goal for this segment.
Sources: Batiuk et al., 1992; Chesapeake Bay Program, unpublished data b; Orth et al., 1979, 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Gordon, 1975; Orth and Nowak, 1990.

James River



The James River and its two major tidal tributaries, the Chickahominy and Appomatox rivers, are included in this section. Anecdotal evidence and historical photography indicate that dense SAV beds were found along the shores above the James River bridge as late as the 1960s. The earliest available photographs, from the late 1930s, show what appear to be dense SAV beds in these same sections of the river. *Zostera marina* was probably the dominant species, although *R. maritima* was most likely present also.

By 1991, the only SAV in the James River mainstem was growing on the Hampton Flats in the lower portion of the river (Figure 126, Table 50)—a small three-hectare bed of *Z. marina*. Although the amount of SAV was greater in previous years (particularly in 1978 when ten hectares were reported), the total abundances represent only a fraction of the potential SAV habitat (Tier III restoration target). Much of the Lower James River has highly developed and modified shorelines (shipyards and naval piers) that will probably never support SAV.

No SAV has been reported through the aerial survey from the mainstem of the middle and upper James River for the past two decades, except 13 hectares in 1986 in the middle river segment (Figures 128 and 130; Tables 51 and 52). The marsh creeks of the Chickahominy River, however, supported a diverse assemblage of freshwater SAV (*V. americana*, *N. guadalupensis*, *E. canadensis*, *N. minor*, and *C. demersum*) in 1978 (Orth et al., 1979). Citizen SAV survey reports from the last several years confirm the presence of many of these species from the same marsh creeks.

Water quality conditions for all three James River segments have generally met two or fewer of the SAV habitat requirements (Figures 127, 129, and 131). There has been no progress towards the tiered restoration goals and targets, given the virtual absence of SAV in the James River during the past twenty years (Tables 50, 51, and 52).

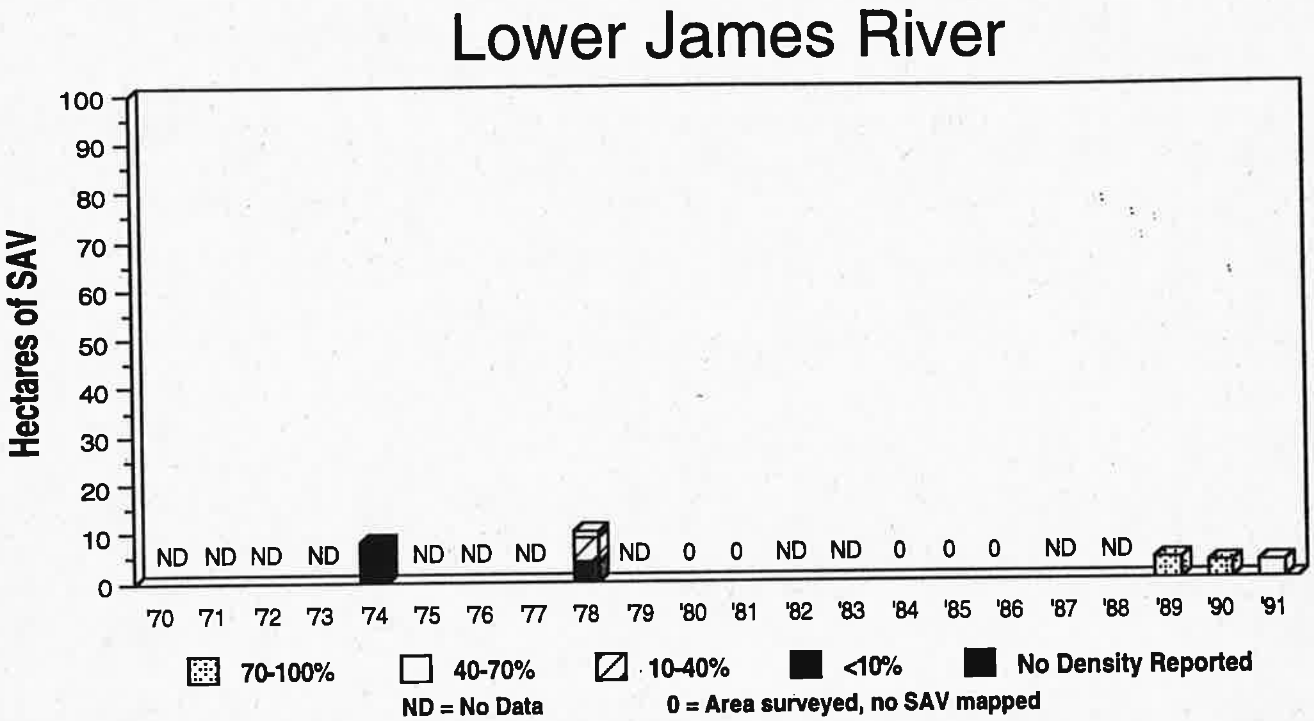


Figure 126. Hectares of SAV by density category for all years for which aerial survey data were available. For CBP Segment LE5 (Lower James River), the Tier I SAV restoration goal is 16 hectares.
Sources: Batiuk et al., 1992; Chesapeake Bay Program, unpublished data b; Orth et al., 1979, 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Gordon, 1975; Orth and Nowak, 1990.

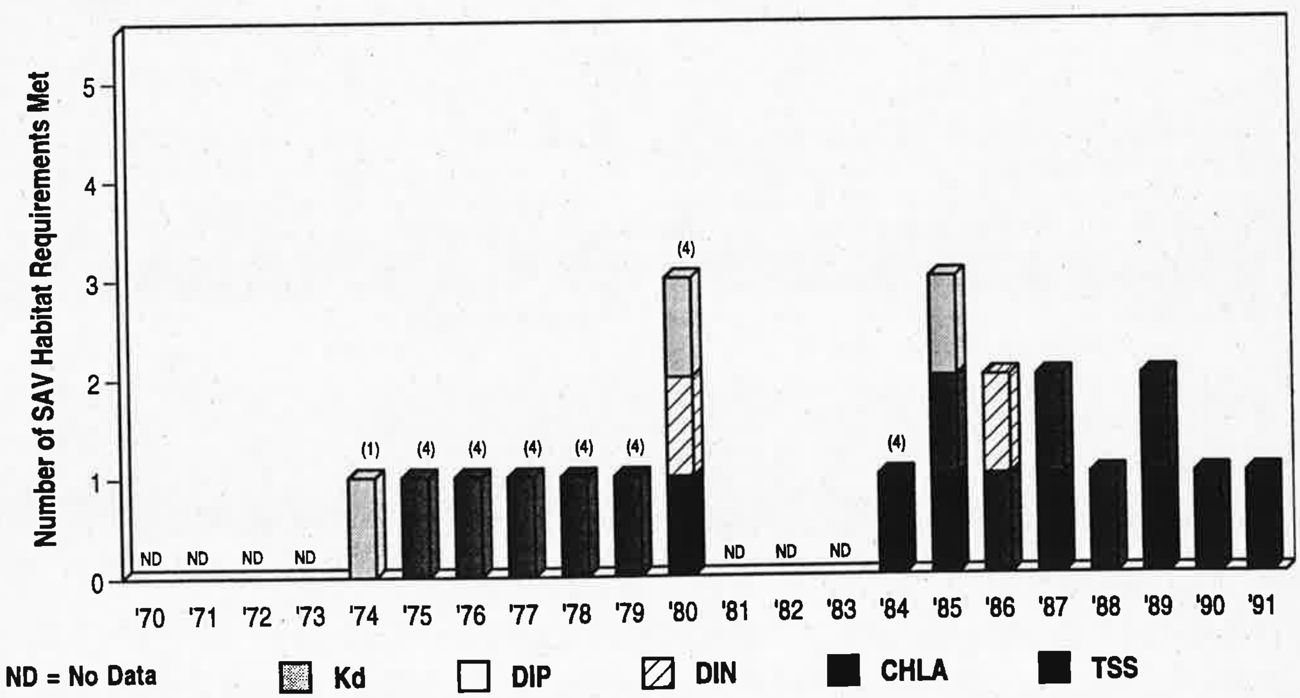


Figure 127. The number of SAV habitat requirements met over the SAV growing season from 1970 to 1991 for CBP Segment LE5 (Lower James River). No SAV habitat requirements met = 0; no water quality data available = ND. Sufficient data for the following parameters were not available to calculate growing season medians: Kd (1970-1973, 1981-1983); TSS (1970-1979, 1981-1983); CHLA (1970-1974, 1980-1984); DIP (1970-1974, 1981-1983); and DIN (1970-1974, 1981-1983). Numbers of SAV habitat requirements with growing season medians are shown above bars when some values were missing.
Sources: Chesapeake Bay Program, 1993a and 1993b.

Lower James River

Year	Hectares of SAV by Density Category <10%	10-40%	40-70%	70-100%	Segment Total	% of Tier I Restoration Goal	% of Tier III Restoration Goal
'70	-	-	-	-	-	-	-
'71	-	-	-	-	-	-	-
'72	-	-	-	-	-	-	-
'73	-	-	-	-	-	-	-
'74	-	-	-	-	8	50%	<1%
'75	-	-	-	-	-	-	-
'76	-	-	-	-	-	-	-
'77	-	-	-	-	-	-	-
'78	4	5	<1	0	10	63%	<1%
'79	-	-	-	-	-	-	-
'80	0	0	0	0	0	0%	0%
'81	0	0	0	0	0	0%	0%
'82	-	-	-	-	-	-	-
'83	-	-	-	-	-	-	-
'84	0	0	0	0	0	0%	0%
'85	0	0	0	0	0	0%	0%
'86	0	0	0	0	0	0%	0%
'87	0	3	0	0	3	0%	0%
'88	-	-	-	-	-	-	-
'89	0	0	0	4	4	11%	<1%
'90	0	0	0	3	3	19%	<1%
'91	0	0	3	0	3	17%	0%

Table 50. Hectares of SAV by density category and percentage of Tier I SAV restoration goal (16 hectares) and Tier III SAV restoration target (13,841 hectares) are listed for 1970 to 1991 for CBP Segment LE5 (Lower James River). Sources: Batiuk et al., 1992; Chesapeake Bay Program, unpublished data b; Orth et al., 1979, 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Gordon, 1975; Orth and Nowak, 1990.

Middle James River

Year	Hectares of SAV by Density Category <10%	10-40%	40-70%	70-100%	Segment Total	% of Tier I Restoration Goal	% of Tier III Restoration Goal
'70	-	-	-	-	-	-	-
'71	-	-	-	-	0	0%	0%
'72	-	-	-	-	-	-	-
'73	-	-	-	-	-	-	-
'74	-	-	-	-	0	0%	0%
'75	-	-	-	-	-	-	-
'76	-	-	-	-	-	-	-
'77	-	-	-	-	-	-	-
'78	0	0	0	0	0	0%	0%
'79	-	-	-	-	-	-	-
'80	0	0	0	0	0	0%	0%
'81	0	0	0	0	0	0%	0%
'82	-	-	-	-	-	-	-
'83	-	-	-	-	-	-	-
'84	0	0	0	0	0	0%	0%
'85	0	0	0	0	0	0%	0%
'86	0	0	0	13	13	100%	<1%
'87	0	0	0	0	0	0%	0%
'88	-	-	-	-	-	-	-
'89	0	0	0	0	0	0%	0%
'90	0	0	0	0	0	0%	0%
'91	0	0	0	0	0	0%	0%

Table 51. Hectares of SAV by density category and percentage of Tier I SAV restoration goal (13 hectares) and Tier III SAV restoration target (4,987 hectares) are listed for 1970 to 1991 for CBP Segment RET5 (Middle James River). Sources: Batiuk et al., 1992; Chesapeake Bay Program, unpublished data b; Orth et al., 1979, 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Gordon, 1975; Orth and Nowak, 1990.

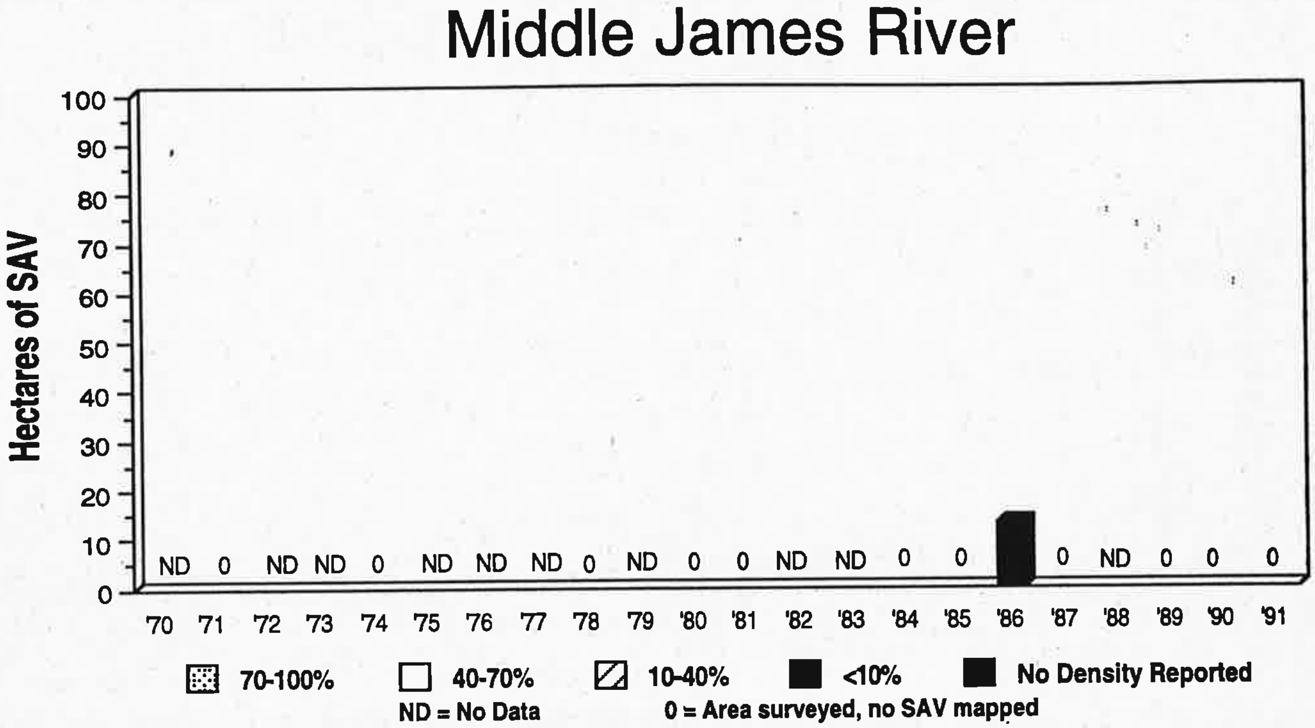


Figure 128. Hectares of SAV by density category for all years for which aerial survey data were available. For CBP Segment RET5 (Middle James River), the Tier I SAV restoration goal is 13 hectares.
Sources: Batiuk et al., 1992; Chesapeake Bay Program, unpublished data b; Orth et al., 1979, 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Gordon, 1975; Orth and Nowak, 1990.

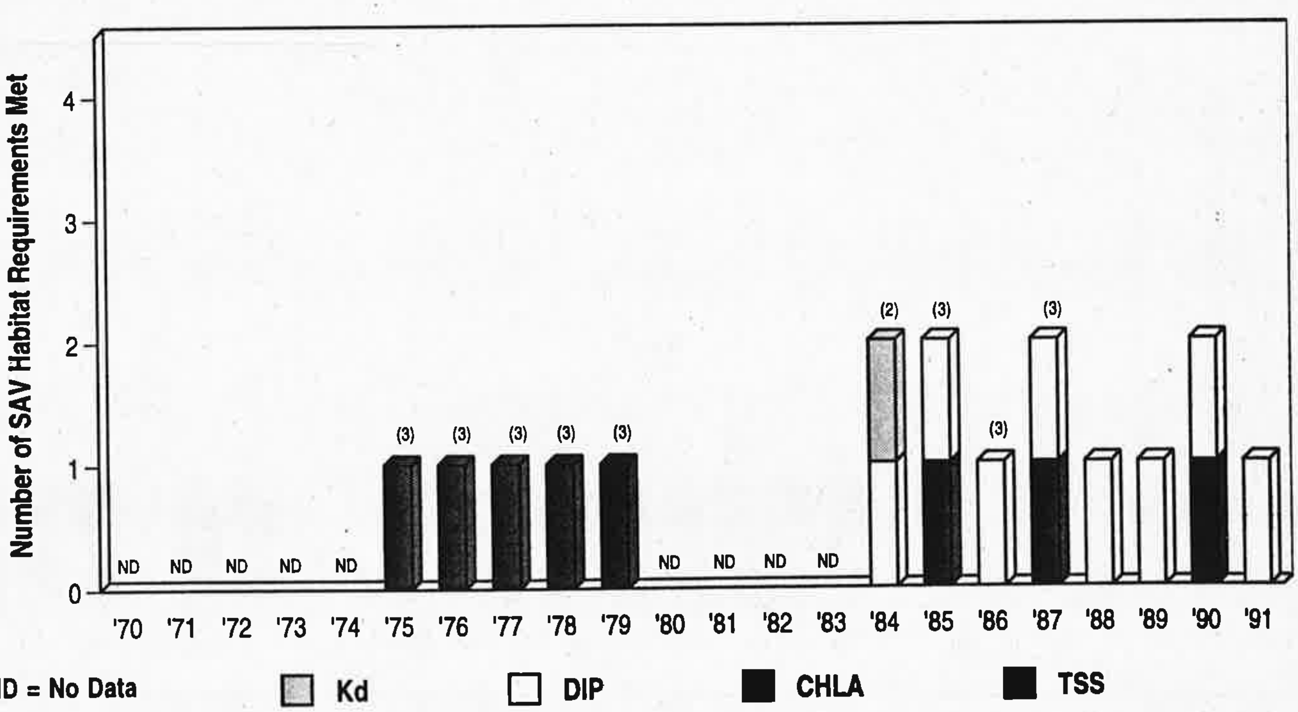


Figure 129. The number of SAV habitat requirements met over the SAV growing season from 1970 to 1991 for CBP Segment RET5 (Middle James River). No SAV habitat requirements met = 0; no water quality data available = ND. Sufficient data for the following parameters were not available to calculate growing season medians: Kd (1970-1974, 1980-1983); TSS (1970-1987); CHLA (1970-1974, 1980-1984); and DIP (1970-1974, 1980-1983). Numbers of SAV habitat requirements with growing season medians are shown above bars when some values were missing.
Sources: Chesapeake Bay Program, 1993a and 1993b.

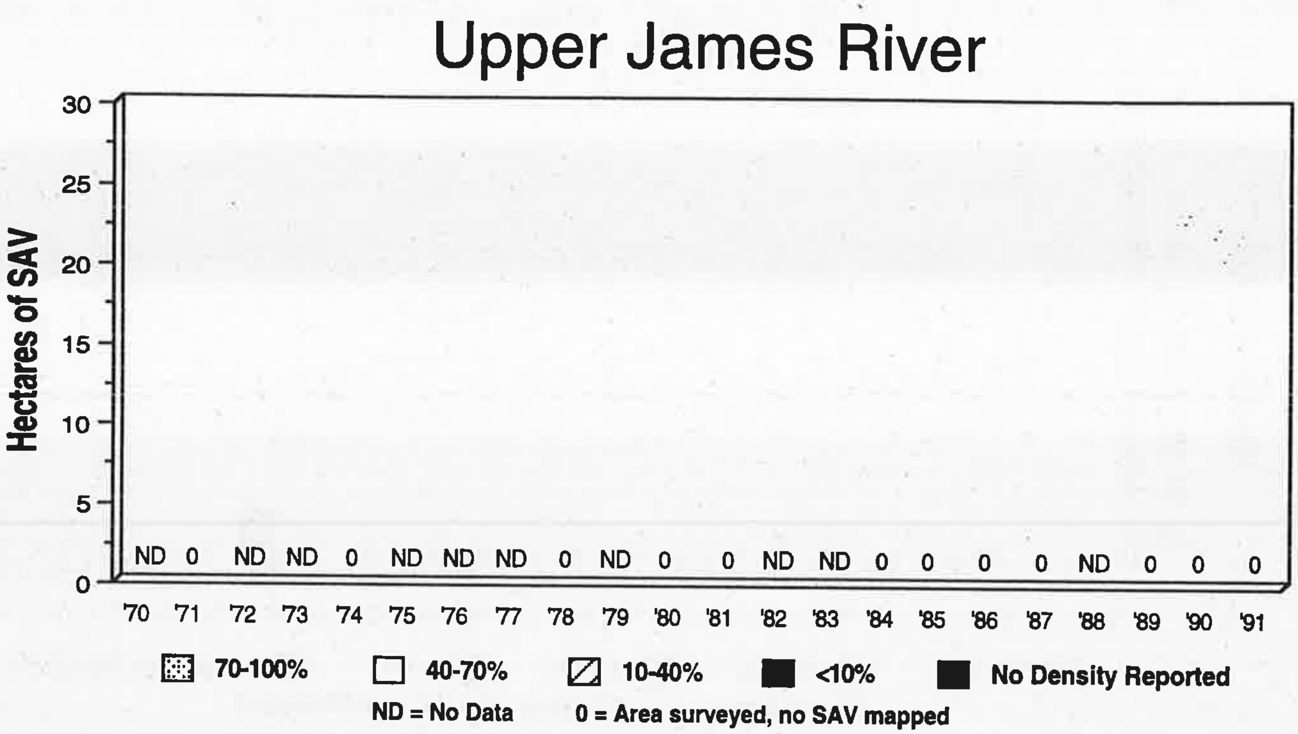


Figure 130. Hectares of SAV by density category for all years for which aerial survey data were available. For CBP Segment TF5 (Upper James River), there is no Tier I SAV restoration goal.
Sources: Batiuk et al., 1992; Chesapeake Bay Program, unpublished data b; Orth et al., 1979, 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Gordon, 1975; Orth and Nowak, 1990.

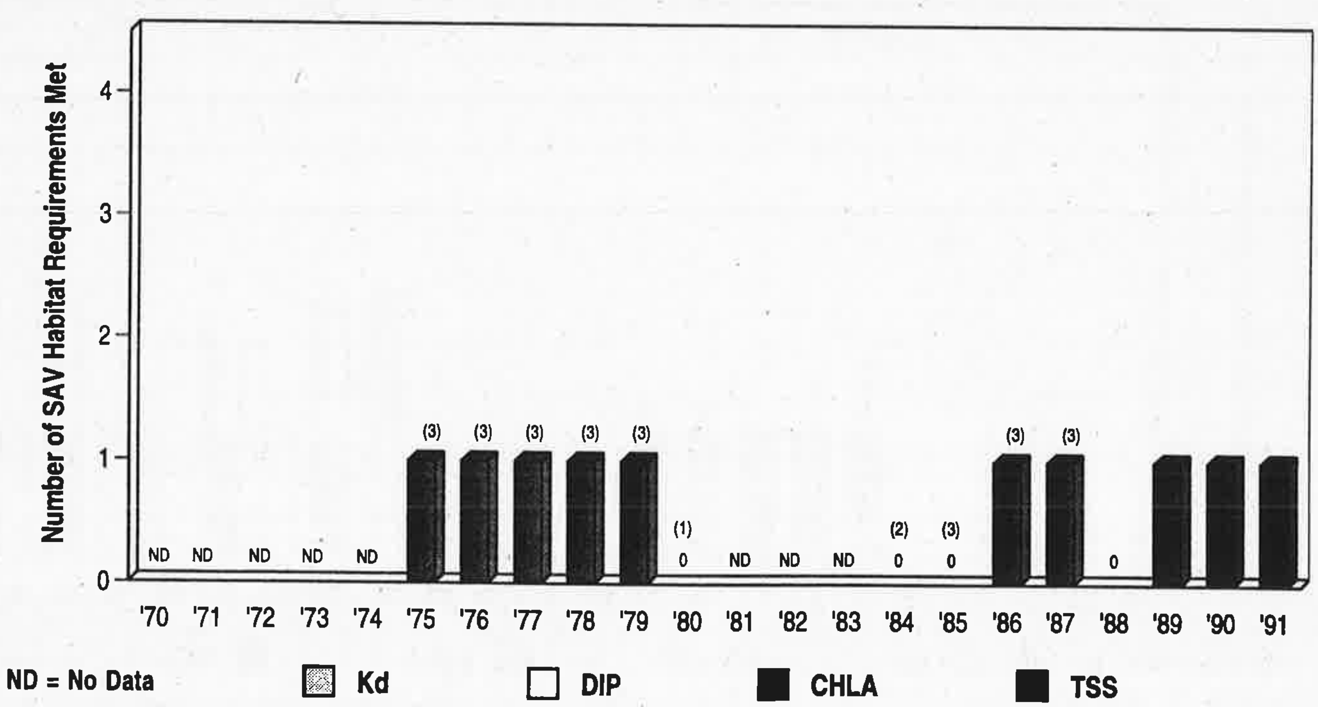


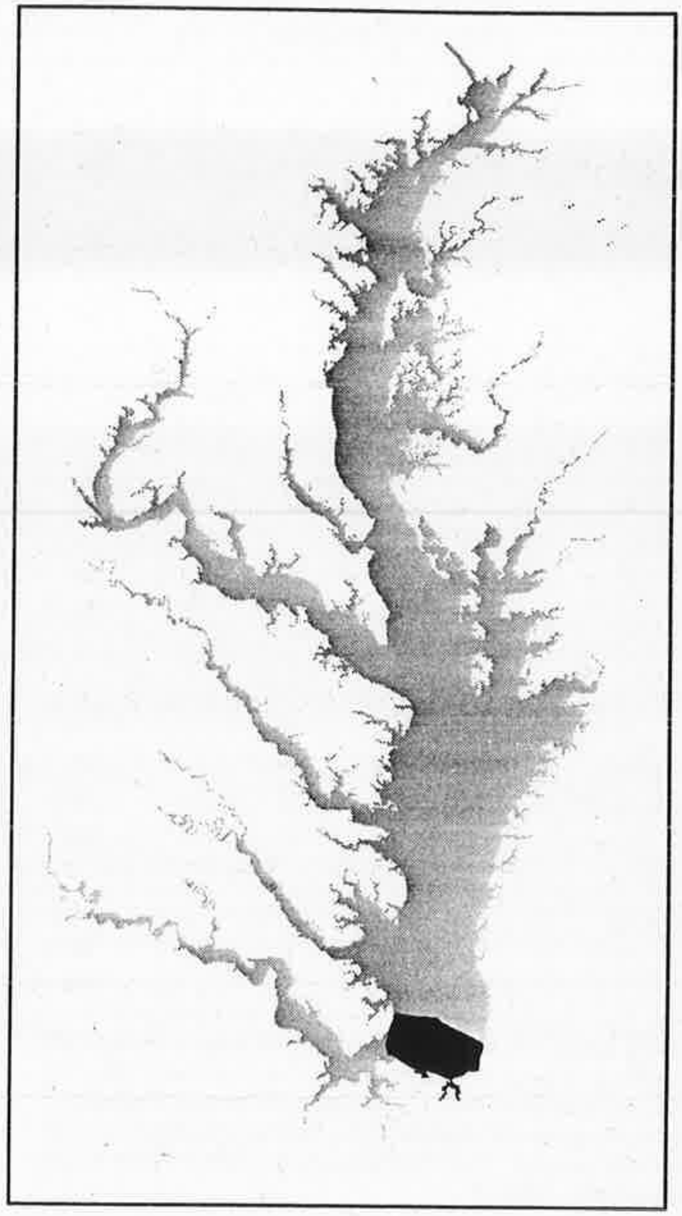
Figure 131. The number of SAV habitat requirements met over the SAV growing season from 1970 to 1991 for CBP Segment TF5 (Upper James River). No SAV habitat requirements met = 0; no water quality data available = ND. Sufficient data for the following parameters were not available to calculate growing season medians: Kd (1970-1974, 1981-1983); TSS (1970-1987); CHLA (1970-1974, 1980-1984); and DIP (1970-1974, 1980-1983). Numbers of SAV habitat requirements with growing season medians are shown above bars when some values were missing.
Sources: Chesapeake Bay Program, 1993a and 1993b.

Upper James River

Year	Hectares of SAV by Density Category <10%	10-40%	40-70%	70-100%	Segment Total	% of Tier I Restoration Goal	% of Tier III Restoration Goal
'70	-	-	-	-	-	-	-
'71	-	-	-	-	0	-	0%
'72	-	-	-	-	-	-	-
'73	-	-	-	-	-	-	-
'74	-	-	-	-	0	-	0%
'75	-	-	-	-	-	-	-
'76	-	-	-	-	-	-	-
'77	-	-	-	-	-	-	-
'78	0	0	0	0	0	-	0%
'79	-	-	-	-	-	-	-
'80	0	0	0	0	0	-	0%
'81	0	0	0	0	0	-	0%
'82	-	-	-	-	-	-	-
'83	-	-	-	-	-	-	-
'84	0	0	0	0	0	-	0%
'85	0	0	0	0	0	-	0%
'86	0	0	0	0	0	-	0%
'87	0	0	0	0	0	-	0%
'88	-	-	-	-	-	-	-
'89	0	0	0	0	0	-	0%
'90	0	0	0	0	0	-	0%
'91	0	0	0	0	0	-	0%

Table 52. Hectares of SAV by density category and percentage of the Tier III SAV restoration target (5,780 hectares) are listed for 1970 to 1991 for CBP Segment TF5 (Upper James River). There is no Tier I SAV restoration goal for this segment. Sources: Batiuk et al., 1992; Chesapeake Bay Program, unpublished data b; Orth et al., 1979, 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Gordon, 1975; Orth and Nowak, 1990.

Mouth of Chesapeake Bay



The Mouth of the Chesapeake Bay segment encompasses the area from just below the mouth of Back River to Cape Henry, including the small embayments of the Lynnhaven River and Lynnhaven and Broad bays. *Zostera marina* and *R. maritima* have been documented only in Broad Bay since 1984. The vegetation exists as small fringing beds of sparse to moderate density with total abundance ranging from 24 to 38 hectares between 1984 and 1991 (Figure 132, Table 53). No aerial overflights of this area were flown prior to 1984, although it is likely that these beds were present in the past.

Water quality conditions since 1984, as measured in the mainstem Bay portion of this segment, have met all five SAV habitat requirements with the exception of 1987 when the chlorophyll *a* requirement was not met (Figure 133). The 1991 SAV coverage in this segment is 28 percent and 1 percent of the Tier I restoration goal and Tier III restoration target, respectively (Table 53). These low percentages, despite good water quality in the mainstem Bay portion of this segment, indicate that most of the potential SAV habitat is found in the smaller, semi-enclosed tributaries with urbanized watersheds where water quality conditions are likely to be unsuitable for SAV survival.

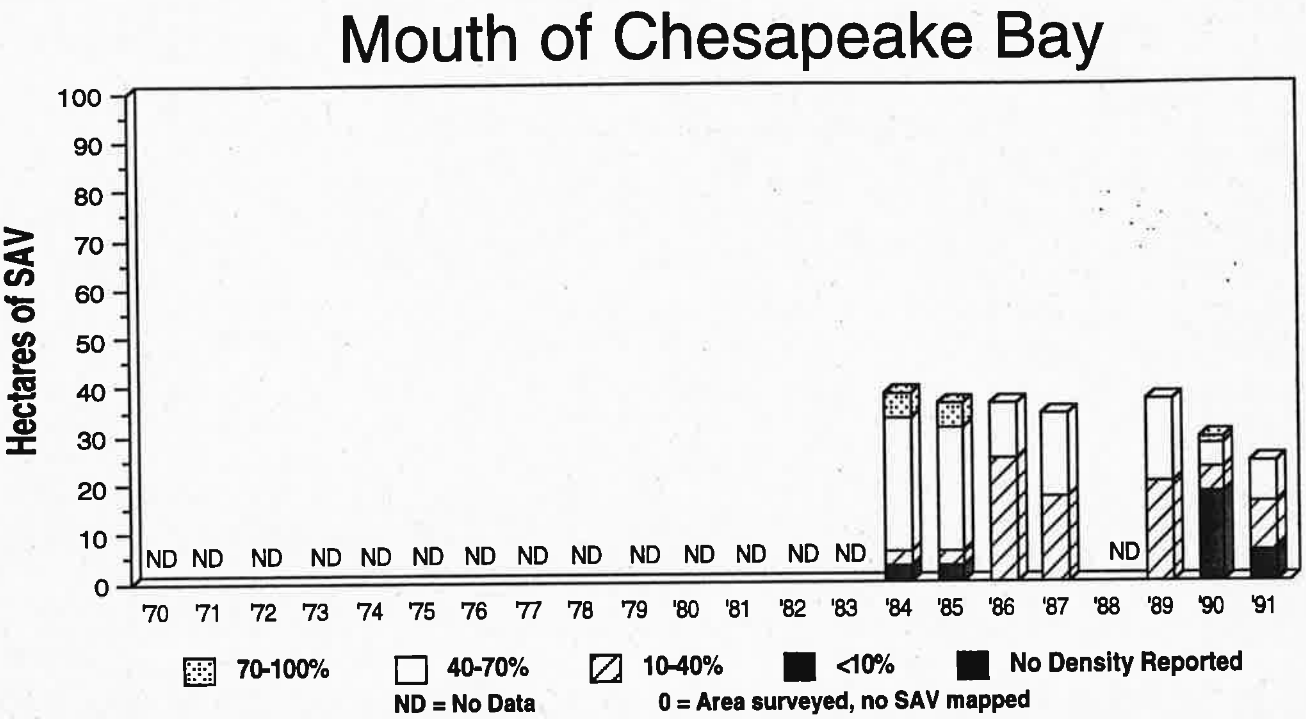


Figure 132. Hectares of SAV by density category for all years for which aerial survey data were available. For CBP Segment CB8 (Mouth of the Chesapeake Bay), the Tier I SAV restoration goal is 86 hectares.
Sources: Batiuk et al., 1992; Orth et al. 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Nowak, 1990.

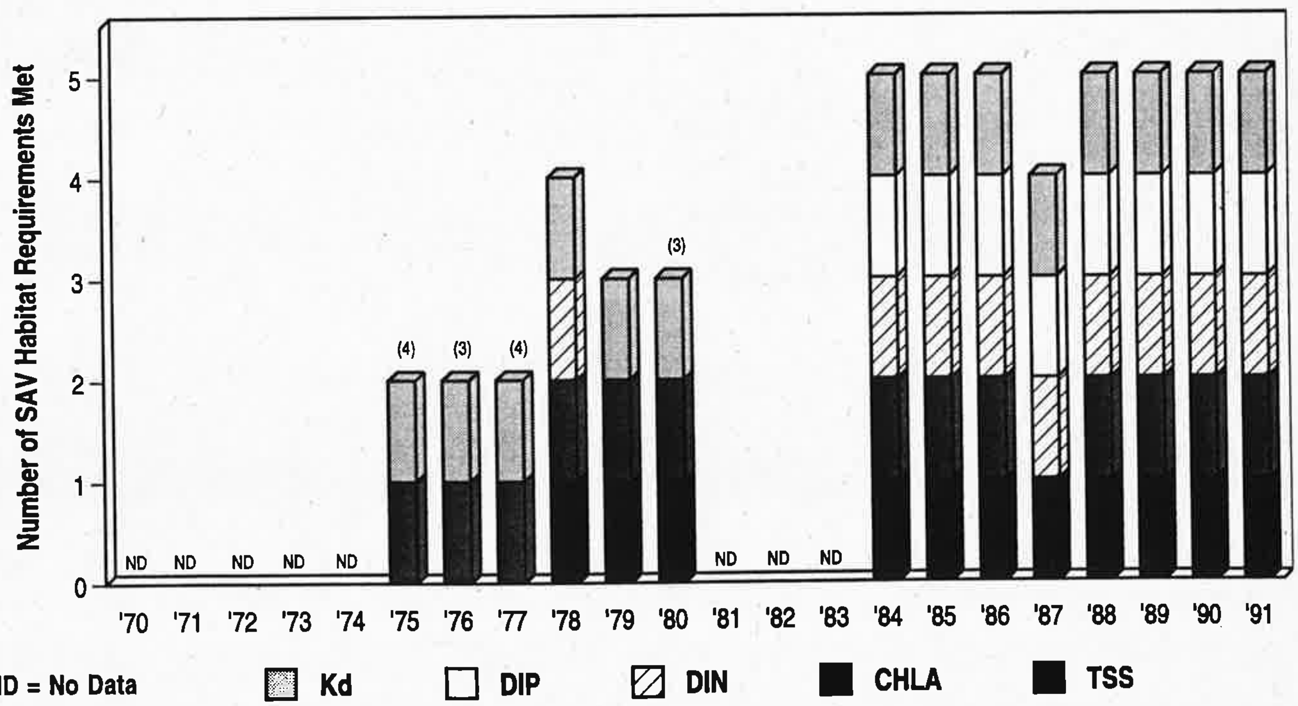


Figure 133. The number of SAV habitat requirements met over the SAV growing season from 1970 to 1991 for CBP Segment CB8 (Mouth of Chesapeake Bay). No SAV habitat requirements met = 0; no water quality data available = ND. Sufficient data for the following parameters were not available to calculate growing season medians: Kd (1970-1974, 1981-1983); TSS (1970-1977, 1981-1983); CHLA (1970-1974, 1981-1983); DIP (1970-1974, 1978, 1980-1983); and DIN (1970-1974, 1976, 1980-1983). Numbers of SAV habitat requirements with growing season medians are shown above bars when some values were missing.
Sources: Chesapeake Bay Program, 1993a and 1993b.

Mouth of Chesapeake Bay

	Hectares of SAV by Density Category						
Year	<10%	10-40%	40-70%	70-100%	Segment Total	% of Tier I Restoration Goal	% of Tier III Restoration Goal
'70	-	-	-	-	-	-	-
'71	-	-	-	-	-	-	-
'72	-	-	-	-	-	-	-
'73	-	-	-	-	-	-	-
'74	-	-	-	-	-	-	-
'75	-	-	-	-	-	-	-
'76	-	-	-	-	-	-	-
'77	-	-	-	-	-	-	-
'78	-	-	-	-	-	-	-
'79	-	-	-	-	-	-	-
'80	-	-	-	-	-	-	-
'81	-	-	-	-	-	-	-
'82	-	-	-	-	-	-	-
'83	-	-	-	-	-	-	-
'84	3	3	28	5	38	44%	2%
'85	3	3	26	5	36	42%	2%
'86	0	31	12	0	36	42%	2%
'87	0	23	18	0	34	39%	2%
'88	-	-	-	-	-	-	-
'89	0	20	17	0	37	43%	2%
'90	18	5	5	<1	29	34%	2%
'91	6	10	8	0	24	28%	1%

Table 53. Hectares of SAV by density category and percentage of Tier I (86 hectares) SAV restoration goal and Tier III (1,928 hectares) SAV restoration target are listed for 1970 to 1991 for CBP Segment CB8 (Mouth of Chesapeake Bay).
Sources: Batiuk et al., 1992; Orth et al., 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Nowak, 1990.

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Appendix A. Sources of 1970-1983 Water Quality Data Used to Calculate SAV Growing Season Medians.

Plankton Ecology Project - conducted by W.R. Taylor, W.B. Cronin, and V. Grant, The Johns Hopkins University, Chesapeake Bay Institute, from April 1969 through April 1971. This first phase of the project (the Aesop cruises) was designed to characterize the nutrient and photosynthetic pigment distributions from just south of the Susquehanna River's mouth to the mouth of the Bay. Later studies focused on the role and significance of nitrogen species in plankton ecology, dissolved carbon release by Bay phytoplankton, and the factors regulating primary productivity in the Bay.

Water Quality Survey of the Chesapeake Bay, 1979 - conducted by Michael Champ, American University and the EPA Central Regional Laboratory, from May 1979 to October 1979. This survey contains data in the mainstem Bay segments CB1, CB2, CB3, and CB4 (upper) and was conducted by EPA to determine water quality conditions in the mainstem Chesapeake Bay and tidal Potomac River.

Chesapeake Bay Institute Data Bank Compilation of Cruise Data from 1949 through 1982 - conducted by Donald Pritchard and staff of the Johns Hopkins University, Chesapeake Bay Institute (CBI), from 1949 through 1982. This data set is a compilation of Chesapeake Bay mainstem cruise data from the CBI data bank. There are over 100,000 observations of water temperature and salinity, over 20,000 observations of pH, and more than 13,000 observations of dissolved oxygen, and current data. There are many fewer records for chlorophyll, inorganic phosphate, and total phosphorus.

Ecological Effects of Nuclear Steam Electric Station Operations on Estuarine Systems - conducted by J. A. Mihursky, D. R. Heinle, and W. R. Boynton, University of Maryland, from 1971 to 1978. This data set provides an extraordinarily regular and complete record of dissolved oxygen, temperature, salinity, and Secchi data over an extended period of time at a single location off Calvert Cliffs, Maryland.

Light Studies for the Chesapeake Bay - conducted by Michael Champ, American University, and the EPA Central Regional Laboratory from May 21, 1979 to May 22, 1979. This data file contains 17 observations and is part of the data set collected for the light studies in the tidal Potomac River and Chesapeake Bay.

Section 106 Ambient Water Quality Monitoring for Maryland Tidal Waters, 1965 to 1981 - conducted by the Maryland Department of the Environment (formerly the Office of Environmental Programs and the Water Resources Administration) from 1962-1981. The data set contains nutrient (nitrogen and phosphorus), chlorophyll, and other water quality data from the Maryland portion of the Chesapeake Bay.

Nutrient Cruises Upper Chesapeake Bay 1964 to 1966 and Patapsco River (Baltimore Harbor Study) 1968 - conducted by R.C. Whaley, J.H. Carpenter, and R.L. Baker, The Johns Hopkins University, Chesapeake Bay Institute, from 1964 to 1966. The purpose of the study was to inventory distributions of the various forms of nitrogen and phosphorus. On these cruises, samples were also collected to inventory the abundance and distribution of phytoplankton and zooplankton. Only chlorophyll concentrations and rates of primary production, however, are included in this data set.

Chesapeake Bay Institute Chesapeake Bay Transect Studies - conducted by J. Taft, The Johns Hopkins University, Chesapeake Bay Institute, from 1977 to 1978. The data file contains physical-

SAV Growing Season Water Quality Medians By Segment (1970 to 1991)

CBP Segment CB1 – Northern Chesapeake Bay (Tidal Fresh)

Year	Kd(m^{-1}) Med	Kd Rqmt	Kd Over	Kd N	TSS(mg/l) Med	TSS Rqmt	TSS Over	TSS N	CHL*a* (µg/l) Med	CHLa Rqmt	CHLa Over	CHLa N	DIN(mg/l) Med	DIN Rqmt	DIN Over	DIN N	DIP(mg/l) Med	DIP Rqmt	DIP Over	DIP N
1970	•	•	•	0	17.9	15	2.9	14	•	•	•	0	•	•	•	0	•	•	•	0
1971	•	•	•	0	8.5	15	•	4	48.0	15.0	33.0	12	0.2595	•	•	8	0.0150	0.0200	•	6
1972	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1973	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1974	•	•	•	0	15.0	15	•	9	22.5	15.0	7.5	9	0.4950	•	•	9	0.0100	0.0200	•	9
1975	3.7	2.0	1.7	2	9.0	15	•	8	24.4	15.0	9.4	26	0.8070	•	•	26	0.0150	0.0200	•	26
1976	1.9	2.0	•	3	13.0	15	•	14	24.2	15.0	9.2	16	0.7475	•	•	16	0.0250	0.0200	0.0050	16
1977	1.9	2.0	•	5	16.0	15	1.0	8	12.0	15.0	•	8	0.7850	•	•	8	0.0200	0.0200	•	8
1978	1.3	2.0	•	8	9.0	15	•	16	15.0	15.0	•	19	0.9800	•	•	13	0.0400	0.0200	0.0200	15
1979	1.6	2.0	•	21	10.5	15	•	18	15.0	15.0	•	34	0.9530	•	•	26	0.0130	0.0200	•	26
1980	1.8	2.0	•	9	14.0	15	•	19	11.7	15.0	•	17	1.1190	•	•	11	0.0100	0.0200	•	11
1981	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1982	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1983	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1984	1.6	2.0	•	7	5.0	15	•	7	11.4	15.0	•	8	1.2612	•	•	8	0.0080	0.0200	•	8
1985	1.5	2.0	•	14	6.4	15	•	14	7.5	15.0	•	13	0.9340	•	•	14	0.0066	0.0200	•	14
1986	1.5	2.0	•	13	6.9	15	•	14	10.5	15.0	•	14	0.9695	•	•	14	0.0042	0.0200	•	14
1987	1.6	2.0	•	14	6.8	15	•	14	9.7	15.0	•	14	0.9810	•	•	14	0.0036	0.0200	•	14
1988	1.5	2.0	•	14	5.6	15	•	14	12.0	15.0	•	13	1.0240	•	•	14	0.0033	0.0200	•	14
1989	1.6	2.0	•	14	10.9	15	•	12	8.6	15.0	•	14	1.4230	•	•	14	0.0093	0.0200	•	14
1990	1.8	2.0	•	13	8.8	15	•	14	7.3	15.0	•	13	1.1710	•	•	14	0.0071	0.0200	•	14
1991	1.2	2.0	•	14	3.8	15	•	14	9.3	15.0	•	12	0.9860	•	•	14	0.0031	0.0200	•	14

Med = Median Value for Growing Season
Rqmt = Habitat Requirement
Over = Amount the Median Exceeds Requirement
N = Number of Observations

Sources: Chesapeake Bay Program, 1993a, 1993b.

SAV Growing Season Water Quality Medians By Segment (1970 to 1991)

CBP Segment CB2 – Upper Chesapeake Bay (Oligohaline)

Year	Kd (m^{-1})				TSS (mg/l)				CHL *a* (µg/l)				DIN (mg/l)				DIP (mg/l)			
	Med	Rqmt	Over	N	Med	Rqmt	Over	N	Med	Rqmt	Over	N	Med	Rqmt	Over	N	Med	Rqmt	Over	N
1970	•	•	•	0	17.4	15	2.4	18	21.4	15.0	6.4	4	•	•	•	0	0.1070	0.0200	0.0870	1
1971	•	•	•	0	•	•	•	0	30.2	15.0	15.2	22	0.4895	•	•	20	0.0200	0.0200	•	13
1972	•	•	•	0	•	•	•	0	•	•	•	0	0.5830	•	•	2	0.0300	0.0200	0.0100	2
1973	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1974	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1975	•	•	•	0	•	•	•	0	36.0	15.0	21.0	3	0.4750	•	•	3	0.0100	0.0200	•	3
1976	2.7	2.0	0.7	5	•	•	•	0	15.0	15.0	•	7	0.7060	•	•	7	0.0400	0.0200	0.0200	7
1977	3.0	2.0	1.0	13	29.0	15	14.0	16	18.0	15.0	3.0	17	0.5830	•	•	17	0.0300	0.0200	0.0100	15
1978	2.2	2.0	0.2	26	14.5	15	•	28	17.1	15.0	2.1	40	0.7250	•	•	21	0.0300	0.0200	0.0100	24
1979	2.6	2.0	0.6	46	23.5	15	8.5	26	18.0	15.0	3.0	77	0.8695	•	•	53	0.0130	0.0200	•	53
1980	2.4	2.0	0.4	26	19.6	15	4.6	26	15.0	15.0	•	33	0.7820	•	•	15	0.0200	0.0200	•	15
1981	2.9	2.0	0.9	7	22.0	15	7.0	7	67.8	15.0	52.8	7	0.4760	•	•	7	0.0250	0.0200	0.0050	6
1982	2.4	2.0	0.4	6	18.0	15	3.0	7	19.2	15.0	4.2	3	1.0140	•	•	7	0.1000	0.0200	0.0800	6
1983	2.4	2.0	0.4	7	29.0	15	14.0	7	9.6	15.0	•	1	1.1500	•	•	7	0.2000	0.0200	0.1800	7
1984	2.1	2.0	0.1	19	13.5	15	•	18	10.7	15.0	•	18	0.9590	•	•	20	0.0110	0.0200	•	20
1985	2.9	2.0	0.9	27	18.0	15	3.0	27	9.0	15.0	•	26	0.6280	•	•	27	0.0118	0.0200	•	27
1986	2.9	2.0	0.9	26	20.8	15	5.8	28	9.0	15.0	•	28	0.6895	•	•	28	0.0111	0.0200	•	28
1987	2.4	2.0	0.4	28	15.8	15	0.8	28	10.1	15.0	•	28	0.7860	•	•	28	0.0104	0.0200	•	28
1988	1.8	2.0	•	28	11.2	15	•	28	4.5	15.0	•	24	0.7740	•	•	28	0.0134	0.0200	•	28
1989	2.7	2.0	0.7	28	19.7	15	4.7	28	3.7	15.0	•	26	1.1340	•	•	28	0.0145	0.0200	•	28
1990	2.4	2.0	0.4	26	18.7	15	3.7	28	5.2	15.0	•	25	1.0365	•	•	28	0.0100	0.0200	•	28
1991	1.8	2.0	•	28	11.6	15	•	28	4.5	15.0	•	21	0.4505	•	•	28	0.0094	0.0200	•	28

Med = Median Value for Growing Season
Rqmt = Habitat Requirement
Over = Amount the Median Exceeds Requirement
N = Number of Observations

Sources: Chesapeake Bay Program, 1993a and 1993b.

SAV Growing Season Water Quality Medians By Segment (1970 to 1991)

CBP Segment CB3 - Upper Central Chesapeake Bay (Mesohaline)

Year	Kd (m^{-1})				TSS (mg/l)				CHL *a* (µg/l)				DIN (mg/l)				DIP (mg/l)			
	Med	Rqmt	Over	N	Med	Rqmt	Over	N	Med	Rqmt	Over	N	Med	Rqmt	Over	N	Med	Rqmt	Over	N
1970	1.9	1.5	0.4	56	8.7	15	•	20	36.0	15.0	21.0	57	0.2850	0.1500	0.1350	90	0.0294	0.0100	0.0194	42
1971	1.6	1.5	0.1	57	•	•	•	0	28.4	15.0	13.4	80	0.2700	0.1500	0.1200	73	0.0640	0.0100	0.0540	40
1972	5.8	1.5	4.3	6	9.0	15	•	13	28.4	15.0	13.4	32	0.5690	0.1500	0.4190	23	0.0900	0.0100	0.0800	27
1973	0.9	1.5	•	6	•	•	•	0	17.8	15.0	2.8	26	•	•	•	0	0.0800	0.0100	0.0700	27
1974	0.7	1.5	•	1	7.0	15	•	7	21.7	15.0	6.7	34	0.3665	0.1500	0.2165	18	0.0200	0.0100	0.0100	36
1975	0.6	1.5	•	11	8.0	15	•	38	17.8	15.0	2.8	79	0.6430	0.1500	0.4930	63	0.0500	0.0100	0.0400	75
1976	1.1	1.5	•	73	7.0	15	•	21	30.9	15.0	15.9	78	0.2400	0.1500	0.0900	44	0.0400	0.0100	0.0300	66
1977	2.4	1.5	0.9	77	17.8	15	2.8	90	25.5	15.0	10.5	107	0.1505	0.1500	0.0005	98	0.0365	0.0100	0.0265	108
1978	1.9	1.5	0.4	74	11.5	15	•	94	9.0	15.0	•	130	0.4280	0.1500	0.2780	87	0.0400	0.0100	0.0300	95
1979	1.9	1.5	0.4	73	15.0	15	•	32	18.5	15.0	3.5	108	0.4080	0.1500	0.2580	77	0.0130	0.0100	0.0030	83
1980	1.4	1.5	•	86	13.0	15	•	115	13.0	15.0	•	120	0.2343	0.1500	0.0843	67	0.0200	0.0100	0.0100	73
1981	1.2	1.5	•	7	8.0	15	•	14	32.4	15.0	17.4	11	0.2980	0.1500	0.1480	11	0.0350	0.0100	0.0250	14
1982	1.2	1.5	•	8	22.5	15	7.5	16	10.0	15.0	•	6	0.4560	0.1500	0.3060	12	0.0300	0.0100	0.0200	13
1983	1.0	1.5	•	5	10.0	15	•	16	7.3	15.0	•	3	1.4500	0.1500	1.3000	11	0.2000	0.0100	0.1900	11
1984	1.3	1.5	•	37	4.3	15	•	40	10.0	15.0	•	35	0.4590	0.1500	0.3090	44	0.0120	0.0100	0.0020	43
1985	1.5	1.5	•	52	8.4	15	•	54	11.0	15.0	•	53	0.2405	0.1500	0.0905	54	0.0092	0.0100	•	54
1986	1.6	1.5	0.1	50	8.5	15	•	56	10.5	15.0	•	56	0.2460	0.1500	0.0960	56	0.0091	0.0100	•	56
1987	1.5	1.5	•	56	7.0	15	•	56	10.4	15.0	•	56	0.3380	0.1500	0.1880	56	0.0085	0.0100	•	56
1988	1.3	1.5	•	56	7.2	15	•	55	9.0	15.0	•	51	0.3980	0.1500	0.2480	56	0.0091	0.0100	•	56
1989	1.5	1.5	•	54	7.8	15	•	54	7.6	15.0	•	51	0.7660	0.1500	0.6160	54	0.0117	0.0100	0.0017	54
1990	1.6	1.5	0.1	54	8.1	15	•	56	7.3	15.0	•	55	0.6455	0.1500	0.4955	56	0.0096	0.0100	•	56
1991	1.5	1.5	•	56	8.1	15	•	56	10.1	15.0	•	52	0.1542	0.1500	0.0042	56	0.0067	0.0100	•	56

Med = Median Value for Growing Season
Rqmt = Habitat Requirement
Over = Amount the Median Exceeds Requirement
N = Number of Observations

Sources: Chesapeake Bay Program, 1993a, 1993b.

SAV Growing Season Water Quality Medians By Segment (1970 to 1991)

CBP Segment CB4 - Middle Central Chesapeake Bay (Mesohaline)

Year	Kd (m^{-1})				TSS (mg/l)				CHL *a* (µg/l)				DIN (mg/l)				DIP (mg/l)			
	Med	Rqmt	Over	N	Med	Rqmt	Over	N	Med	Rqmt	Over	N	Med	Rqmt	Over	N	Med	Rqmt	Over	N
1970	•	•	•	0	4.9	15	•	17	•	•	•	0	0.1029	0.1500	•	48	0.0170	0.0100	0.0070	50
1971	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1972	1.0	1.5	•	21	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1973	0.8	1.5	•	42	•	•	•	0	31.5	15.0	16.5	4	0.2755	0.1500	0.1255	4	0.0200	0.0100	0.0100	4
1974	0.8	1.5	•	24	19.0	15	4.0	4	19.5	15.0	4.5	4	0.2755	0.1500	0.1255	4	0.0100	0.0100	•	4
1975	0.5	1.5	•	11	16.0	15	1.0	9	16.5	15.0	1.5	15	0.4890	0.1500	0.3390	10	0.0300	0.0100	0.0200	10
1976	0.8	1.5	•	69	13.0	15	•	36	13.8	15.0	•	67	0.2155	0.1500	0.0655	56	0.0300	0.0100	0.0200	56
1977	0.8	1.5	•	72	18.0	15	3.0	46	13.8	15.0	•	73	0.1200	0.1500	•	68	0.0180	0.0100	0.0080	101
1978	0.8	1.5	•	59	9.0	15	•	58	9.0	15.0	•	110	0.2310	0.1500	0.0810	61	0.0200	0.0100	0.0100	62
1979	0.9	1.5	•	68	5.8	15	•	42	11.9	15.0	•	98	0.3050	0.1500	0.1550	62	0.0130	0.0100	0.0030	67
1980	0.9	1.5	•	53	6.0	15	•	72	12.5	15.0	•	63	0.0860	0.1500	•	52	0.0200	0.0100	0.0100	52
1981	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1982	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1983	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1984	0.8	1.5	•	40	4.0	15	•	36	11.2	15.0	•	38	0.1425	0.1500	•	40	0.0070	0.0100	•	41
1985	0.9	1.5	•	69	5.7	15	•	70	9.0	15.0	•	67	0.1125	0.1500	•	70	0.0055	0.0100	•	69
1986	0.8	1.5	•	65	4.5	15	•	70	8.8	15.0	•	67	0.1006	0.1500	•	70	0.0044	0.0100	•	70
1987	0.8	1.5	•	69	4.8	15	•	70	11.6	15.0	•	70	0.1124	0.1500	•	70	0.0050	0.0100	•	70
1988	0.9	1.5	•	69	5.7	15	•	69	9.5	15.0	•	64	0.1440	0.1500	•	70	0.0038	0.0100	•	70
1989	1.0	1.5	•	66	5.3	15	•	66	11.4	15.0	•	59	0.3598	0.1500	0.2098	66	0.0050	0.0100	•	66
1990	1.0	1.5	•	69	5.3	15	•	69	9.3	15.0	•	68	0.1570	0.1500	0.0070	69	0.0045	0.0100	•	69
1991	0.9	1.5	•	69	5.0	15	•	70	8.1	15.0	•	63	0.0520	0.1500	•	70	0.0033	0.0100	•	69

Med = Median Value for Growing Season
Rqmt = Habitat Requirement
Over = Amount the Median Exceeds Requirement
N = Number of Observations

Sources: Chesapeake Bay Program, 1993a and 1993b.

SAV Growing Season Water Quality Medians By Segment (1970 to 1991)

CBP Segment CB5 - Lower Chesapeake Bay (Mesohaline)

Year	Kd (m^{-1}) Med	Kd Rqmt	Kd Over	Kd N	TSS (mg/l) Med	TSS Rqmt	TSS Over	TSS N	CHL *a* (µg/l) Med	CHL *a* Rqmt	CHL *a* Over	CHL *a* N	DIN (mg/l) Med	DIN Rqmt	DIN Over	DIN N	DIP (mg/l) Med	DIP Rqmt	DIP Over	DIP N
1970	•	•	•	0	4.0	15	•	19	•	•	•	0	0.0392	0.1500	•	44	0.0124	0.0100	0.0024	51
1971	•	•	•	0	•	•	•	0	•	•	•	0	0.3514	0.1500	0.2014	12	0.0062	0.0100	•	5
1972	•	•	•	0	•	•	•	0	•	•	•	0	0.3736	0.1500	0.2236	7	•	•	•	0
1973	•	•	•	0	•	•	•	0	•	•	•	0	0.3084	0.1500	0.1584	7	•	•	•	0
1974	•	•	•	0	9.5	15	•	2	30.0	15.0	15.0	2	0.2865	0.1500	0.1365	2	0.0150	0.0100	0.0050	2
1975	•	•	•	0	20.0	15	5.0	3	12.7	15.0	•	14	0.1792	0.1500	0.0292	6	0.0064	0.0100	•	6
1976	0.7	1.5	•	4	11.0	15	•	4	5.3	15.0	•	15	0.0602	0.1500	•	9	0.0200	0.0100	0.0100	8
1977	0.7	1.5	•	9	26.0	15	11.0	5	11.0	15.0	•	17	0.0660	0.1500	•	27	0.0030	0.0100	•	39
1978	0.7	1.5	•	23	7.5	15	•	24	11.9	15.0	•	56	0.2268	0.1500	0.0768	31	0.0200	0.0100	0.0100	30
1979	0.6	1.5	•	16	5.1	15	•	17	8.0	15.0	•	29	0.2550	0.1500	0.1050	5	0.0100	0.0100	•	5
1980	0.7	1.5	•	39	14.0	15	•	75	8.0	15.0	•	52	0.0439	0.1500	•	47	0.0135	0.0100	0.0035	48
1981	2.4	1.5	0.9	14	19.0	15	4.0	16	17.8	15.0	2.8	15	0.0800	0.1500	•	16	0.0062	0.0100	•	16
1982	0.7	1.5	•	7	4.0	15	•	7	12.4	15.0	•	7	0.4230	0.1500	0.2730	7	0.1000	0.0100	0.0900	7
1983	0.7	1.5	•	19	4.0	15	•	37	11.3	15.0	•	30	0.3240	0.1500	0.1740	37	0.0100	0.0100	•	37
1984	0.7	1.5	•	54	4.0	15	•	79	9.2	15.0	•	38	0.1125	0.1500	•	82	0.0100	0.0100	•	81
1985	0.7	1.5	•	76	5.9	15	•	78	5.6	15.0	•	77	0.0547	0.1500	•	77	0.0084	0.0100	•	76
1986	0.7	1.5	•	79	4.0	15	•	83	6.8	15.0	•	80	0.0695	0.1500	•	83	0.0062	0.0100	•	82
1987	0.8	1.5	•	80	5.0	15	•	83	8.4	15.0	•	83	0.0511	0.1500	•	82	0.0058	0.0100	•	82
1988	0.9	1.5	•	85	8.0	15	•	82	10.6	15.0	•	82	0.0383	0.1500	•	83	0.0031	0.0100	•	85
1989	0.8	1.5	•	81	7.0	15	•	80	9.6	15.0	•	70	0.1440	0.1500	•	81	0.0039	0.0100	•	81
1990	0.9	1.5	•	81	6.1	15	•	82	9.1	15.0	•	77	0.0726	0.1500	•	82	0.0033	0.0100	•	82
1991	0.7	1.5	•	81	4.9	15	•	81	6.0	15.0	•	76	0.0291	0.1500	•	82	0.0027	0.0100	•	82

Med = Median Value for Growing Season
Rqmt = Habitat Requirement
Over = Amount the Median Exceeds Requirement
N = Number of Observations

Sources: Chesapeake Bay Program, 1993a, 1993b.

SAV Growing Season Water Quality Medians By Segment (1970 to 1991)

Segment CB6 - Western Lower Chesapeake Bay (Polyhaline)

Year	Kd (m^{-1}) Med	Kd Rqmt	Kd Over	Kd N	TSS (mg/l) Med	TSS Rqmt	TSS Over	TSS N	CHL *a* (µg/l) Med	CHL *a* Rqmt	CHL *a* Over	CHL *a* N	DIN (mg/l) Med	DIN Rqmt	DIN Over	DIN N	DIP (mg/l) Med	DIP Rqmt	DIP Over	DIP N
1970	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1971	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1972	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1973	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1974	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1975	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1976	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1977	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1978	•	•	•	0	•	•	•	0	3.4	15.0	•	1	0.2020	0.1500	0.0520	1	•	•	•	0
1979	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1980	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1981	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1982	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1983	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1984	0.9	1.5	•	15	13.0	15	•	16	8.9	15.0	•	16	0.0400	0.1500	•	16	0.0100	0.0200	•	16
1985	0.7	1.5	•	33	6.0	15	•	43	5.5	15.0	•	43	0.0660	0.1500	•	43	0.0100	0.0200	•	43
1986	0.6	1.5	•	44	5.0	15	•	44	6.9	15.0	•	44	0.1175	0.1500	•	44	0.0100	0.0200	•	44
1987	0.9	1.5	•	43	7.0	15	•	44	8.4	15.0	•	43	0.0985	0.1500	•	44	0.0110	0.0200	•	44
1988	0.8	1.5	•	40	11.5	15	•	40	7.7	15.0	•	40	0.0360	0.1500	•	40	0.0020	0.0200	•	40
1989	0.8	1.5	•	36	14.9	15	•	36	5.8	15.0	•	36	0.0849	0.1500	•	36	0.0030	0.0200	•	36
1990	0.9	1.5	•	34	9.0	15	•	36	10.6	15.0	•	36	0.0357	0.1500	•	36	0.0030	0.0200	•	36
1991	0.7	1.5	•	35	9.0	15	•	35	6.4	15.0	•	36	0.0883	0.1500	•	36	0.0032	0.0200	•	36

Med = Median Value for Growing Season
Rqmt = Habitat Requirement
Over = Amount the Median Exceeds Requirement
N = Number of Observations

Sources: Chesapeake Bay Program, 1993a and 1993b.

SAV Growing Season Water Quality Medians By Segment (1970 to 1991)

CBP Segment CB7 - Eastern Lower Chesapeake Bay (Polyhaline)

Year	Kd (m^{-1})				TSS (mg/l)				CHL *a* (µg/l)				DIN (mg/l)				DIP (mg/l)			
	Med	Rqmt	Over	N	Med	Rqmt	Over	N	Med	Rqmt	Over	N	Med	Rqmt	Over	N	Med	Rqmt	Over	N
1970	•	•	•	0	2.9	15	•	11	0.5	15.0	•	11	0.0420	0.1500	•	19	0.0062	0.0200	•	23
1971	•	•	•	0	•	•	•	0	3.5	15.0	•	9	0.1078	0.1500	•	3	0.0124	0.0200	•	3
1972	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1973	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1974	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1975	•	•	•	0	•	•	•	0	9.8	15.0	•	3	0.0308	0.1500	•	1	•	•	•	0
1976	•	•	•	0	•	•	•	0	3.5	15.0	•	4	•	•	•	0	•	•	•	0
1977	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1978	0.7	1.5	•	4	4.0	15	•	4	6.3	15.0	•	14	0.0953	0.1500	•	2	0.0010	0.0200	•	1
1979	0.7	1.5	•	6	5.3	15	•	6	19.0	15.0	4.0	12	•	•	•	0	•	•	•	0
1980	0.7	1.5	•	12	4.3	15	•	12	10.0	15.0	•	20	•	•	•	0	•	•	•	0
1981	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1982	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1983	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1984	0.7	1.5	•	14	17.5	15	2.5	14	8.3	15.0	•	14	0.0400	0.1500	•	13	0.0100	0.0200	•	14
1985	0.6	1.5	•	31	7.9	15	•	32	4.5	15.0	•	32	0.0470	0.1500	•	32	0.0100	0.0200	•	32
1986	0.6	1.5	•	33	4.0	15	•	33	6.1	15.0	•	33	0.1170	0.1500	•	33	0.0100	0.0200	•	33
1987	0.9	1.5	•	31	7.0	15	•	33	10.8	15.0	•	33	0.0610	0.1500	•	33	0.0110	0.0200	•	33
1988	0.7	1.5	•	27	9.5	15	•	30	6.6	15.0	•	30	0.0255	0.1500	•	30	0.0020	0.0200	•	30
1989	0.8	1.5	•	27	14.4	15	•	27	5.1	15.0	•	27	0.0807	0.1500	•	27	0.0030	0.0200	•	27
1990	0.8	1.5	•	27	9.0	15	•	25	9.1	15.0	•	27	0.0415	0.1500	•	27	0.0030	0.0200	•	27
1991	0.6	1.5	•	26	7.0	15	•	27	5.9	15.0	•	27	0.1174	0.1500	•	27	0.0037	0.0200	•	27

Med = Median Value for Growing Season
Rqmt = Habitat Requirement
Over = Amount the Median Exceeds Requirement
N = Number of Observations

Sources: Chesapeake Bay Program, 1993a, 1993b.

SAV Growing Season Water Quality Medians By Segment (1970 to 1991)

CBP Segment CB8 - Mouth of Chesapeake Bay (Polyhaline)

Year	Kd (m^{-1})				TSS (mg/l)				CHL *a* (µg/l)				DIN (mg/l)				DIP (mg/l)			
	Med	Rqmt	Over	N	Med	Rqmt	Over	N	Med	Rqmt	Over	N	Med	Rqmt	Over	N	Med	Rqmt	Over	N
1970	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1971	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1972	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1973	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1974	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1975	1.3	1.5	•	3	•	•	•	0	2.3	15.0	•	1	0.3533	0.1500	0.2033	2	0.0349	0.0200	0.0149	2
1976	1.2	1.5	•	6	•	•	•	0	5.6	15.0	•	2	•	•	•	0	0.0352	0.0200	0.0152	2
1977	1.3	1.5	•	4	•	•	•	0	11.1	15.0	•	4	0.1599	0.1500	0.0099	3	0.0369	0.0200	0.0169	3
1978	0.9	1.5	•	3	6.1	15	•	2	11.0	15.0	•	5	0.1020	0.1500	•	1	•	•	•	0
1979	0.9	1.5	•	9	5.4	15	•	3	10.5	15.0	•	8	0.3399	0.1500	0.1899	3	0.0400	0.0200	0.0200	3
1980	0.7	1.5	•	7	4.0	15	•	3	7.0	15.0	•	4	•	•	•	0	•	•	•	0
1981	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1982	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1983	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1984	1.0	1.5	•	5	8.5	15	•	5	9.3	15.0	•	4	0.0340	0.1500	•	5	0.0100	0.0200	•	5
1985	0.7	1.5	•	11	4.6	15	•	11	4.2	15.0	•	11	0.0280	0.1500	•	11	0.0160	0.0200	•	11
1986	0.9	1.5	•	11	7.0	15	•	11	6.5	15.0	•	11	0.0700	0.1500	•	11	0.0100	0.0200	•	11
1987	1.1	1.5	•	11	7.9	15	•	11	15.1	15.0	0.1	10	0.0341	0.1500	•	11	0.0120	0.0200	•	11
1988	0.9	1.5	•	10	7.6	15	•	10	4.5	15.0	•	10	0.0306	0.1500	•	10	0.0065	0.0200	•	10
1989	0.9	1.5	•	9	6.5	15	•	9	4.9	15.0	•	9	0.1193	0.1500	•	9	0.0150	0.0200	•	9
1990	0.6	1.5	•	9	5.6	15	•	9	6.2	15.0	•	9	0.0649	0.1500	•	9	0.0120	0.0200	•	9
1991	0.9	1.5	•	9	7.8	15	•	9	4.7	15.0	•	9	0.0638	0.1500	•	9	0.0070	0.0200	•	9

Med = Median Value for Growing Season
Rqmt = Habitat Requirement
Over = Amount the Median Exceeds Requirement
N = Number of Observations

Sources: Chesapeake Bay Program, 1993a and 1993b.

SAV Growing Season Water Quality Medians By Segment (1970 to 1991)

CBP Segment WT1 - Bush River (Oligohaline)

Year	Kd (m^{-1}) Med	Kd Rqmt	Kd Over	Kd N	TSS (mg/l) Med	TSS Rqmt	TSS Over	TSS N	CHL *a* (µg/l) Med	CHL *a* Rqmt	CHL *a* Over	CHL *a* N	DIN (mg/l) Med	DIN Rqmt	DIN Over	DIN N	DIP (mg/l) Med	DIP Rqmt	DIP Over	DIP N
1970	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1971	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1972	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1973	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1974	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1975	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1976	•	•	•	0	2.5	15	•	6	8.3	15.0	•	6	1.5740	•	•	6	0.0250	0.0200	0.0050	6
1977	•	•	•	0	24.0	15	9.0	13	34.5	15.0	19.5	14	0.0330	•	•	14	0.0300	0.0200	0.0100	14
1978	•	•	•	0	11.5	15	•	4	22.5	15.0	7.5	3	1.9870	•	•	3	0.0400	0.0200	0.0200	4
1979	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1980	4.2	2.0	2.2	4	31.4	15	16.4	11	18.0	15.0	3.0	10	2.4310	•	•	1	0.0800	0.0200	0.0600	1
1981	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1982	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1983	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1984	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1985	3.6	2.0	1.6	5	32.0	15	17.0	5	38.2	15.0	23.2	5	0.4200	•	•	5	0.0100	0.0200	•	5
1986	4.8	2.0	2.8	7	39.0	15	24.0	7	6.5	15.0	•	7	0.1480	•	•	7	0.0060	0.0200	•	7
1987	3.9	2.0	1.9	6	28.0	15	13.0	7	21.7	15.0	6.7	7	0.2890	•	•	7	0.0040	0.0200	•	7
1988	4.8	2.0	2.8	7	25.5	15	10.5	7	68.5	15.0	53.5	7	0.0320	•	•	7	0.0040	0.0200	•	6
1989	4.8	2.0	2.8	7	20.0	15	5.0	7	45.5	15.0	30.5	7	0.3480	•	•	7	0.0040	0.0200	•	6
1990	4.8	2.0	2.8	7	26.0	15	11.0	7	50.3	15.0	35.3	7	0.5560	•	•	7	0.0040	0.0200	•	7
1991	3.6	2.0	1.6	7	17.5	15	2.5	7	28.9	15.0	13.9	7	0.6350	•	•	7	0.0040	0.0200	•	7

Med = Median Value for Growing Season
Rqmt = Habitat Requirement
Over = Amount the Median Exceeds Requirement
N = Number of Observations

Sources: Chesapeake Bay Program, 1993a, 1993b.

SAV Growing Season Water Quality Medians By Segment (1970 to 1991)

CBP Segment WT2 - Gunpowder River (Oligohaline)

Year	Kd (m^{-1}) Med	Kd Rqmt	Kd Over	Kd N	TSS (mg/l) Med	TSS Rqmt	TSS Over	TSS N	CHL *a* (µg/l) Med	CHL *a* Rqmt	CHL *a* Over	CHL *a* N	DIN (mg/l) Med	DIN Rqmt	DIN Over	DIN N	DIP (mg/l) Med	DIP Rqmt	DIP Over	DIP N
1970	•	•	•	0	44.0	15	29.0	1	•	•	•	0	0.9500	•	•	1	•	•	•	0
1971	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1972	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1973	•	•	•	0	21.0	15	6.0	6	50.0	15.0	35.0	3	0.3690	•	•	6	0.0200	0.0200	•	6
1974	•	•	•	0	14.0	15	•	11	16.5	15.0	1.5	11	1.1780	•	•	11	0.0200	0.0200	•	11
1975	•	•	•	0	10.0	15	•	12	7.5	15.0	•	11	0.6430	•	•	12	0.0200	0.0200	•	12
1976	3.2	2.0	1.2	3	12.0	15	•	29	10.4	15.0	•	30	0.6865	•	•	30	0.0300	0.0200	0.0100	30
1977	•	•	•	0	8.0	15	•	34	4.3	15.0	•	32	1.2625	•	•	34	0.0200	0.0200	•	33
1978	•	•	•	0	6.0	15	•	12	15.5	15.0	0.5	12	1.5690	•	•	9	0.0400	0.0200	0.0200	12
1979	•	•	•	0	110.5	15	95.5	2	•	•	•	0	1.5125	•	•	2	0.0300	0.0200	0.0100	2
1980	3.3	2.0	1.3	6	25.5	15	10.5	10	18.0	15.0	3.0	13	1.8320	•	•	1	0.0100	0.0200	•	1
1981	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1982	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1983	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1984	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1985	1.1	2.0	•	2	4.5	15	•	2	2.4	15.0	•	2	0.4300	•	•	2	0.0100	0.0200	•	2
1986	4.8	2.0	2.8	7	18.0	15	3.0	7	13.8	15.0	•	7	0.0760	•	•	7	0.0040	0.0200	•	7
1987	3.3	2.0	1.3	6	18.0	15	3.0	7	16.3	15.0	1.3	7	0.1820	•	•	7	0.0040	0.0200	•	7
1988	3.6	2.0	1.6	7	21.5	15	6.5	7	35.4	15.0	20.4	7	0.0540	•	•	7	0.0040	0.0200	•	6
1989	3.6	2.0	1.6	7	24.0	15	9.0	7	30.4	15.0	15.4	7	0.3130	•	•	7	0.0050	0.0200	•	6
1990	3.6	2.0	1.6	7	27.0	15	12.0	7	41.2	15.0	26.2	7	0.5560	•	•	7	0.0040	0.0200	•	7
1991	3.6	2.0	1.6	7	19.0	15	4.0	7	19.4	15.0	4.4	7	0.5500	•	•	7	0.0040	0.0200	•	7

Med = Median Value for Growing Season
Rqmt = Habitat Requirement
Over = Amount the Median Exceeds Requirement
N = Number of Observations

Sources: Chesapeake Bay Program, 1993a and 1993b.

SAV Growing Season Water Quality Medians By Segment (1970 to 1991)

CBP Segment WT3 - Middle River (Obligohaline)

Year	Kd (m^{-1}) Med	Kd Rqmt	Kd Over	Kd N	TSS (mg/l) Med	TSS Rqmt	TSS Over	TSS N	CHL *a* (µg/l) Med	CHL *a* Rqmt	CHL *a* Over	CHL *a* N	DIN (mg/l) Med	DIN Rqmt	DIN Over	DIN N	DIP (mg/l) Med	DIP Rqmt	DIP Over	DIP N
1970	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1971	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1972	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1973	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1974	•	•	•	0	17.0	15	2.0	3	45.0	15.0	30.0	3	0.1300	•	•	3	0.0150	0.0200	•	2
1975	•	•	•	0	10.0	15	•	3	15.0	15.0	•	3	0.3970	•	•	3	0.0200	0.0200	•	3
1976	1.9	2.0	•	4	6.0	15	•	4	10.4	15.0	•	4	0.1740	•	•	4	0.0450	0.0200	0.0250	4
1977	2.6	2.0	0.6	4	23.5	15	8.5	4	41.0	15.0	26.0	4	0.0390	•	•	4	0.0300	0.0200	0.0100	4
1978	2.3	2.0	0.3	3	14.0	15	•	3	13.2	15.0	•	3	0.5105	•	•	2	0.0400	0.0200	0.0200	3
1979	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1980	2.1	2.0	0.1	1	11.0	15	•	1	10.6	15.0	•	1	0.0550	•	•	1	0.0100	0.0200	•	1
1981	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1982	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1983	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1984	0.9	2.0	•	1	2.0	15	•	1	8.3	15.0	•	1	•	•	•	0	0.0100	0.0200	•	1
1985	1.8	2.0	•	3	12.0	15	•	3	25.6	15.0	10.6	3	0.0400	•	•	3	0.0100	0.0200	•	3
1986	2.1	2.0	0.1	7	10.0	15	•	7	19.7	15.0	4.7	7	0.0400	•	•	7	0.0040	0.0200	•	7
1987	2.7	2.0	0.7	6	13.0	15	•	7	17.3	15.0	2.3	7	0.1840	•	•	7	0.0040	0.0200	•	7
1988	2.9	2.0	0.9	7	18.0	15	3.0	7	28.2	15.0	13.2	7	0.1880	•	•	7	0.0040	0.0200	•	6
1989	2.9	2.0	0.9	7	15.0	15	•	7	31.4	15.0	16.4	7	0.1620	•	•	7	0.0070	0.0200	•	6
1990	2.4	2.0	0.4	7	14.0	15	•	7	18.9	15.0	3.9	7	0.2880	•	•	7	0.0040	0.0200	•	7
1991	2.1	2.0	0.1	7	18.0	15	3.0	7	19.2	15.0	4.2	6	0.0480	•	•	7	0.0040	0.0200	•	7

Med = Median Value for Growing Season
Rqmt = Habitat Requirement
Over = Amount the Median Exceeds Requirement
N = Number of Observations

Sources: Chesapeake Bay Program, 1993a, 1993b.

SAV Growing Season Water Quality Medians By Segment (1970 to 1991)

CBP Segment WT4 - Back River (Oligohaline)

Year	Kd (m^{-1})				TSS (mg/l)				CHL *a* (µg/l)				DIN (mg/l)				DIP (mg/l)			
	Med	Rqmt	Over	N	Med	Rqmt	Over	N	Med	Rqmt	Over	N	Med	Rqmt	Over	N	Med	Rqmt	Over	N
1970	5.3	2.0	3.3	12	•	•	•	0	48.3	15.0	33.3	12	•	•	•	0	0.8450	0.0200	0.8250	18
1971	4.3	2.0	2.3	36	•	•	•	0	46.0	15.0	31.0	42	•	•	•	0	0.9100	0.0200	0.8900	42
1972	5.8	2.0	3.8	12	•	•	•	0	34.2	15.0	19.2	42	•	•	•	0	1.2300	0.0200	1.2100	36
1973	1.7	2.0	•	12	•	•	•	0	41.6	15.0	26.6	50	•	•	•	0	1.1250	0.0200	1.1050	50
1974	3.2	2.0	1.2	35	59.0	15	44.0	7	83.4	15.0	68.4	56	2.8975	•	•	24	0.5900	0.0200	0.5700	77
1975	2.4	2.0	0.4	48	30.0	15	15.0	15	103.5	15.0	88.5	105	5.2930	•	•	75	1.2250	0.0200	1.2050	116
1976	1.6	2.0	•	63	44.0	15	29.0	18	139.6	15.0	124.6	79	1.7860	•	•	19	0.9000	0.0200	0.8800	70
1977	3.9	2.0	1.9	4	49.0	15	34.0	8	193.5	15.0	178.5	8	1.7940	•	•	8	0.2900	0.0200	0.2700	7
1978	4.8	2.0	2.8	3	46.0	15	31.0	7	91.8	15.0	76.8	7	5.5070	•	•	5	0.2000	0.0200	0.1800	7
1979	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1980	3.0	2.0	1.0	11	45.0	15	30.0	36	117.6	15.0	102.6	29	6.2055	•	•	54	0.9400	0.0200	0.9200	54
1981	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1982	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1983	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1984	•	•	•	0	•	•	•	0	113.2	15.0	98.2	1	•	•	•	0	•	•	•	0
1985	4.8	2.0	2.8	7	36.0	15	21.0	7	130.7	15.0	115.7	7	3.0900	•	•	7	0.0200	0.0200	•	7
1986	4.8	2.0	2.8	7	33.5	15	18.5	7	104.3	15.0	89.3	7	2.4500	•	•	7	0.0070	0.0200	•	7
1987	4.8	2.0	2.8	7	31.5	15	16.5	7	86.6	15.0	71.6	7	3.3625	•	•	6	0.0300	0.0200	0.0100	7
1988	3.6	2.0	1.6	7	29.0	15	14.0	7	92.0	15.0	77.0	7	4.0630	•	•	6	0.0095	0.0200	•	6
1989	4.8	2.0	2.8	7	23.0	15	8.0	7	101.2	15.0	86.2	7	2.4500	•	•	5	0.0130	0.0200	•	6
1990	4.8	2.0	2.8	7	33.0	15	18.0	7	130.1	15.0	115.1	7	2.2870	•	•	6	0.0140	0.0200	•	7
1991	4.8	2.0	2.8	7	32.5	15	17.5	7	43.9	15.0	28.9	7	2.0560	•	•	7	0.0820	0.0200	0.0620	7

Med = Median Value for Growing Season
Rqmt = Habitat Requirement
Over = Amount the Median Exceeds Requirement
N = Number of Observations

Sources: Chesapeake Bay Program, 1993a and 1993b.

SAV Growing Season Water Quality Medians By Segment (1970 to 1991)

CBP Segment WT5 - Patapsco River (Mesohaline)

Year	Kd (m^{-1}) Med	Kd Rqmt	Kd Over	Kd N	TSS (mg/l) Med	TSS Rqmt	TSS Over	TSS N	CHL *a* (µg/l) Med	CHL *a* Rqmt	CHL *a* Over	CHL *a* N	DIN (mg/l) Med	DIN Rqmt	DIN Over	DIN N	DIP (mg/l) Med	DIP Rqmt	DIP Over	DIP N
1970	1.9	1.5	0.4	50	•	•	•	0	42.0	15.0	27.0	46	1.0420	0.1500	0.8920	64	•	•	•	0
1971	1.6	1.5	0.1	38	•	•	•	0	38.0	15.0	23.0	42	1.0400	0.1500	0.8900	46	•	•	•	0
1972	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1973	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1974	•	•	•	0	28.0	15	13.0	24	60.0	15.0	45.0	13	0.9530	0.1500	0.8030	13	0.0400	0.0100	0.0300	13
1975	•	•	•	0	20.0	15	5.0	19	29.3	15.0	14.3	10	1.0980	0.1500	0.9480	10	0.0400	0.0100	0.0300	10
1976	1.4	1.5	•	3	17.0	15	2.0	27	12.8	15.0	•	14	1.2990	0.1500	1.1490	14	0.0400	0.0100	0.0300	13
1977	1.5	1.5	•	1	23.0	15	8.0	20	20.3	15.0	5.3	16	0.8715	0.1500	0.7215	16	0.0300	0.0100	0.0200	16
1978	1.6	1.5	0.1	6	12.0	15	•	15	11.4	15.0	•	15	1.0470	0.1500	0.8970	13	0.0500	0.0100	0.0400	15
1979	2.0	1.5	0.5	6	17.5	15	2.5	14	24.6	15.0	9.6	11	1.2380	0.1500	1.0880	12	0.0250	0.0100	0.0150	12
1980	1.6	1.5	0.1	26	11.7	15	•	69	23.0	15.0	8.0	47	1.3270	0.1500	1.1770	11	0.0400	0.0100	0.0300	11
1981	•	•	•	0	12.0	15	•	1	•	•	•	0	•	•	•	0	•	•	•	0
1982	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1983	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1984	1.5	1.5	•	3	6.0	15	•	7	23.3	15.0	8.3	6	0.9300	0.1500	0.7800	7	0.0200	0.0100	0.0100	7
1985	2.2	1.5	0.7	6	8.0	15	•	13	26.2	15.0	11.2	13	0.5700	0.1500	0.4200	13	0.0200	0.0100	0.0100	13
1986	1.8	1.5	0.3	13	17.5	15	2.5	14	34.8	15.0	19.8	14	0.4000	0.1500	0.2500	13	0.0200	0.0100	0.0100	13
1987	1.8	1.5	0.3	14	11.5	15	•	14	32.2	15.0	17.2	14	0.7920	0.1500	0.6420	13	0.0160	0.0100	0.0060	14
1988	2.1	1.5	0.6	13	11.5	15	•	14	29.7	15.0	14.7	14	0.6530	0.1500	0.5030	14	0.0070	0.0100	•	14
1989	1.6	1.5	0.1	14	9.5	15	•	14	23.6	15.0	8.6	13	0.8340	0.1500	0.6840	14	0.0090	0.0100	•	14
1990	2.1	1.5	0.6	13	18.0	15	3.0	14	33.4	15.0	18.4	12	0.5710	0.1500	0.4210	14	0.0060	0.0100	•	13
1991	2.1	1.5	0.6	14	13.0	15	•	13	26.1	15.0	11.1	10	0.3440	0.1500	0.1940	12	0.0050	0.0100	•	12

Med = Median Value for Growing Season
Rqmt = Habitat Requirement
Over = Amount the Median Exceeds Requirement
N = Number of Observations

Sources: Chesapeake Bay Program, 1993a, 1993b.

SAV Growing Season Water Quality Medians By Segment (1970 to 1991)

CBP Segment WT6 - Magothy River (Mesohaline)

Year	Kd (m^{-1}) Med	Kd Rqmt	Kd Over	Kd N	TSS (mg/l) Med	TSS Rqmt	TSS Over	TSS N	CHL *a* (µg/l) Med	CHL *a* Rqmt	CHL *a* Over	CHL *a* N	DIN (mg/l) Med	DIN Rqmt	DIN Over	DIN N	DIP (mg/l) Med	DIP Rqmt	DIP Over	DIP N
1970	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1971	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1972	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1973	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1974	•	•	•	0	11.0	15	•	3	21.0	15.0	6.0	3	0.2980	0.1500	0.1480	3	0.0100	0.0100	•	3
1975	•	•	•	0	22.0	15	7.0	3	42.0	15.0	27.0	55	0.1140	0.1500	•	55	0.0400	0.0100	0.0300	55
1976	1.6	1.5	0.1	3	9.0	15	•	4	25.5	15.0	10.5	25	0.4470	0.1500	0.2970	25	0.0200	0.0100	0.0100	25
1977	1.9	1.5	0.4	46	12.0	15	•	65	36.8	15.0	21.8	84	0.1125	0.1500	•	84	0.0300	0.0100	0.0200	82
1978	1.6	1.5	0.1	3	23.0	15	8.0	3	7.5	15.0	•	3	0.5690	0.1500	0.4190	2	0.0400	0.0100	0.0300	3
1979	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1980	2.4	1.5	0.9	2	11.0	15	•	1	84.9	15.0	69.9	1	0.0730	0.1500	•	1	0.0400	0.0100	0.0300	1
1981	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1982	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1983	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1984	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1985	1.5	1.5	•	6	5.0	15	•	6	14.2	15.0	•	6	0.0625	0.1500	•	6	0.0200	0.0100	0.0100	6
1986	1.6	1.5	0.1	7	8.0	15	•	7	17.2	15.0	2.2	7	0.0540	0.1500	•	7	0.0060	0.0100	•	7
1987	1.5	1.5	•	7	5.0	15	•	7	14.8	15.0	•	7	0.0560	0.1500	•	7	0.0040	0.0100	•	7
1988	1.3	1.5	•	7	9.0	15	•	7	16.4	15.0	1.4	7	0.3500	0.1500	0.2000	7	0.0040	0.0100	•	7
1989	1.8	1.5	0.3	7	18.0	15	3.0	7	45.7	15.0	30.7	6	0.1760	0.1500	0.0260	7	0.0040	0.0100	•	7
1990	2.1	1.5	0.6	7	13.0	15	•	7	12.6	15.0	•	7	0.1540	0.1500	0.0040	7	0.0040	0.0100	•	7
1991	2.1	1.5	0.6	7	11.0	15	•	7	16.4	15.0	1.4	5	0.0720	0.1500	•	7	0.0040	0.0100	•	7

Med = Median Value for Growing Season
Rqmt = Habitat Requirement
Over = Amount the Median Exceeds Requirement
N = Number of Observations

Sources: Chesapeake Bay Program, 1993a and 1993b.

SAV Growing Season Water Quality Medians By Segment (1970 to 1991)

CBP Segment WT7 - Severn River (Mesohaline)

Year	Kd (m^{-1})				TSS (mg/l)				CHL *a* (µg/l)				DIN (mg/l)				DIP (mg/l)			
	Med	Rqmt	Over	N	Med	Rqmt	Over	N	Med	Rqmt	Over	N	Med	Rqmt	Over	N	Med	Rqmt	Over	N
1970	•	•	•	0	•	•	•	0	26.5	15.0	11.5	14	•	•	•	0	•	•	•	0
1971	•	•	•	0	•	•	•	0	25.0	15.0	10.0	19	•	•	•	0	•	•	•	0
1972	•	•	•	0	•	•	•	0	46.5	15.0	31.5	4	•	•	•	0	0.0200	0.0100	0.0100	4
1973	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1974	•	•	•	0	21.0	15	6.0	6	33.0	15.0	18.0	5	0.1870	0.1500	0.0370	6	0.0250	0.0100	0.0150	6
1975	•	•	•	0	6.0	15	•	3	16.5	15.0	1.5	3	0.3430	0.1500	0.1930	3	0.0200	0.0100	0.0100	3
1976	•	•	•	0	8.5	15	•	6	20.8	15.0	5.8	6	0.2080	0.1500	0.0580	6	0.0250	0.0100	0.0150	6
1977	1.6	1.5	0.1	8	11.0	15	•	5	31.5	15.0	16.5	16	0.0420	0.1500	•	16	0.0300	0.0100	0.0200	15
1978	•	•	•	0	9.0	15	•	3	10.8	15.0	•	4	0.7990	0.1500	0.6490	3	0.0300	0.0100	0.0200	4
1979	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1980	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1981	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1982	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1983	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1984	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1985	1.6	1.5	0.1	3	9.0	15	•	3	25.4	15.0	10.4	3	0.0500	0.1500	•	3	0.0200	0.0100	0.0100	3
1986	1.6	1.5	0.1	7	7.0	15	•	7	14.7	15.0	•	7	0.0940	0.1500	•	7	0.0100	0.0100	•	7
1987	1.5	1.5	•	7	9.0	15	•	7	26.1	15.0	11.1	6	0.0600	0.1500	•	7	0.0100	0.0100	•	7
1988	1.0	1.5	•	7	6.0	15	•	7	15.1	15.0	0.1	7	0.1300	0.1500	•	7	0.0080	0.0100	•	7
1989	1.5	1.5	•	8	16.5	15	1.5	8	36.0	15.0	21.0	7	0.2380	0.1500	0.0880	8	0.0060	0.0100	•	8
1990	2.1	1.5	0.6	7	17.0	15	2.0	7	25.5	15.0	10.5	6	0.0560	0.1500	•	7	0.0060	0.0100	•	7
1991	1.8	1.5	0.3	7	10.0	15	•	7	14.3	15.0	•	4	0.0640	0.1500	•	7	0.0100	0.0100	•	7

Med = Median Value for Growing Season
Rqmt = Habitat Requirement
Over = Amount the Median Exceeds Requirement
N = Number of Observations

Sources: Chesapeake Bay Program, 1993a, 1993b.

SAV Growing Season Water Quality Medians By Segment (1970 to 1991)

CBP Segment WT8 - South/Rhode/West Rivers (Mesohaline)

	Kd (m^{-1})				TSS (mg/l)				CHL *a* (µg/l)				DIN (mg/l)				DIP (mg/l)			
Year	Med	Rqmt	Over	N	Med	Rqmt	Over	N	Med	Rqmt	Over	N	Med	Rqmt	Over	N	Med	Rqmt	Over	N
1970	1.6	1.5	0.1	1	20.0	15	5.0	1	39.0	15.0	24.0	29	•	•	•	0	0.0400	0.0100	0.0300	1
1971	•	•	•	0	•	•	•	0	36.0	15.0	21.0	35	•	•	•	0	•	•	•	0
1972	•	•	•	0	•	•	•	0	82.8	15.0	67.8	8	•	•	•	0	0.0300	0.0100	0.0200	8
1973	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1974	•	•	•	0	13.5	15	•	8	39.8	15.0	24.8	8	0.0900	0.1500	•	8	0.0400	0.0100	0.0300	8
1975	•	•	•	0	16.0	15	1.0	9	15.0	15.0	•	9	0.1670	0.1500	0.0170	9	0.0400	0.0100	0.0300	9
1976	1.5	1.5	•	5	16.0	15	1.0	14	40.8	15.0	25.8	15	0.1660	0.1500	0.0160	15	0.0300	0.0100	0.0200	14
1977	1.7	1.5	0.2	52	12.0	15	•	11	22.5	15.0	7.5	65	0.0420	0.1500	•	65	0.0683	0.0100	0.0583	64
1978	1.6	1.5	0.1	4	12.0	15	•	11	14.1	15.0	•	11	0.3810	0.1500	0.2310	9	0.0400	0.0100	0.0300	11
1979	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1980	2.3	1.5	0.8	2	12.5	15	•	2	11.9	15.0	•	2	0.0485	0.1500	•	2	0.0300	0.0100	0.0200	2
1981	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1982	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1983	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1984	1.9	1.5	0.4	3	13.0	15	•	3	10.1	15.0	•	3	0.1850	0.1500	0.0350	3	0.0200	0.0100	0.0100	3
1985	1.9	1.5	0.4	18	10.5	15	•	18	15.2	15.0	0.2	18	0.0500	0.1500	•	18	0.0200	0.0100	0.0100	18
1986	2.1	1.5	0.6	21	14.0	15	•	21	16.6	15.0	1.6	20	0.0420	0.1500	•	21	0.0100	0.0100	•	21
1987	1.8	1.5	0.3	20	14.0	15	•	21	17.3	15.0	2.3	20	0.0460	0.1500	•	21	0.0120	0.0100	0.0020	21
1988	2.1	1.5	0.6	21	14.0	15	•	21	26.6	15.0	11.6	21	0.0400	0.1500	•	21	0.0080	0.0100	•	21
1989	2.1	1.5	0.6	24	19.0	15	4.0	24	39.9	15.0	24.9	16	0.0430	0.1500	•	24	0.0070	0.0100	•	24
1990	2.4	1.5	0.9	21	20.0	15	5.0	21	22.7	15.0	7.7	21	0.0520	0.1500	•	21	0.0040	0.0100	•	21
1991	2.1	1.5	0.6	25	18.0	15	3.0	25	20.8	15.0	5.8	20	0.0600	0.1500	•	25	0.0060	0.0100	•	25

Med = Median Value for Growing Season
Rqmt = Habitat Requirement
Over = Amount the Median Exceeds Requirement
N = Number of Observations

Sources: Chesapeake Bay Program, 1993a and 1993b.

SAV Growing Season Water Quality Medians By Segment (1970 to 1991)

CBP Segment TF1 - Upper Patuxent River (Oligohaline)

	Kd (m^{-1})				TSS (mg/l)				CHL *a* (µg/l)				DIN (mg/l)				DIP (mg/l)			
Year	Med	Rqmt	Over	N	Med	Rqmt	Over	N	Med	Rqmt	Over	N	Med	Rqmt	Over	N	Med	Rqmt	Over	N
1970	4.3	2.0	2.3	1	69.8	15	54.8	7	40.1	15.0	25.1	10	37.6875	•	•	11	2.0875	0.0200	2.0675	13
1971	•	•	•	0	43.6	15	28.6	1	•	•	•	0	52.4857	•	•	1	2.2143	0.0200	2.1943	1
1972	•	•	•	0	47.4	15	32.4	2	•	•	•	0	•	•	•	0	0.1995	0.0200	0.1795	2
1973	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1974	•	•	•	0	41.0	15	26.0	26	28.5	15.0	13.5	26	1.1455	•	•	26	0.1950	0.0200	0.1750	26
1975	•	•	•	0	29.0	15	14.0	14	22.8	15.0	7.8	14	1.2070	•	•	14	0.1050	0.0200	0.0850	14
1976	•	•	•	0	17.0	15	2.0	20	5.4	15.0	•	21	2.0200	•	•	21	0.2700	0.0200	0.2500	21
1977	2.9	2.0	0.9	40	32.3	15	17.3	16	27.4	15.0	12.4	36	1.7010	•	•	36	0.2950	0.0200	0.2750	36
1978	3.2	2.0	1.2	105	26.0	15	11.0	241	17.6	15.0	2.6	142	1.6075	•	•	238	0.1200	0.0200	0.1000	240
1979	•	•	•	0	34.0	15	19.0	7	12.0	15.0	•	6	2.2730	•	•	7	0.3000	0.0200	0.2800	7
1980	12.5	2.0	10.5	48	32.5	15	17.5	70	29.2	15.0	14.2	77	1.3245	•	•	62	0.0750	0.0200	0.0550	62
1981	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1982	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1983	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1984	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1985	4.8	2.0	2.8	49	23.0	15	8.0	93	11.7	15.0	•	76	0.9200	•	•	93	0.0500	0.0200	0.0300	91
1986	4.8	2.0	2.8	66	26.0	15	11.0	121	13.0	15.0	•	121	0.9700	•	•	120	0.0520	0.0200	0.0320	122
1987	3.6	2.0	1.6	56	23.5	15	8.5	102	7.2	15.0	•	98	1.0240	•	•	98	0.0500	0.0200	0.0300	93
1988	3.6	2.0	1.6	55	24.0	15	9.0	84	12.6	15.0	•	81	0.7230	•	•	78	0.0370	0.0200	0.0170	84
1989	4.8	2.0	2.8	49	20.0	15	5.0	76	6.1	15.0	•	59	1.0160	•	•	75	0.0370	0.0200	0.0170	76
1990	3.6	2.0	1.6	56	24.9	15	9.9	84	11.6	15.0	•	72	0.8670	•	•	84	0.0314	0.0200	0.0114	82
1991	3.6	2.0	1.6	56	19.4	15	4.4	84	15.7	15.0	0.7	80	0.3975	•	•	84	0.0353	0.0200	0.0153	84

Med = Median Value for Growing Season
Rqmt = Habitat Requirement
Over = Amount the Median Exceeds Requirement
N = Number of Observations

Sources: Chesapeake Bay Program, 1993a, 1993b.

SAV Growing Season Water Quality Medians By Segment (1970 to 1991)

CBP Segment RET1 - Middle Patuxent River (Mesohaline)

Year	Kd (m^{-1}) Med	Rqmt	Over	N	TSS (mg/l) Med	Rqmt	Over	N	CHL *a* (µg/l) Med	Rqmt	Over	N	DIN (mg/l) Med	Rqmt	Over	N	DIP (mg/l) Med	Rqmt	Over	N
1970	2.9	1.5	1.4	1	•	•	•	0	32.3	15.0	17.3	6	•	•	•	0	0.1360	0.0100	0.1260	6
1971	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1972	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	0.0484	0.0100	0.0384	2
1973	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1974	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1975	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1976	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1977	2.3	1.5	0.8	9	•	•	•	0	45.0	15.0	30.0	3	0.0380	0.1500	•	3	0.0500	0.0100	0.0400	3
1978	2.6	1.5	1.1	23	25.0	15	10.0	32	21.3	15.0	6.3	15	0.2200	0.1500	0.0700	31	0.0500	0.0100	0.0400	33
1979	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1980	7.7	1.5	6.2	9	22.5	15	7.5	11	16.6	15.0	1.6	12	0.0527	0.1500	•	7	0.0567	0.0100	0.0467	7
1981	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1982	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1983	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1984	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1985	2.9	1.5	1.4	14	24.0	15	9.0	14	14.0	15.0	•	12	0.0800	0.1500	•	13	0.0450	0.0100	0.0350	14
1986	2.9	1.5	1.4	17	19.0	15	4.0	17	10.5	15.0	•	17	0.1340	0.1500	•	17	0.0820	0.0100	0.0720	17
1987	2.2	1.5	0.7	14	14.0	15	•	14	12.3	15.0	•	14	0.2040	0.1500	0.0540	14	0.0480	0.0100	0.0380	13
1988	2.2	1.5	0.7	14	16.0	15	1.0	14	10.0	15.0	•	14	0.3000	0.1500	0.1500	13	0.0430	0.0100	0.0330	14
1989	2.9	1.5	1.4	13	21.0	15	6.0	13	11.2	15.0	•	13	0.3800	0.1500	0.2300	13	0.0340	0.0100	0.0240	13
1990	2.4	1.5	0.9	14	19.7	15	4.7	14	17.3	15.0	2.3	14	0.1560	0.1500	0.0060	14	0.0436	0.0100	0.0336	14
1991	2.9	1.5	1.4	14	18.7	15	3.7	14	17.0	15.0	2.0	14	0.0692	0.1500	•	14	0.0442	0.0100	0.0342	14

Med = Median Value for Growing Season
Rqmt = Habitat Requirement
Over = Amount the Median Exceeds Requirement
N = Number of Observations

Sources: Chesapeake Bay Program, 1993a and 1993b.

SAV Growing Season Water Quality Medians By Segment (1970 to 1991)

CBP Segment LE1 - Lower Patuxent River (Mesohaline)

Year	Kd (m^{-1}) Med	Kd Rqmt	Kd Over	Kd N	TSS (mg/l) Med	TSS Rqmt	TSS Over	TSS N	CHL *a* (µg/l) Med	CHL *a* Rqmt	CHL *a* Over	CHL *a* N	DIN (mg/l) Med	DIN Rqmt	DIN Over	DIN N	DIP (mg/l) Med	DIP Rqmt	DIP Over	DIP N
1970	•	•	•	0	38.0	15	23.0	6	45.0	15.0	30.0	5	4.2000	0.1500	4.0500	6	0.2270	0.0100	0.2170	11
1971	•	•	•	0	18.0	15	3.0	1	•	•	•	0	1.7000	0.1500	1.5500	1	0.2000	0.0100	0.1900	1
1972	•	•	•	0	17.4	15	2.4	2	•	•	•	0	•	•	•	0	0.0264	0.0100	0.0164	2
1973	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	0.3000	0.0100	0.2900	1
1974	•	•	•	0	10.0	15	•	2	36.0	15.0	21.0	2	0.2805	0.1500	0.1305	2	0.0150	0.0100	0.0050	2
1975	•	•	•	0	24.0	15	9.0	3	11.3	15.0	•	3	0.4150	0.1500	0.2650	3	0.0600	0.0100	0.0500	3
1976	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1977	0.9	1.5	•	3	64.0	15	49.0	1	13.5	15.0	•	1	0.0950	0.1500	•	1	0.0100	0.0100	•	1
1978	1.2	1.5	•	13	18.0	15	3.0	11	13.3	15.0	•	8	0.1580	0.1500	0.0080	11	0.0400	0.0100	0.0300	11
1979	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1980	3.9	1.5	2.4	21	19.3	15	4.3	53	12.5	15.0	•	29	0.0530	0.1500	•	39	0.0147	0.0100	0.0047	40
1981	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1982	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1983	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1984	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1985	1.2	1.5	•	56	9.0	15	•	56	5.2	15.0	•	46	0.1000	0.1500	•	56	0.0100	0.0100	•	56
1986	1.2	1.5	•	67	7.5	15	•	68	9.1	15.0	•	68	0.0920	0.1500	•	68	0.0125	0.0100	0.0025	68
1987	1.0	1.5	•	55	6.0	15	•	56	10.5	15.0	•	56	0.1210	0.1500	•	56	0.0140	0.0100	0.0040	52
1988	1.0	1.5	•	57	10.5	15	•	57	9.9	15.0	•	56	0.1640	0.1500	0.0140	53	0.0120	0.0100	0.0020	57
1989	1.1	1.5	•	52	16.0	15	1.0	52	14.3	15.0	•	50	0.1730	0.1500	0.0230	52	0.0080	0.0100	•	52
1990	1.4	1.5	•	56	9.9	15	•	56	11.7	15.0	•	53	0.0893	0.1500	•	56	0.0056	0.0100	•	56
1991	1.1	1.5	•	56	6.5	15	•	56	7.7	15.0	•	55	0.0918	0.1500	•	56	0.0077	0.0100	•	56

Med = Median Value for Growing Season
Rqmt = Habitat Requirement
Over = Amount the Median Exceeds Requirement
N = Number of Observations

Sources: Chesapeake Bay Program, 1993a, 1993b.

SAV Growing Season Water Quality Medians By Segment (1970 to 1991)

CBP Segment TF2 - Upper Potomac River (Tidal Fresh)

Year	Kd (m^{-1})				TSS (mg/l)				CHL *a* (µg/l)				DIN (mg/l)				DIP (mg/l)			
	Med	Rqmt	Over	N	Med	Rqmt	Over	N	Med	Rqmt	Over	N	Med	Rqmt	Over	N	Med	Rqmt	Over	N
1970	•	•	•	0	•	•	•	0	97.5	15.0	82.5	49	1.1700	•	•	49	•	•	•	0
1971	•	•	•	0	•	•	•	0	100.0	15.0	85.0	12	•	•	•	0	0.2050	0.0200	0.1850	2
1972	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1973	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1974	•	•	•	0	24.0	15	9.0	55	30.0	15.0	15.0	58	0.2885	•	•	58	0.0500	0.0200	0.0300	58
1975	2.4	2.0	0.4	21	18.0	15	3.0	31	23.0	15.0	8.0	49	1.4700	•	•	52	0.0800	0.0200	0.0600	51
1976	2.4	2.0	0.4	33	20.0	15	5.0	23	55.5	15.0	40.5	61	1.0330	•	•	61	0.0600	0.0200	0.0400	61
1977	2.5	2.0	0.5	34	14.0	15	•	53	34.0	15.0	19.0	53	1.0350	•	•	59	0.0400	0.0200	0.0200	59
1978	2.6	2.0	0.6	40	23.0	15	8.0	64	31.9	15.0	16.9	60	0.8770	•	•	55	0.0600	0.0200	0.0400	65
1979	1.1	2.0	•	344	18.0	15	3.0	57	24.5	15.0	9.5	296	1.4255	•	•	240	0.0500	0.0200	0.0300	329
1980	2.4	2.0	0.4	21	14.0	15	•	53	32.7	15.0	17.7	45	1.0900	•	•	53	0.0300	0.0200	0.0100	53
1981	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1982	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1983	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1984	1.9	2.0	•	3	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1985	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1986	2.4	2.0	0.4	53	15.6	15	0.6	53	9.9	15.0	•	53	1.6700	•	•	53	0.0240	0.0200	0.0040	53
1987	2.1	2.0	0.1	56	14.0	15	•	56	7.8	15.0	•	55	1.7700	•	•	56	0.0300	0.0200	0.0100	56
1988	2.1	2.0	0.1	64	17.6	15	2.6	64	7.9	15.0	•	61	1.8440	•	•	55	0.0240	0.0200	0.0040	62
1989	2.4	2.0	0.4	55	13.5	15	•	56	6.9	15.0	•	50	1.9820	•	•	56	0.0320	0.0200	0.0120	56
1990	2.4	2.0	0.4	55	18.0	15	3.0	56	5.4	15.0	•	56	2.0220	•	•	56	0.0300	0.0200	0.0100	51
1991	1.9	2.0	•	56	11.0	15	•	56	8.0	15.0	•	53	2.0380	•	•	52	0.0160	0.0200	•	56

Med = Median Value for Growing Season
Rqmt = Habitat Requirement
Over = Amount the Median Exceeds Requirement
N = Number of Observations

Sources: Chesapeake Bay Program, 1993a and 1993b.

SAV Growing Season Water Quality Medians By Segment (1970 to 1991)

CBP Segment RET2 - Middle Potomac River (Oligohaline)

Year	Kd (m^{-1})				TSS (mg/l)				CHL *a* (µg/l)				DIN (mg/l)				DIP (mg/l)			
	Med	Rqmt	Over	N	Med	Rqmt	Over	N	Med	Rqmt	Over	N	Med	Rqmt	Over	N	Med	Rqmt	Over	N
1970	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	0.3315	0.0200	0.3115	7
1971	•	•	•	0	•	•	•	0	40.0	15.0	25.0	7	0.2215	•	•	7	0.2700	0.0200	0.2500	14
1972	•	•	•	0	•	•	•	0	•	•	•	0	0.7435	•	•	7	0.2200	0.0200	0.2000	7
1973	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1974	•	•	•	0	18.0	15	3.0	54	24.0	15.0	9.0	58	0.3805	•	•	58	0.0500	0.0200	0.0300	58
1975	2.4	2.0	0.4	17	10.0	15	•	17	12.0	15.0	•	34	0.8800	•	•	33	0.0700	0.0200	0.0500	35
1976	2.2	2.0	0.2	32	12.0	15	•	12	10.5	15.0	•	46	0.5075	•	•	46	0.0600	0.0200	0.0400	46
1977	2.8	2.0	0.8	19	23.0	15	8.0	22	33.0	15.0	18.0	23	0.3260	•	•	27	0.0800	0.0200	0.0600	27
1978	2.6	2.0	0.6	28	17.0	15	2.0	30	20.4	15.0	5.4	31	0.6980	•	•	27	0.0900	0.0200	0.0700	31
1979	1.0	2.0	•	124	17.3	15	2.3	34	22.5	15.0	7.5	97	0.8460	•	•	55	0.0494	0.0200	0.0294	114
1980	2.3	2.0	0.3	26	14.0	15	•	68	35.4	15.0	20.4	24	0.4350	•	•	67	0.0420	0.0200	0.0220	68
1981	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1982	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1983	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1984	2.8	2.0	0.8	4	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1985	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1986	2.1	2.0	0.1	56	13.6	15	•	56	4.3	15.0	•	56	0.5830	•	•	56	0.0600	0.0200	0.0400	56
1987	2.1	2.0	0.1	56	12.5	15	•	56	5.1	15.0	•	54	0.8720	•	•	56	0.0485	0.0200	0.0285	56
1988	1.9	2.0	•	60	13.0	15	•	60	4.5	15.0	•	55	0.7120	•	•	60	0.0530	0.0200	0.0330	60
1989	2.4	2.0	0.4	55	14.5	15	•	56	4.5	15.0	•	53	1.5120	•	•	50	0.0500	0.0200	0.0300	56
1990	2.9	2.0	0.9	53	20.0	15	5.0	53	3.4	15.0	•	50	1.3160	•	•	53	0.0480	0.0200	0.0280	50
1991	1.8	2.0	•	42	12.5	15	•	42	6.8	15.0	•	37	0.5210	•	•	38	0.0300	0.0200	0.0100	42

Med = Median Value for Growing Season
Rqmt = Habitat Requirement
Over = Amount the Median Exceeds Requirement
N = Number of Observations

Sources: Chesapeake Bay Program, 1993a, 1993b.

SAV Growing Season Water Quality Medians By Segment (1970 to 1991)

CBP Segment LE2 - Lower Potomac River (Mesohaline)

Year	Kd (m^{-1})				TSS (mg/l)				CHL *a* (µg/l)				DIN (mg/l)				DIP (mg/l)			
	Med	Rqmt	Over	N	Med	Rqmt	Over	N	Med	Rqmt	Over	N	Med	Rqmt	Over	N	Med	Rqmt	Over	N
1970	•	•	•	0	20.0	15	5.0	1	•	•	•	0	3.5000	0.1500	3.3500	1	0.2800	0.0100	0.2700	7
1971	•	•	•	0	•	•	•	0	•	•	•	0	0.4190	0.1500	0.2690	7	0.1800	0.0100	0.1700	7
1972	•	•	•	0	•	•	•	0	•	•	•	0	0.5660	0.1500	0.4160	7	0.1200	0.0100	0.1100	7
1973	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1974	•	•	•	0	16.0	15	1.0	37	16.5	15.0	1.5	37	0.1260	0.1500	•	37	0.0400	0.0100	0.0300	37
1975	•	•	•	0	8.0	15	•	25	15.0	15.0	•	28	0.3660	0.1500	0.2160	25	0.0500	0.0100	0.0400	28
1976	•	•	•	0	6.0	15	•	24	5.3	15.0	•	24	0.1720	0.1500	0.0220	24	0.0400	0.0100	0.0300	24
1977	•	•	•	0	11.0	15	•	27	6.8	15.0	•	28	0.1597	0.1500	0.0097	27	0.0400	0.0100	0.0300	27
1978	•	•	•	0	18.0	15	3.0	16	13.1	15.0	•	16	0.2890	0.1500	0.1390	13	0.0600	0.0100	0.0500	17
1979	1.5	1.5	•	1	24.0	15	9.0	3	17.6	15.0	2.6	71	0.4050	0.1500	0.2550	5	0.0173	0.0100	0.0073	56
1980	0.9	1.5	•	8	5.9	15	•	60	7.0	15.0	•	7	0.0579	0.1500	•	46	0.0130	0.0100	0.0030	47
1981	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1982	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1983	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1984	0.7	1.5	•	8	4.0	15	•	10	9.0	15.0	•	9	0.0690	0.1500	•	11	0.0070	0.0100	•	11
1985	0.9	1.5	•	18	7.0	15	•	25	7.7	15.0	•	24	0.0794	0.1500	•	24	0.0095	0.0100	•	23
1986	0.9	1.5	•	26	5.0	15	•	27	7.6	15.0	•	27	0.0974	0.1500	•	27	0.0060	0.0100	•	27
1987	1.0	1.5	•	27	4.4	15	•	28	13.7	15.0	•	27	0.0670	0.1500	•	28	0.0048	0.0100	•	28
1988	1.0	1.5	•	27	8.0	15	•	26	14.2	15.0	•	26	0.0520	0.1500	•	27	0.0043	0.0100	•	27
1989	1.0	1.5	•	28	6.9	15	•	28	15.0	15.0	•	22	0.1240	0.1500	•	27	0.0060	0.0100	•	28
1990	1.2	1.5	•	27	7.4	15	•	26	10.2	15.0	•	24	0.0870	0.1500	•	27	0.0046	0.0100	•	26
1991	0.9	1.5	•	28	5.7	15	•	28	7.2	15.0	•	25	0.0600	0.1500	•	27	0.0040	0.0100	•	28

Med = Median Value for Growing Season
Rqmt = Habitat Requirement
Over = Amount the Median Exceeds Requirement
N = Number of Observations

Sources: Chesapeake Bay Program, 1993a and 1993b.

SAV Growing Season Water Quality Medians By Segment (1970 to 1991)

CBP Segment TF3 - Upper Rappahannock River (Oligohaline)

Year	Kd (m^{-1})				TSS (mg/l)				CHL *a* (µg/l)				DIN (mg/l)				DIP (mg/l)			
	Med	Rqmt	Over	N	Med	Rqmt	Over	N	Med	Rqmt	Over	N	Med	Rqmt	Over	N	Med	Rqmt	Over	N
1970	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1971	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1972	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1973	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1974	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1975	2.4	2.0	0.4	46	•	•	•	0	4.5	15.0	•	22	0.5615	•	•	74	0.0127	0.0200	•	74
1976	2.9	2.0	0.9	157	•	•	•	0	1.8	15.0	•	82	0.6159	•	•	61	0.0310	0.0200	0.0110	80
1977	2.9	2.0	0.9	155	•	•	•	0	8.0	15.0	•	205	0.4125	•	•	44	0.0273	0.0200	0.0073	69
1978	3.6	2.0	1.6	70	•	•	•	0	3.2	15.0	•	109	0.5529	•	•	51	0.0370	0.0200	0.0170	80
1979	2.4	2.0	0.4	50	•	•	•	0	1.5	15.0	•	50	0.5900	•	•	23	0.0201	0.0200	0.0001	68
1980	3.3	2.0	1.3	2	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1981	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1982	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1983	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1984	2.4	2.0	0.4	9	•	•	•	0	•	•	•	0	0.2900	•	•	12	0.0100	0.0200	•	12
1985	2.4	2.0	0.4	14	•	•	•	0	21.2	15.0	6.2	18	0.1900	•	•	27	0.0100	0.0200	•	27
1986	2.7	2.0	0.7	12	•	•	•	0	11.3	15.0	•	27	0.1100	•	•	27	0.0100	0.0200	•	22
1987	3.6	2.0	1.6	12	•	•	•	0	6.8	15.0	•	24	0.4600	•	•	23	0.0100	0.0200	•	24
1988	2.9	2.0	0.9	35	17.5	15	2.5	32	11.9	15.0	•	33	0.2850	•	•	36	0.0100	0.0200	•	36
1989	3.6	2.0	1.6	46	25.0	15	10.0	47	7.7	15.0	•	49	0.6250	•	•	48	0.0100	0.0200	•	48
1990	3.6	2.0	1.6	44	22.5	15	7.5	46	8.9	15.0	•	45	0.6000	•	•	45	0.0100	0.0200	•	45
1991	2.9	2.0	0.9	49	23.0	15	8.0	50	12.7	15.0	•	40	0.2500	•	•	49	0.0100	0.0200	•	49

Med = Median Value for Growing Season
Rqmt = Habitat Requirement
Over = Amount the Median Exceeds Requirement
N = Number of Observations

Sources: Chesapeake Bay Program, 1993a, 1993b.

SAV Growing Season Water Quality Medians By Segment (1970 to 1991)

CBP Segment RET3 - Middle Rappahannock River (Mesohaline)

Year	Kd (m^{-1})				TSS (mg/l)				CHL *a* (µg/l)				DIN (mg/l)				DIP (mg/l)			
	Med	Rqmt	Over	N	Med	Rqmt	Over	N	Med	Rqmt	Over	N	Med	Rqmt	Over	N	Med	Rqmt	Over	N
1970	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1971	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1972	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1973	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1974	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1975	2.7	1.5	1.2	8	•	•	•	0	4.0	15.0	•	4	0.4870	0.1500	0.3370	13	0.0152	0.0100	0.0052	13
1976	2.9	1.5	1.4	31	•	•	•	0	2.6	15.0	•	17	0.2135	0.1500	0.0635	12	0.0223	0.0100	0.0123	16
1977	2.9	1.5	1.4	23	•	•	•	0	7.2	15.0	•	24	0.5314	0.1500	0.3814	5	0.0174	0.0100	0.0074	22
1978	4.8	1.5	3.3	19	•	•	•	0	6.7	15.0	•	24	0.1414	0.1500	•	14	0.0170	0.0100	0.0070	21
1979	3.6	1.5	2.1	19	•	•	•	0	4.8	15.0	•	8	0.5600	0.1500	0.4100	4	0.0211	0.0100	0.0111	11
1980	2.9	1.5	1.4	4	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1981	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1982	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1983	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1984	2.1	1.5	0.6	12	13.0	15	•	4	•	•	•	0	0.1500	0.1500	•	13	0.0100	0.0100	•	14
1985	2.0	1.5	0.5	28	35.0	15	20.0	8	10.3	15.0	•	18	0.1000	0.1500	•	28	0.0100	0.0100	•	28
1986	2.9	1.5	1.4	26	29.0	15	14.0	6	10.6	15.0	•	28	0.1000	0.1500	•	26	0.0100	0.0100	•	22
1987	2.9	1.5	1.4	26	42.5	15	27.5	2	11.5	15.0	•	26	0.2450	0.1500	0.0950	16	0.0100	0.0100	•	26
1988	2.5	1.5	1.0	26	29.5	15	14.5	20	7.6	15.0	•	25	0.1000	0.1500	•	23	0.0100	0.0100	•	26
1989	3.2	1.5	1.7	25	28.0	15	13.0	28	16.4	15.0	1.4	28	0.1300	0.1500	•	28	0.0100	0.0100	•	28
1990	3.2	1.5	1.7	27	38.0	15	23.0	26	8.3	15.0	•	28	0.1050	0.1500	•	26	0.0100	0.0100	•	26
1991	2.9	1.5	1.4	27	22.5	15	7.5	28	12.0	15.0	•	28	0.1300	0.1500	•	28	0.0100	0.0100	•	28

Med = Median Value for Growing Season
Rqmt = Habitat Requirement
Over = Amount the Median Exceeds Requirement
N = Number of Observations

Sources: Chesapeake Bay Program, 1993a and 1993b.

SAV Growing Season Water Quality Medians By Segment (1970 to 1991)

CBP Segment LE3—Lower Rappahannock River (Mesohaline)

Year	Kd (m^{-1}) Med	Kd Rqmt	Kd Over	Kd N	TSS (mg/l) Med	TSS Rqmt	TSS Over	TSS N	CHL *a* (µg/l) Med	CHL *a* Rqmt	CHL *a* Over	CHL *a* N	DIN (mg/l) Med	DIN Rqmt	DIN Over	DIN N	DIP (mg/l) Med	DIP Rqmt	DIP Over	DIP N
1970	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1971	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1972	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1973	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1974	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1975	0.7	1.5	•	10	•	•	•	0	7.0	15.0	•	5	0.2342	0.1500	0.0842	15	0.0118	0.0100	0.0018	16
1976	1.0	1.5	•	40	•	•	•	0	8.0	15.0	•	21	0.1604	0.1500	0.0104	15	0.0118	0.0100	0.0018	19
1977	1.3	1.5	•	29	•	•	•	0	7.0	15.0	•	31	0.2213	0.1500	0.0713	5	0.0127	0.0100	0.0027	27
1978	1.2	1.5	•	17	•	•	•	0	6.4	15.0	•	20	0.1705	0.1500	0.0205	10	0.0126	0.0100	0.0026	20
1979	1.2	1.5	•	21	•	•	•	0	9.2	15.0	•	4	0.3000	0.1500	0.1500	2	0.0099	0.0100	•	5
1980	1.2	1.5	•	5	29.9	15	14.9	9	•	•	•	0	0.0515	0.1500	•	9	0.0146	0.0100	0.0046	9
1981	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1982	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1983	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1984	1.0	1.5	•	29	5.0	15	•	18	9.8	15.0	•	8	0.1000	0.1500	•	28	0.0100	0.0100	•	33
1985	0.9	1.5	•	65	6.0	15	•	35	7.8	15.0	•	49	0.1000	0.1500	•	70	0.0100	0.0100	•	69
1986	1.0	1.5	•	69	7.5	15	•	32	8.0	15.0	•	68	0.1000	0.1500	•	65	0.0100	0.0100	•	62
1987	1.1	1.5	•	66	7.0	15	•	20	9.6	15.0	•	66	0.1000	0.1500	•	28	0.0100	0.0100	•	66
1988	1.0	1.5	•	65	13.0	15	•	55	7.4	15.0	•	65	0.0800	0.1500	•	49	0.0100	0.0100	•	65
1989	0.9	1.5	•	65	8.0	15	•	69	7.9	15.0	•	69	0.0900	0.1500	•	69	0.0100	0.0100	•	69
1990	1.1	1.5	•	67	21.0	15	6.0	68	7.1	15.0	•	68	0.0800	0.1500	•	68	0.0100	0.0100	•	68
1991	1.0	1.5	•	67	8.0	15	•	69	8.2	15.0	•	69	0.1600	0.1500	0.0100	69	0.0100	0.0100	•	69

Med = Median Value for Growing Season
Rqmt = Habitat Requirement
Over = Amount the Median Exceeds Requirement
N = Number of Observations

Sources: Chesapeake Bay Program, 1993a, 1993b.

SAV Growing Season Water Quality Medians By Segment (1970 to 1991)

CBP Segment TF4 - Upper York River (Oligohaline)

Year	Kd (m^{-1}) Med	Kd Rqmt	Kd Over	Kd N	TSS (mg/l) Med	TSS Rqmt	TSS Over	TSS N	CHL *a* (µg/l) Med	CHL *a* Rqmt	CHL *a* Over	CHL *a* N	DIN (mg/l) Med	DIN Rqmt	DIN Over	DIN N	DIP (mg/l) Med	DIP Rqmt	DIP Over	DIP N
1970	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1971	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1972	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1973	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1974	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1975	2.1	2.0	0.1	22	•	•	•	0	1.9	15.0	•	8	0.1655	•	•	42	0.0130	0.0200	•	39
1976	2.9	2.0	0.9	69	•	•	•	0	33.3	15.0	18.3	16	0.1081	•	•	15	0.0102	0.0200	•	16
1977	2.4	2.0	0.4	106	•	•	•	0	8.7	15.0	•	121	0.1599	•	•	10	0.0099	0.0200	•	80
1978	2.9	2.0	0.9	65	•	•	•	0	7.5	15.0	•	84	0.0859	•	•	32	0.0211	0.0200	0.0011	58
1979	3.6	2.0	1.6	10	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1980	3.6	2.0	1.6	5	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1981	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1982	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1983	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1984	1.8	2.0	•	7	•	•	•	0	•	•	•	0	0.2000	•	•	13	0.0300	0.0200	0.0100	13
1985	1.8	2.0	•	20	•	•	•	0	6.1	15.0	•	18	0.2100	•	•	28	0.0150	0.0200	•	28
1986	1.6	2.0	•	24	•	•	•	0	3.7	15.0	•	28	0.1700	•	•	28	0.0100	0.0200	•	23
1987	1.6	2.0	•	22	•	•	•	0	3.1	15.0	•	22	0.2700	•	•	22	0.0250	0.0200	0.0050	22
1988	1.6	2.0	•	19	9.5	15	•	24	3.6	15.0	•	24	0.2300	•	•	24	0.0200	0.0200	•	24
1989	1.8	2.0	•	26	9.0	15	•	27	3.1	15.0	•	28	0.2700	•	•	27	0.0200	0.0200	•	27
1990	1.8	2.0	•	25	10.0	15	•	28	3.1	15.0	•	28	0.2400	•	•	28	0.0200	0.0200	•	28
1991	1.8	2.0	•	22	12.0	15	•	27	3.4	15.0	•	27	0.1500	•	•	27	0.0200	0.0200	•	27

Med = Median Value for Growing Season
Rqmt = Habitat Requirement
Over = Amount the Median Exceeds Requirement
N = Number of Observations

Sources: Chesapeake Bay Program, 1993a and 1993b.

SAV Growing Season Water Quality Medians By Segment (1970 to 1991)

CBP Segment RET4 - Middle York River (Mesohaline)

Year	Kd (m^{-1}) Med	Kd Rqmt	Kd Over	Kd N	TSS (mg/l) Med	TSS Rqmt	TSS Over	TSS N	CHL *a* (µg/l) Med	CHL Rqmt	CHL Over	CHL N	DIN (mg/l) Med	DIN Rqmt	DIN Over	DIN N	DIP (mg/l) Med	DIP Rqmt	DIP Over	DIP N
1970	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1971	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1972	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1973	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1974	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1975	2.4	1.5	0.9	21	•	•	•	0	5.5	15.0	•	9	0.1923	0.1500	0.0423	31	0.0226	0.0100	0.0126	29
1976	4.8	1.5	3.3	55	•	•	•	0	47.5	15.0	32.5	17	0.1793	0.1500	0.0293	17	0.0174	0.0100	0.0074	17
1977	2.4	1.5	0.9	97	•	•	•	0	9.1	15.0	•	101	0.1599	0.1500	0.0099	7	0.0229	0.0100	0.0129	97
1978	3.6	1.5	2.1	50	•	•	•	0	8.5	15.0	•	63	0.1369	0.1500	•	22	0.0239	0.0100	0.0139	62
1979	3.6	1.5	2.1	40	•	•	•	0	3.4	15.0	•	12	0.1250	0.1500	•	4	0.0291	0.0100	0.0191	13
1980	2.9	1.5	1.4	7	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1981	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1982	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1983	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1984	2.91.5	1.4	18	24.0	15	9.0	7	•	•	•	00.15000.1500		•	210.02000.01000.0100			21			
1985	2.91.5	1.4	39	20.0	15	5.0	13	8.5	15.0	•	270.12000.1500		•	390.01000.0100		•	38			
1986	3.61.5	2.1	40	28.5	15	13.5	14	9.2	15.0	•	42	0.1600	0.1500	0.0100	410.0100		0.0100	•	36	
1987	3.6	1.5	2.1	32	24.5	15	9.5	6	7.0	15.0	•	33	0.2400	0.1500	0.0900	27	0.0200	0.0100	0.0100	33
1988	3.6	1.5	2.1	32	44.0	15	29.0	24	10.4	15.0	•	33	0.1700	0.1500	0.0200	29	0.0200	0.0100	0.0100	33
1989	4.8	1.5	3.3	40	40.0	15	25.0	41	10.0	15.0	•	42	0.2400	0.1500	0.0900	41	0.0200	0.0100	0.0100	41
1990	3.6	1.5	2.1	42	42.0	15	27.0	41	8.1	15.0	•	42	0.2050	0.1500	0.0550	42	0.0200	0.0100	0.0100	42
1991	3.6	1.5	2.1	36	36.0	15	21.0	40	12.4	15.0	•	41	0.1300	0.1500	•	40	0.0300	0.0100	0.0200	40

Med = Median Value for Growing Season
Rqmt = Habitat Requirement
Over = Amount the Median Exceeds Requirement
N = Number of Observations

Sources: Chesapeake Bay Program, 1993a, 1993b.

SAV Growing Season Water Quality Medians By Segment (1970 to 1991)

CBP Segment LE4 - Lower York River (Polyhaline)

Year	Kd (m^{-1}) Med	Kd Rqmt	Kd Over	Kd N	TSS (mg/l) Med	TSS Rqmt	TSS Over	TSS N	CHL *a* (µg/l) Med	CHL *a* Rqmt	CHL *a* Over	CHL *a* N	DIN (mg/l) Med	DIN Rqmt	DIN Over	DIN N	DIP (mg/l) Med	DIP Rqmt	DIP Over	DIP N
1970	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1971	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1972	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1973	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1974	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1975	1.3	1.5	•	6	•	•	•	0	5.0	15.0	•	1	0.2233	0.1500	0.0733	6	0.0299	0.0200	0.0099	6
1976	2.4	1.5	0.9	6	•	•	•	0	5.4	15.0	•	2	0.1812	0.1500	0.0312	2	0.0270	0.0200	0.0070	2
1977	1.8	1.5	0.3	10	•	•	•	0	7.4	15.0	•	10	0.1804	0.1500	0.0304	2	0.0415	0.0200	0.0215	7
1978	3.0	1.5	1.5	4	•	•	•	0	4.6	15.0	•	6	0.2845	0.1500	0.1345	2	0.0459	0.0200	0.0259	5
1979	2.1	1.5	0.6	5	•	•	•	0	8.8	15.0	•	4	0.1599	0.1500	0.0099	2	0.0201	0.0200	0.0001	4
1980	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1981	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1982	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1983	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1984	1.5	1.5	•	15	5.0	15	•	5	•	•	•	0	0.1500	0.1500	•	14	0.0200	0.0200	•	18
1985	1.5	1.5	•	30	7.5	15	•	6	4.2	15.0	•	15	0.1100	0.1500	•	30	0.0100	0.0200	•	30
1986	1.7	1.5	0.2	30	6.0	15	•	6	6.4	15.0	•	30	0.1000	0.1500	•	27	0.0100	0.0200	•	30
1987	1.7	1.5	0.2	27	18.0	15	3.0	3	13.9	15.0	•	27	0.1450	0.1500	•	6	0.0100	0.0200	•	25
1988	1.8	1.5	0.3	31	12.0	15	•	16	7.1	15.0	•	31	0.0800	0.1500	•	29	0.0100	0.0200	•	32
1989	1.6	1.5	0.1	30	11.5	15	•	30	8.5	15.0	•	30	0.1800	0.1500	0.0300	29	0.0100	0.0200	•	29
1990	1.5	1.5	•	29	16.0	15	1.0	30	5.2	15.0	•	30	0.1250	0.1500	•	30	0.0250	0.0200	0.0050	30
1991	1.6	1.5	0.1	33	21.0	15	6.0	33	9.9	15.0	•	33	0.1700	0.1500	0.0200	33	0.0100	0.0200	•	33

Med = Median Value for Growing Season
Rqmt = Habitat Requirement
Over = Amount the Median Exceeds Requirement
N = Number of Observations

Sources: Chesapeake Bay Program, 1993a and 1993b.

SAV Growing Season Water Quality Medians By Segment (1970 to 1991)

CBP Segment WE4 - Mobjack Bay (Polyhaline)

Year	Kd (m^{-1})				TSS (mg/l)				CHL *a* (µg/l)				DIN (mg/l)				DIP (mg/l)			
	Med	Rqmt	Over	N	Med	Rqmt	Over	N	Med	Rqmt	Over	N	Med	Rqmt	Over	N	Med	Rqmt	Over	N
1970	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1971	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1972	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1973	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1974	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1975	1.1	1.5	•	12	•	•	•	0	5.1	15.0	•	4	0.1994	0.1500	0.0494	12	0.0246	0.0200	0.0046	12
1976	1.3	1.5	•	13	•	•	•	0	7.6	15.0	•	4	0.1690	0.1500	0.0190	4	0.0170	0.0200	•	4
1977	1.3	1.5	•	17	•	•	•	0	5.7	15.0	•	20	0.1012	0.1500	•	3	0.0226	0.0200	0.0026	16
1978	1.3	1.5	•	9	•	•	•	0	7.6	15.0	•	10	0.2649	0.1500	0.1149	4	0.0250	0.0200	0.0050	10
1979	1.5	1.5	•	9	•	•	•	0	15.0	15.0	•	7	0.1400	0.1500	•	3	0.0201	0.0200	0.0001	7
1980	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1981	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1982	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1983	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1984	1.2	1.5	•	19	14.2	15	•	20	5.7	15.0	•	20	0.0400	0.1500	•	19	0.0100	0.0200	•	20
1985	0.9	1.5	•	42	10.0	15	•	44	4.2	15.0	•	44	0.0420	0.1500	•	44	0.0100	0.0200	•	44
1986	1.0	1.5	•	40	7.0	15	•	43	4.4	15.0	•	43	0.0610	0.1500	•	43	0.0100	0.0200	•	43
1987	1.1	1.5	•	39	9.0	15	•	44	9.7	15.0	•	44	0.0405	0.1500	•	44	0.0110	0.0200	•	44
1988	1.2	1.5	•	38	16.0	15	1.0	40	6.4	15.0	•	39	0.0314	0.1500	•	40	0.0020	0.0200	•	39
1989	1.0	1.5	•	35	22.0	15	7.0	36	6.7	15.0	•	35	0.0364	0.1500	•	36	0.0030	0.0200	•	36
1990	1.0	1.5	•	31	13.6	15	•	33	6.6	15.0	•	34	0.0138	0.1500	•	34	0.0030	0.0200	•	34
1991	1.2	1.5	•	33	12.0	15	•	36	7.8	15.0	•	36	0.0361	0.1500	•	36	0.0049	0.0200	•	35

Med = Median Value for Growing Season
Rqmt = Habitat Requirement
Over = Amount the Median Exceeds Requirement
N = Number of Observations

Sources: Chesapeake Bay Program, 1993a, 1993b.

SAV Growing Season Water Quality Medians By Segment (1970 to 1991)

CBP Segment TF5 - Upper James River (Tidal Fresh)

	Kd (m^{-1})				TSS (mg/l)				CHL *a* (µg/l)				DIN (mg/l)				DIP (mg/l)			
Year	Med	Rqmt	Over	N	Med	Rqmt	Over	N	Med	Rqmt	Over	N	Med	Rqmt	Over	N	Med	Rqmt	Over	N
1970	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1971	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1972	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1973	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1974	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1975	2.4	2.0	0.4	35	•	•	•	0	5.0	15.0	•	22	0.6686	•	•	16	0.0400	0.0200	0.0200	29
1976	2.9	2.0	0.9	71	•	•	•	0	4.5	15.0	•	39	0.5500	•	•	14	0.1299	0.0200	0.1099	41
1977	2.4	2.0	0.4	105	•	•	•	0	10.0	15.0	•	100	0.7201	•	•	39	0.0744	0.0200	0.0544	18
1978	2.9	2.0	0.9	82	•	•	•	0	7.8	15.0	•	95	0.6242	•	•	56	0.0860	0.0200	0.0660	58
1979	2.4	2.0	0.4	124	•	•	•	0	6.2	15.0	•	126	0.5250	•	•	42	0.0499	0.02	0.0299	129
1980	2.9	2.0	0.9	2	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1981	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1982	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1983	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1984	2.4	2.0	0.4	27	•	•	•	0	•	•	•	0	0.4500	•	•	20	0.0550	0.0200	0.0350	38
1985	2.4	2.0	0.4	48	•	•	•	0	16.8	15.0	1.8	45	0.5500	•	•	64	0.0400	0.0200	0.0200	64
1986	2.4	2.0	0.4	55	•	•	•	0	14.9	15.0	•	70	0.6000	•	•	69	0.0350	0.0200	0.0150	64
1987	2.4	2.0	0.4	49	•	•	•	0	14.0	15.0	•	63	0.4950	•	•	64	0.0300	0.0200	0.0100	64
1988	2.9	2.0	0.9	62	17.0	15	2.0	86	28.8	15.0	13.8	85	0.6100	•	•	82	0.0500	0.0200	0.0300	85
1989	2.4	2.0	0.4	80	18.0	15	3.0	96	5.8	15.0	•	97	0.5250	•	•	96	0.0500	0.0200	0.0300	96
1990	2.4	2.0	0.4	74	20.0	15	5.0	98	9.6	15.0	•	98	0.4750	•	•	98	0.0300	0.0200	0.0100	98
1991	2.1	2.0	0.1	78	18.0	15	3.0	98	10.8	15.0	•	98	0.2350	•	•	98	0.0300	0.0200	0.0100	98

Med = Median Value for Growing Season
Rqmt = Habitat Requirement
Over = Amount the Median Exceeds Requirement
N = Number of Observations

Sources: Chesapeake Bay Program, 1993a and 1993b.

SAV Growing Season Water Quality Medians By Segment (1970 to 1991)

CBP Segment RET5 - Middle James River (Oligohaline)

	Kd (m^{-1})				TSS (mg/l)				CHL *a* (µg/l)				DIN (mg/l)				DIP (mg/l)			
Year	Med	Rqmt	Over	N	Med	Rqmt	Over	N	Med	Rqmt	Over	N	Med	Rqmt	Over	N	Med	Rqmt	Over	N
1970	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1971	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1972	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1973	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1974	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1975	3.6	2.0	1.6	11	•	•	•	0	6.7	15.0	•	6	0.6352	•	•	6	0.0304	0.0200	0.0104	10
1976	3.6	2.0	1.6	35	•	•	•	0	3.6	15.0	•	22	0.7243	•	•	14	0.0301	0.0200	0.0101	23
1977	2.9	2.0	0.9	40	•	•	•	0	4.7	15.0	•	39	0.5562	•	•	15	0.0257	0.0200	0.0057	29
1978	3.6	2.0	1.6	33	•	•	•	0	3.6	15.0	•	35	0.7429	•	•	15	0.0220	0.0200	0.0020	20
1979	3.6	2.0	1.6	43	•	•	•	0	3.5	15.0	•	43	0.8900	•	•	15	0.0290	0.0200	0.0090	44
1980	2.9	2.0	0.9	32	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1981	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1982	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1983	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1984	1.9	2.0	•	13	•	•	•	0	•	•	•	0	0.3000	•	•	8	0.0200	0.0200	•	15
1985	2.1	2.0	0.1	25	•	•	•	0	12.7	15.0	•	18	0.1700	•	•	25	0.0100	0.0200	•	25
1986	2.2	2.0	0.2	26	•	•	•	0	15.3	15.0	0.3	28	0.1750	•	•	28	0.0100	0.0200	•	27
1987	2.7	2.0	0.7	20	•	•	•	0	10.5	15.0	•	26	0.2100	•	•	25	0.0200	0.0200	•	26
1988	2.9	2.0	0.9	23	18.0	15	3.0	21	21.2	15.0	6.2	24	0.1500	•	•	24	0.0100	0.0200	•	23
1989	2.9	2.0	0.9	26	22.0	15	7.0	28	22.2	15.0	7.2	28	0.2900	•	•	27	0.0200	0.0200	•	28
1990	2.4	2.0	0.4	27	20.5	15	5.5	28	13.7	15.0	•	28	0.0900	•	•	28	0.0200	0.0200	•	28
1991	2.4	2.0	0.4	28	20.5	15	5.5	28	17.7	15.0	2.7	28	0.1400	•	•	28	0.0150	0.0200	•	28

Med = Median Value for Growing Season
Rqmt = Habitat Requirement
Over = Amount the Median Exceeds Requirement
N = Number of Observations

Sources: Chesapeake Bay Program, 1993a, 1993b.

SAV Growing Season Water Quality Medians By Segment (1970 to 1991)

CBP Segment LE5 - Lower James River (Mesohaline)

Year	Kd (m^{-1})				TSS (mg/l)				CHL *a* (µg/l)				DIN (mg/l)				DIP (mg/l)			
	Med	Rqmt	Over	N	Med	Rqmt	Over	N	Med	Rqmt	Over	N	Med	Rqmt	Over	N	Med	Rqmt	Over	N
1970	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1971	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1972	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1973	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1974	1.5	1.5	•	13	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1975	2.4	1.5	0.9	5	•	•	•	0	1.8	15.0	•	3	0.5935	0.1500	0.4435	7	0.0341	0.0100	0.0241	7
1976	2.1	1.5	0.6	42	•	•	•	0	4.8	15.0	•	32	0.2611	0.1500	0.1111	28	0.0508	0.0100	0.0408	32
1977	1.6	1.5	0.1	25	•	•	•	0	4.2	15.0	•	25	0.2150	0.1500	0.0650	8	0.0428	0.0100	0.0328	21
1978	2.1	1.5	0.6	14	•	•	•	0	1.9	15.0	•	10	0.4700	0.1500	0.3200	5	0.0346	0.0100	0.0246	10
1979	2.9	1.5	1.4	23	•	•	•	0	2.9	15.0	•	23	0.5600	0.1500	0.4100	6	0.0350	0.0100	0.0250	22
1980	1.5	1.5	•	34	8.7	15	•	9	•	•	•	0	0.0934	0.1500	•	6	0.0231	0.0100	0.0131	9
1981	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1982	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1983	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1984	1.9	1.5	0.4	3	9.0	15	•	1	•	•	•	0	0.2600	0.1500	0.1100	4	0.0500	0.0100	0.0400	4
1985	1.5	1.5	•	56	12.0	15	•	7	5.3	15.0	•	36	0.1800	0.1500	0.0300	56	0.0200	0.0100	0.0100	53
1986	1.8	1.5	0.3	56	23.0	15	8.0	5	4.3	15.0	•	55	0.1500	0.1500	•	52	0.0200	0.0100	0.0100	54
1987	1.8	1.5	0.3	53	12.0	15	•	3	4.8	15.0	•	52	0.3400	0.1500	0.1900	25	0.0200	0.0100	0.0100	50
1988	1.8	1.5	0.3	51	16.0	15	1.0	39	5.9	15.0	•	52	0.2150	0.1500	0.0650	44	0.0350	0.0100	0.0250	52
1989	2.1	1.5	0.6	47	14.0	15	•	52	6.6	15.0	•	52	0.3700	0.1500	0.2200	52	0.0400	0.0100	0.0300	51
1990	1.9	1.5	0.4	56	23.5	15	8.5	56	4.9	15.0	•	56	0.2200	0.1500	0.0700	56	0.0300	0.0100	0.0200	56
1991	1.9	1.5	0.4	54	16.0	15	1.0	55	5.2	15.0	•	53	0.2200	0.1500	0.0700	55	0.0400	0.0100	0.0300	55

Med = Median Value for Growing Season
Rqmt = Habitat Requirement
Over = Amount the Median Exceeds Requirement
N = Number of Observations

Sources: Chesapeake Bay Program, 1993a and 1993b.

SAV Growing Season Water Quality Medians By Segment (1970 to 1991)

CBP Segment ET1 - Northeast River (Oligohaline)

Year	Kd (m^{-1}) Med	Kd Rqmt	Kd Over	Kd N	TSS (mg/l) Med	TSS Rqmt	TSS Over	TSS N	CHL *a* (µg/l) Med	CHL Rqmt	CHL Over	CHL N	DIN (mg/l) Med	DIN Rqmt	DIN Over	DIN N	DIP (mg/l) Med	DIP Rqmt	DIP Over	DIP N
1970	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1971	•	•	•	0	•	•	•	0	76.0	15.0	61.0	23	0.1900	•	•	23	0.0300	0.0200	0.0100	18
1972	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1973	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1974	•	•	•	0	22.0	15	7.0	17	60.0	15.0	45.0	19	0.4740	•	•	19	0.0300	0.0200	0.0100	19
1975	2.5	2.0	0.5	3	26.0	15	11.0	3	52.5	15.0	37.5	19	0.2830	•	•	19	0.0100	0.0200	•	19
1976	3.0	2.0	1.0	4	22.0	15	7.0	3	37.5	15.0	22.5	3	0.4510	•	•	3	0.0300	0.0200	0.0100	3
1977	2.9	2.0	0.9	4	14.0	15	•	4	33.0	15.0	18.0	4	0.3750	•	•	4	0.0300	0.0200	0.0100	4
1978	2.0	2.0	•	3	16.0	15	1.0	2	27.9	15.0	12.9	3	0.6985	•	•	2	0.0400	0.0200	0.0200	3
1979	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1980	3.9	2.0	1.9	1	40.0	15	25.0	1	61.8	15.0	46.8	1	0.1370	•	•	1	0.0100	0.0200	•	1
1981	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1982	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1983	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1984	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1985	4.8	2.0	2.8	1	30.0	15	15.0	1	43.7	15.0	28.7	1	0.3100	•	•	1	0.0100	0.0200	•	1
1986	3.6	2.0	1.6	7	22.0	15	7.0	7	26.7	15.0	11.7	7	0.1280	•	•	7	0.0040	0.0200	•	7
1987	3.6	2.0	1.6	7	22.0	15	7.0	7	34.4	15.0	19.4	7	0.3580	•	•	7	0.0060	0.0200	•	7
1988	2.9	2.0	0.9	7	28.0	15	13.0	7	52.0	15.0	37.0	7	0.1320	•	•	7	0.0040	0.0200	•	6
1989	3.6	2.0	1.6	7	16.0	15	1.0	7	46.4	15.0	31.4	7	0.3620	•	•	7	0.0040	0.0200	•	7
1990	2.9	2.0	0.9	7	22.0	15	7.0	7	31.4	15.0	16.4	7	0.5880	•	•	7	0.0040	0.0200	•	6
1991	3.6	2.0	1.6	7	24.0	15	9.0	7	41.9	15.0	26.9	7	0.0300	•	•	6	0.0040	0.0200	•	7

Med = Median Value for Growing Season
Rqmt = Habitat Requirement
Over = Amount the Median Exceeds Requirement
N = Number of Observations

Sources: Chesapeake Bay Program, 1993a, 1993b.

SAV Growing Season Water Quality Medians By Segment (1970 to 1991)

CBP Segment ET2 - Elk/Bohemia Rivers (Oligohaline)

Year	Kd (m^{-1}) Med	Kd Rqmt	Kd Over	Kd N	TSS (mg/l) Med	TSS Rqmt	TSS Over	TSS N	CHL *a* (µg/l) Med	CHL Rqmt	CHL Over	CHL N	DIN (mg/l) Med	DIN Rqmt	DIN Over	DIN N	DIP (mg/l) Med	DIP Rqmt	DIP Over	DIP N
1970	•	•	•	0	21.0	15	6.0	12	31.6	15.0	16.6	14	•	•	•	0	•	•	•	0
1971	•	•	•	0	40.0	15	25.0	11	57.0	15.0	42.0	63	0.4410	•	•	52	0.0400	0.0200	0.0200	38
1972	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1973	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1974	•	•	•	0	28.0	15	13.0	81	31.5	15.0	16.5	89	0.8750	•	•	89	0.0300	0.0200	0.0100	89
1975	•	•	•	0	28.0	15	13.0	19	25.8	15.0	10.8	30	1.1710	•	•	30	0.0400	0.0200	0.0200	30
1976	4.3	2.0	2.3	19	16.0	15	1.0	29	36.0	15.0	21.0	52	0.6575	•	•	52	0.0400	0.0200	0.0200	52
1977	3.0	2.0	1.0	4	29.0	15	14.0	24	18.8	15.0	3.8	24	0.6560	•	•	25	0.0300	0.0200	0.0100	25
1978	2.6	2.0	0.6	5	30.5	15	15.5	20	17.4	15.0	2.4	23	1.5950	•	•	15	0.0400	0.0200	0.0200	19
1979	2.9	2.0	0.9	4	33.2	15	18.2	8	20.5	15.0	5.5	8	•	•	•	0	•	•	•	0
1980	2.1	2.0	0.1	5	25.6	15	10.6	11	17.0	15.0	2.0	7	2.4950	•	•	3	0.0300	0.0200	0.0100	3
1981	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1982	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1983	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1984	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1985	3.6	2.0	1.6	2	21.5	15	6.5	2	37.6	15.0	22.6	2	0.5200	•	•	2	0.0200	0.0200	•	2
1986	4.8	2.0	2.8	14	36.5	15	21.5	14	20.1	15.0	5.1	14	0.5050	•	•	14	0.0100	0.0200	•	14
1987	3.6	2.0	1.6	14	31.0	15	16.0	14	14.3	15.0	•	14	0.8350	•	•	14	0.0060	0.0200	•	14
1988	2.9	2.0	0.9	14	22.5	15	7.5	14	17.9	15.0	2.9	14	0.6720	•	•	14	0.0060	0.0200	•	11
1989	2.9	2.0	0.9	14	19.5	15	4.5	14	17.0	15.0	2.0	14	1.0040	•	•	14	0.0110	0.0200	•	14
1990	3.9	2.0	1.9	14	33.5	15	18.5	14	8.9	15.0	•	14	0.9710	•	•	14	0.0080	0.0200	•	11
1991	2.5	2.0	0.5	14	22.5	15	7.5	14	12.4	15.0	•	14	0.4270	•	•	14	0.0080	0.0200	•	14

Med = Median Value for Growing Season
Rqmt = Habitat Requirement
Over = Amount the Median Exceeds Requirement
N = Number of Observations

Sources: Chesapeake Bay Program, 1993a and 1993b.

SAV Growing Season Water Quality Medians By Segment (1970 to 1991)

CBP Segment ET3 - Sassafras River (Oligohaline)

Year	Kd (m^{-1})				TSS (mg/l)				CHL *a* (µg/l)				DIN (mg/l)				DIP (mg/l)			
	Med	Rqmt	Over	N	Med	Rqmt	Over	N	Med	Rqmt	Over	N	Med	Rqmt	Over	N	Med	Rqmt	Over	N
1970	•	•	•	0	25.5	15	10.5	16	42.0	15.0	27.0	20	•	•	•	0	•	•	•	0
1971	•	•	•	0	14.0	15	•	16	54.0	15.0	39.0	48	0.0890	•	•	31	0.0300	0.0200	0.0100	24
1972	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1973	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1974	•	•	•	0	21.0	15	6.0	24	45.0	15.0	30.0	26	0.3420	•	•	26	0.0300	0.0200	0.0100	26
1975	•	•	•	0	28.0	15	13.0	11	30.0	15.0	15.0	11	0.7420	•	•	11	0.0600	0.0200	0.0400	11
1976	2.7	2.0	0.7	23	14.0	15	•	9	42.8	15.0	27.8	32	0.0915	•	•	32	0.0400	0.0200	0.0200	32
1977	•	•	•	0	21.0	15	6.0	5	79.5	15.0	64.5	5	0.3890	•	•	5	0.0300	0.0200	0.0100	5
1978	•	•	•	0	28.5	15	13.5	4	69.2	15.0	54.2	4	0.5980	•	•	3	0.0150	0.0200	•	4
1979	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1980	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1981	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1982	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1983	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1984	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1985	3.6	2.0	1.6	1	24.0	15	9.0	1	61.4	15.0	46.4	1	0.1200	•	•	1	0.0100	0.0200	•	1
1986	3.6	2.0	1.6	7	20.0	15	5.0	7	41.1	15.0	26.1	7	0.0360	•	•	6	0.0060	0.0200	•	6
1987	4.8	2.0	2.8	7	27.0	15	12.0	7	62.8	15.0	47.8	7	0.0660	•	•	7	0.0040	0.0200	•	7
1988	4.8	2.0	2.8	7	20.0	15	5.0	7	66.3	15.0	51.3	6	0.0540	•	•	7	0.0040	0.0200	•	7
1989	4.8	2.0	2.8	7	18.0	15	3.0	7	79.7	15.0	64.7	7	0.2200	•	•	7	0.0060	0.0200	•	7
1990	4.8	2.0	2.8	7	20.0	15	5.0	7	73.1	15.0	58.1	6	0.1120	•	•	7	0.0040	0.0200	•	6
1991	4.8	2.0	2.8	7	25.0	15	10.0	7	62.1	15.0	47.1	7	0.1320	•	•	7	0.0040	0.0200	•	7

Med = Median Value for Growing Season
Rqmt = Habitat Requirement
Over = Amount the Median Exceeds Requirement
N = Number of Observations

Sources: Chesapeake Bay Program, 1993a, 1993b.

SAV Growing Season Water Quality Medians By Segment (1970 to 1991)

CBP Segment ET4 - Chester River (Mesohaline)

Year	Kd (m^{-1})				TSS (mg/l)				CHL *a* (µg/l)				DIN (mg/l)				DIP (mg/l)			
	Med	Rqmt	Over	N	Med	Rqmt	Over	N	Med	Rqmt	Over	N	Med	Rqmt	Over	N	Med	Rqmt	Over	N
1970	•	•	•	0	50.0	15	35.0	13	•	•	•	0	•	•	•	0	•	•	•	0
1971	•	•	•	0	54.0	15	39.0	94	•	•	•	0	•	•	•	0	•	•	•	0
1972	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1973	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1974	•	•	•	0	34.0	15	19.0	17	30.0	15.0	15.0	20	0.7140	0.1500	0.5640	20	0.0400	0.0100	0.0300	20
1975	•	•	•	0	34.0	15	19.0	17	8.3	15.0	•	17	0.5340	0.1500	0.3840	17	0.0500	0.0100	0.0400	17
1976	1.6	1.5	0.1	66	14.0	15	•	34	18.0	15.0	3.0	91	0.0920	0.1500	•	91	0.0300	0.0100	0.0200	91
1977	1.4	1.5	•	8	46.0	15	31.0	18	31.5	15.0	16.5	24	0.3163	0.1500	0.1663	24	0.0400	0.0100	0.0300	23
1978	1.3	1.5	•	5	35.0	15	20.0	13	22.5	15.0	7.5	11	0.7265	0.1500	0.5765	10	0.0400	0.0100	0.0300	13
1979	•	•	•	0	73.0	15	58.0	4	50.3	15.0	35.3	4	0.7775	0.1500	0.6275	4	0.0750	0.0100	0.0650	4
1980	1.6	1.5	0.1	96	25.0	15	10.0	87	1.8	15.0	•	89	0.0780	0.1500	•	71	0.0100	0.0100	•	71
1981	1.3	1.5	•	3	33.0	15	18.0	3	5.1	15.0	•	3	0.2930	0.1500	0.1430	3	0.0200	0.0100	0.0100	3
1982	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1983	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1984	0.7	1.5	•	1	9.0	15	•	1	44.9	15.0	29.9	3	0.1160	0.1500	•	1	0.0100	0.0100	•	1
1985	2.1	1.5	0.6	9	42.0	15	27.0	25	31.4	15.0	16.4	25	0.1500	0.1500	•	24	0.0100	0.0100	•	25
1986	2.1	1.5	0.6	27	28.0	15	13.0	28	18.2	15.0	3.2	28	0.0740	0.1500	•	27	0.0120	0.0100	0.0020	26
1987	1.5	1.5	•	26	31.5	15	16.5	28	43.3	15.0	28.3	28	0.2140	0.1500	0.0640	27	0.0080	0.0100	•	27
1988	1.8	1.5	0.3	27	23.5	15	8.5	28	27.4	15.0	12.4	27	0.2800	0.1500	0.1300	27	0.0120	0.0100	0.0020	28
1989	3.9	1.5	2.4	28	13.0	15	•	28	16.3	15.0	1.3	25	0.7580	0.1500	0.6080	27	0.0150	0.0100	0.0050	26
1990	2.7	1.5	1.2	26	26.0	15	11.0	28	25.4	15.0	10.4	27	0.7320	0.1500	0.5820	27	0.0060	0.0100	•	27
1991	2.7	1.5	1.2	26	31.5	15	16.5	28	14.4	15.0	•	27	0.2560	0.1500	0.1060	27	0.0090	0.0100	•	28

Med = Median Value for Growing Season
Rqmt = Habitat Requirement
Over = Amount the Median Exceeds Requirement
N = Number of Observations

Sources: Chesapeake Bay Program, 1993a and 1993b.

SAV Growing Season Water Quality Medians By Segment (1970 to 1991)

CBP Segment EE1 - Eastern Bay (Mesohaline)

Year	Kd (l/m) Med	Kd Rqmt	Kd Over	Kd N	TSS (mg/l) Med	TSS Rqmt	TSS Over	TSS N	CHL a (ug/1) Med	CHL a Rqmt	CHL a Over	CHL a N	DIN (mg/1) Med	DIN Rqmt	DIN Over	DIN N	DIP (mg/1) Med	DIP Rqmt	DIP Over	DIP N
1970	•	•	•	0	•	•	•	0	10.5	15.0	•	16	•	•	•	0	0.1427	0.0100	0.1327	52
1971	•	•	•	0	•	•	•	0	21.0	15.0	6.0	11	•	•	•	0	0.0200	0.0100	0.0100	11
1972	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1973	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1974	•	•	•	0	11.0	15	•	10	13.5	15.0	•	15	0.3030	0.1500	0.1530	15	0.0100	0.0100	•	15
1975	•	•	•	0	23.0	15	8.0	14	6.8	15.0	•	14	0.3390	0.1500	0.1890	14	0.0400	0.0100	0.0300	14
1976	1.4	1.5	•	161	10.0	15	•	14	18.0	15.0	3.0	204	0.0520	0.1500	•	201	0.0300	0.0100	0.0200	204
1977	0.9	1.5	•	11	11.0	15	•	12	12.9	15.0	•	12	0.0815	0.1500	•	12	0.0200	0.0100	0.0100	12
1978	1.0	1.5	•	9	19.0	15	4.0	9	15.6	15.0	0.6	9	0.3960	0.1500	0.2460	6	0.0400	0.0100	0.0300	9
1979	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1980	1.2	1.5	•	3	12.0	15	•	3	9.9	15.0	•	3	0.0410	0.1500	•	3	0.0300	0.0100	0.0200	3
1981	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1982	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1983	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1984	0.6	1.5	•	1	5.5	15	•	2	8.1	15.0	•	2	0.1390	0.1500	•	2	0.0150	0.0100	0.0050	2
1985	1.0	1.5	•	5	7.5	15	•	12	9.0	15.0	•	12	0.0850	0.1500	•	12	0.0100	0.0100	•	11
1986	0.8	1.5	•	14	4.5	15	•	14	5.5	15.0	•	14	0.1200	0.1500	•	13	0.0095	0.0100	•	14
1987	0.7	1.5	•	14	2.0	15	•	14	7.1	15.0	•	14	0.1090	0.1500	•	14	0.0060	0.0100	•	14
1988	0.7	1.5	•	14	5.5	15	•	14	7.7	15.0	•	14	0.0860	0.1500	•	14	0.0040	0.0100	•	14
1989	1.0	1.5	•	14	11.0	15	•	14	10.8	15.0	•	11	0.2690	0.1500	0.1190	14	0.0060	0.0100	•	13
1990	1.0	1.5	•	14	14.5	15	•	14	10.1	15.0	•	14	0.1810	0.1500	0.0310	14	0.0040	0.0100	•	14
1991	1.1	1.5	•	14	16.5	15	1.5	14	9.4	15.0	•	11	0.1010	0.1500	•	14	0.0040	0.0100	•	14

Med = Median Value for Growing Season
Rqmt = Habitat Requirement
Over = Amount the Median Exceeds Requirement
N = Number of Observations

Sources: Chesapeake Bay Program, 1993a, 1993b.

SAV Growing Season Water Quality Medians By Segment (1970 to 1991)

CBP Segment ET5 - Choptank River (Mesohaline)

Year	Kd (l/m) Med	Kd Rqmt	Kd Over	Kd N	TSS (mg/l) Med	TSS Rqmt	TSS Over	TSS N	CHL *a* (ug/1) Med	CHL *a* Rqmt	CHL *a* Over	CHL *a* N	DIN (mg/1) Med	DIN Rqmt	DIN Over	DIN N	DIP (mg/1) Med	DIP Rqmt	DIP Over	DIP N
1970	•	•	•	0	36.5	15	21.5	62	•	•	•	0	•	•	•	0	•	•	•	0
1971	•	•	•	0	26.0	15	11.0	50	•	•	•	0	•	•	•	0	•	•	•	0
1972	•	•	•	0	10.5	15	•	4	32.5	15.0	17.5	4	•	•	•	0	0.0400	0.0100	0.0300	4
1973	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1974	•	•	•	0	20.0	15	5.0	78	30.0	15.0	15.0	78	0.5240	0.1500	0.3740	79	0.0400	0.0100	0.0300	79
1975	•	•	•	0	19.0	15	4.0	24	15.0	15.0	•	24	1.2675	0.1500	1.1175	24	0.0700	0.0100	0.0600	23
1976	2.4	1.5	0.9	105	16.0	15	1.0	48	21.0	15.0	6.0	151	0.0850	0.1500	•	153	0.0400	0.0100	0.0300	153
1977	•	•	•	0	17.3	15	2.3	31	16.5	15.0	1.5	31	0.6450	0.1500	0.4950	31	0.0400	0.0100	0.0300	31
1978	•	•	•	0	12.0	15	•	31	21.5	15.0	6.5	30	1.1300	0.1500	0.9800	28	0.0400	0.0100	0.0300	33
1979	•	•	•	0	9.5	15	•	18	12.0	15.0	•	18	0.9655	0.1500	0.8155	18	0.0600	0.0100	0.0500	17
1980	1.9	1.5	0.4	8	13.9	15	•	37	14.0	15.0	•	30	0.9355	0.1500	0.7855	20	0.0300	0.0100	0.0200	20
1981	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1982	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1983	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1984	1.9	1.5	0.4	5	12.0	15	•	11	25.5	15.0	10.5	9	0.1570	0.1500	0.0070	9	0.0400	0.0100	0.0300	11
1985	2.1	1.5	0.6	11	20.5	15	5.5	24	16.2	15.0	1.2	24	0.1150	0.1500	•	24	0.0200	0.0100	0.0100	24
1986	2.7	1.5	1.2	28	15.8	15	0.8	28	12.0	15.0	•	27	0.1320	0.1500	•	27	0.0260	0.0100	0.0160	27
1987	1.9	1.5	0.4	28	13.0	15	•	28	15.6	15.0	0.6	27	0.1810	0.1500	0.0310	28	0.0250	0.0100	0.0150	28
1988	2.3	1.5	0.8	28	16.0	15	1.0	28	12.8	15.0	•	28	0.2000	0.1500	0.0500	27	0.0210	0.0100	0.0110	28
1989	2.1	1.5	0.6	27	15.3	15	0.3	28	10.6	15.0	•	28	0.6955	0.1500	0.5455	28	0.0260	0.0100	0.0160	27
1990	3.3	1.5	1.8	28	20.5	15	5.5	28	14.0	15.0	•	28	0.4060	0.1500	0.2560	27	0.0140	0.0100	0.0040	25
1991	2.4	1.5	0.9	28	19.0	15	4.0	28	14.6	15.0	•	24	0.1540	0.1500	0.0040	24	0.0100	0.0100	•	23

Med = Median Value for Growing Season
Rqmt = Habitat Requirement
Over = Amount the Median Exceeds Requirement
N = Number of Observations

Sources: Chesapeake Bay Program, 1993a and 1993b.

SAV Growing Season Water Quality Medians By Segment (1970 to 1991)

CBP Segment EE2 - Lower Choptank River (Mesohaline)

Year	Kd (l/m) Med	Kd Rqmt	Kd Over	Kd N	TSS (mg/l) Med	TSS Rqmt	TSS Over	TSS N	CHL *a* (ug/1) Med	CHL *a* Rqmt	CHL *a* Over	CHL *a* N	DIN (mg/1) Med	DIN Rqmt	DIN Over	DIN N	DIP (mg/1) Med	DIP Rqmt	DIP Over	DIP N
1970	•	•	•	0	6.5	15	•	8	•	•	•	0	•	•	•	0	•	•	•	0
1971	•	•	•	0	16.5	15	1.5	8	•	•	•	0	•	•	•	0	•	•	•	0
1972	•	•	•	0	•	•	•	0	33.8	15.0	18.8	2	0.0400	0.1500	•	2	0.0100	0.0100	•	2
1973	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1974	•	•	•	0	16.0	15	1.0	40	22.1	15.0	7.1	40	0.1740	0.1500	0.0240	40	0.0100	0.0100	•	40
1975	1.4	1.5	•	1	20.0	15	5.0	7	10.5	15.0	•	7	0.3240	0.1500	0.1740	7	0.0600	0.0100	0.0500	7
1976	1.2	1.5	•	66	12.5	15	•	2	12.0	15.0	•	74	0.0425	0.1500	•	74	0.0300	0.0100	0.0200	74
1977	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1978	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1979	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1980	1.2	1.5	•	10	8.6	15	•	20	12.0	15.0	•	20	•	•	•	0	•	•	•	0
1981	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1982	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1983	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1984	1.2	1.5	•	4	6.0	15	•	7	8.3	15.0	•	6	0.1600	0.1500	0.0100	5	0.0200	0.0100	0.0100	7
1985	1.0	1.5	•	7	10.0	15	•	12	5.3	15.0	•	12	0.1100	0.1500	•	11	0.0100	0.0100	•	11
1986	0.9	1.5	•	22	8.0	15	•	22	5.3	15.0	•	22	0.1280	0.1500	•	21	0.0100	0.0100	•	21
1987	0.9	1.5	•	26	6.5	15	•	26	9.3	15.0	•	26	0.0560	0.1500	•	25	0.0080	0.0100	•	25
1988	0.9	1.5	•	25	6.0	15	•	25	7.6	15.0	•	24	0.1080	0.1500	•	25	0.0060	0.0100	•	25
1989	1.0	1.5	•	28	12.0	15	•	28	11.0	15.0	•	28	0.2260	0.1500	0.0760	28	0.0080	0.0100	•	26
1990	1.2	1.5	•	28	15.5	15	0.5	28	10.2	15.0	•	28	0.1250	0.1500	•	28	0.0040	0.0100	•	28
1991	1.1	1.5	•	28	11.5	15	•	28	6.9	15.0	•	25	0.1040	0.1500	•	24	0.0040	0.0100	•	26

Med = Median Value for Growing Season
Rqmt = Habitat Requirement
Over = Amount the Median Exceeds Requirement
N = Number of Observations

Sources: Chesapeake Bay Program, 1993a, 1993b.

SAV Growing Season Water Quality Medians By Segment (1970 to 1991)

CBP Segment ET6 - Nanticoke River (Mesohaline)

Year	Kd (l/m) Med	Kd Rqmt	Kd Over	Kd N	TSS (mg/l) Med	TSS Rqmt	TSS Over	TSS N	CHL *a* (ug/1) Med	CHL Rqmt	CHL Over	CHL N	DIN (mg/1) Med	DIN Rqmt	DIN Over	DIN N	DIP (mg/1) Med	DIP Rqmt	DIP Over	DIP N
1970	•	•	•	0	37.0	15	22.0	25	•	•	•	0	0.0850	0.1500	•	21	•	•	•	0
1971	•	•	•	0	38.0	15	23.0	11	•	•	•	0	0.2580	0.1500	0.1080	14	0.0450	0.0100	0.0350	7
1972	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1973	•	•	•	0	8.0	15	•	1	15.0	15.0	•	1	1.4080	0.1500	1.2580	1	0.0400	0.0100	0.0300	1
1974	•	•	•	0	24.0	15	9.0	61	38.6	15.0	23.6	58	0.4790	0.1500	0.3290	61	0.0300	0.0100	0.0200	61
1975	•	•	•	0	28.0	15	13.0	15	18.0	15.0	3.0	15	1.0280	0.1500	0.8780	15	0.0300	0.0100	0.0200	15
1976	2.8	1.5	1.3	50	20.0	15	5.0	18	32.3	15.0	17.3	70	0.0830	0.1500	•	70	0.0300	0.0100	0.0200	62
1977	•	•	•	0	29.3	15	14.3	15	35.8	15.0	20.8	16	0.1897	0.1500	0.0397	15	0.0400	0.0100	0.0300	15
1978	•	•	•	0	22.0	15	7.0	15	20.0	15.0	5.0	15	1.9230	0.1500	1.7730	9	0.0400	0.0100	0.0300	15
1979	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1980	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1981	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1982	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1983	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1984	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1985	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1986	3.3	1.5	1.8	14	23.0	15	8.0	13	16.1	15.0	1.1	13	0.3900	0.1500	0.2400	13	0.0100	0.0100	•	13
1987	2.9	1.5	1.4	14	24.0	15	9.0	14	14.7	15.0	•	13	0.3140	0.1500	0.1640	14	0.0100	0.0100	•	14
1988	3.6	1.5	2.1	14	29.5	15	14.5	14	19.4	15.0	4.4	14	0.3230	0.1500	0.1730	12	0.0080	0.0100	•	12
1989	3.6	1.5	2.1	14	23.5	15	8.5	14	13.2	15.0	•	14	1.9920	0.1500	1.8420	12	0.0180	0.0100	0.0080	13
1990	4.2	1.5	2.7	14	28.5	15	13.5	14	19.7	15.0	4.7	14	0.6090	0.1500	0.4590	12	0.0060	0.0100	•	13
1991	3.6	1.5	2.1	14	28.0	15	13.0	13	16.2	15.0	1.2	12	0.5920	`0.1500	0.4420	12	0.0070	0.0100	•	14

Med = Median Value for Growing Season
Rqmt = Habitat Requirement
Over = Amount the Median Exceeds Requirement
N = Number of Observations

Sources: Chesapeake Bay Program, 1993a and 1993b.

SAV Growing Season Water Quality Medians By Segment (1970 to 1991)

CBP Segment ET7 - Wicomico River (Mesohaline)

Year	Kd (l/m) Med	Kd Rqmt	Kd Over	Kd N	TSS (mg/l) Med	TSS Rqmt	TSS Over	TSS N	CHL *a* (ug/1) Med	CHL *a* Rqmt	CHL *a* Over	CHL *a* N	DIN (mg/1) Med	DIN Rqmt	DIN Over	DIN N	DIP (mg/1) Med	DIP Rqmt	DIP Over	DIP N
1970	•	•	•	0	31.0	15	16.0	40	•	•	•	0	0.9500	0.1500	0.8000	40	•	•	•	0
1971	•	•	•	0	36.0	15	21.0	30	•	•	•	0	0.7500	0.1500	0.6000	40	0.1000	0.0100	0.0900	20
1972	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1973	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1974	•	•	•	0	27.0	15	12.0	74	60.0	15.0	45.0	74	0.8235	0.1500	0.6735	74	0.0600	0.0100	0.0500	74
1975	•	•	•	0	26.0	15	11.0	12	15.0	15.0	•	19	0.9980	0.1500	0.8480	19	0.0400	0.0100	0.0300	19
1976	•	•	•	0	26.0	15	11.0	18	54.0	15.0	39.0	18	0.4000	0.1500	0.2500	18	0.0300	0.0100	0.0200	18
1977	•	•	•	0	24.0	15	9.0	15	52.5	15.0	37.5	15	0.9670	0.1500	0.8170	15	0.0500	0.0100	0.0400	15
1978	•	•	•	0	26.0	15	11.0	15	22.8	15.0	7.8	15	1.5430	0.1500	1.3930	9	0.0600	0.0100	0.0500	15
1979	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1980	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1981	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1982	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1983	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1984	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1985	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1986	2.9	1.5	1.4	7	20.0	15	5.0	7	12.9	15.0	•	7	0.1500	0.1500	•	7	0.0160	0.0100	0.0060	7
1987	2.4	1.5	0.9	7	17.0	15	2.0	7	9.5	15.0	•	6	0.1300	0.1500	•	7	0.0140	0.0100	0.0040	7
1988	2.9	1.5	1.4	7	25.0	15	10.0	7	19.1	15.0	4.1	7	0.1400	0.1500	•	6	0.0140	0.0100	0.0040	6
1989	3.6	1.5	2.1	7	29.0	15	14.0	7	16.7	15.0	1.7	7	0.4860	0.1500	0.3360	7	0.0090	0.0100	•	6
1990	3.6	1.5	2.1	7	38.0	15	23.0	7	17.9	15.0	2.9	7	0.0530	0.1500	•	6	0.0060	0.0100	•	7
1991	2.9	1.5	1.4	7	29.0	15	14.0	7	15.0	15.0	•	7	0.1810	0.1500	0.0310	5	0.0040	0.0100	•	6

Med = Median Value for Growing Season
Rqmt = Habitat Requirement
Over = Amount the Median Exceeds Requirement
N = Number of Observations

Sources: Chesapeake Bay Program, 1993a, 1993b.

SAV Growing Season Water Quality Medians By Segment (1970 to 1991)

CBP Segment ET8 - Manokin River (Mesohaline)

Year	Kd (l/m) Med	Kd Rqmt	Kd Over	Kd N	TSS (mg/l) Med	TSS Rqmt	TSS Over	TSS N	CHL *a* (ug/1) Med	CHL *a* Rqmt	CHL *a* Over	CHL *a* N	DIN (mg/1) Med	DIN Rqmt	DIN Over	DIN N	DIP (mg/1) Med	DIP Rqmt	DIP Over	DIP N
1970	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1971	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1972	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1973	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1974	•	•	•	0	10.0	15	•	1	12.0	15.0	•	1	0.0610	0.1500	•	1	0.0300	0.0100	0.0200	1
1975	•	•	•	0	24.0	15	9.0	3	12.0	15.0	•	3	0.3350	0.1500	0.1850	3	0.0300	0.0100	0.0200	3
1976	2.4	1.5	0.9	3	•	•	•	0	20.1	15.0	5.1	6	0.0320	0.1500	•	6	0.0500	0.0100	0.0400	6
1977	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1978	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1979	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1980	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1981	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1982	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1983	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1984	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1985	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1986	2.4	1.5	0.9	7	16.0	15	1.0	7	12.7	15.0	•	7	0.0420	0.1500	•	7	0.0100	0.0100	•	7
1987	2.1	1.5	0.6	7	18.0	15	3.0	7	11.1	15.0	•	7	0.0520	0.1500	•	7	0.0060	0.0100	•	7
1988	2.9	1.5	1.4	7	21.0	15	6.0	7	12.6	15.0	•	7	0.0390	0.1500	•	6	0.0050	0.0100	•	6
1989	2.1	1.5	0.6	7	30.0	15	15.0	7	13.2	15.0	•	7	0.0360	0.1500	•	7	0.0040	0.0100	•	7
1990	2.9	1.5	1.4	7	34.0	15	19.0	7	14.5	15.0	•	7	0.0560	0.1500	•	6	0.0040	0.0100	•	7
1991	2.1	1.5	0.6	7	22.0	15	7.0	7	10.0	15.0	•	4	0.0640	0.1500	•	6	0.0040	0.0100	•	7

Med = Median Value for Growing Season
Rqmt = Habitat Requirement
Over = Amount the Median Exceeds Requirement
N = Number of Observations

Sources: Chesapeake Bay Program, 1993a and 1993b.

SAV Growing Season Water Quality Medians By Segment (1970 to 1991)

CBP Segment ET9 - Big Annemessex (Mesohaline)

Year	Kd (l/m) Med	Kd Rqmt	Kd Over	Kd N	TSS (mg/l) Med	TSS Rqmt	TSS Over	TSS N	CHL *a* (ug/1) Med	CHL Rqmt	CHL Over	CHL N	DIN (mg/1) Med	DIN Rqmt	DIN Over	DIN N	DIP (mg/1) Med	DIP Rqmt	DIP Over	DIP N
1970	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1971	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1972	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1973	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1974	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1975	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1976	2.3	1.5	0.8	6	•	•	•	0	14.9	15.0	•	8	0.0210	0.1500	•	8	0.0400	0.0100	0.0300	8
1977	•	•	•	0	5.0	15	•	2	31.5	15.0	16.5	2	0.0820	0.1500	•	2	0.0100	0.0100	•	2
1978	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1979	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1980	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1981	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1982	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1983	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1984	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1985	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1986	1.5	1.5	•	7	13.0	15	•	7	6.4	15.0	•	7	0.0400	0.1500	•	7	0.0100	0.0100	•	7
1987	1.3	1.5	•	7	10.0	15	•	7	8.2	15.0	•	7	0.0480	0.1500	•	7	0.0040	0.0100	•	7
1988	1.5	1.5	•	7	17.0	15	2.0	7	11.4	15.0	•	7	0.0360	0.1500	•	6	0.0040	0.0100	•	7
1989	1.5	1.5	•	7	21.0	15	6.0	7	9.6	15.0	•	7	0.0320	0.1500	•	7	0.0060	0.0100	•	7
1990	1.8	1.5	0.3	7	25.0	15	10.0	7	10.2	15.0	•	7	0.0660	0.1500	•	6	0.0040	0.0100	•	7
1991	1.8	1.5	0.3	7	22.0	15	7.0	7	10.9	15.0	•	4	0.0710	0.1500	•	6	0.0040	0.0100	•	7

Med = Median Value for Growing Season
Rqmt = Habitat Requirement
Over = Amount the Median Exceeds Requirement
N = Number of Observations

Sources: Chesapeake Bay Program, 1993a, 1993b.

SAV Growing Season Water Quality Medians By Segment (1970 to 1991)

CBP Segment ET10 – Pocomoke River (Mesohaline)

Year	Kd (l/m) Med	Kd Rqmt	Kd Over	Kd N	TSS (mg/l) Med	TSS Rqmt	TSS Over	TSS N	CHL *a* (ug/1) Med	CHL Rqmt	CHL Over	CHL N	DIN (mg/1) Med	DIN Rqmt	DIN Over	DIN N	DIP (mg/1) Med	DIP Rqmt	DIP Over	DIP N
1970	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1971	•	•	•	0	22.0	15	7.0	59	•	•	•	0	0.8795	0.1500	0.7295	76	•	•	•	0
1972	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1973	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1974	•	•	•	0	16.0	15	1.0	107	28.5	15.0	13.5	107	0.4675	0.1500	0.3175	106	0.0500	0.0100	0.0400	107
1975	•	•	•	0	15.0	15	•	16	15.0	15.0	•	15	0.8500	0.1500	0.7000	16	0.0750	0.0100	0.0650	16
1976	2.9	1.5	1.4	30	18.0	15	3.0	25	21.0	15.0	6.0	64	0.2220	0.1500	0.0720	62	0.0550	0.0100	0.0450	62
1977	•	•	•	0	15.0	15	•	19	18.8	15.0	3.8	20	0.3302	0.1500	0.1802	20	0.0433	0.0100	0.0333	20
1978	•	•	•	0	16.0	15	1.0	14	10.1	15.0	•	18	0.9360	0.1500	0.7860	12	0.1000	0.0100	0.0900	19
1979	•	•	•	0	6.0	15	•	3	5.4	15.0	•	3	1.1240	0.1500	0.9740	3	0.0800	0.0100	0.0700	3
1980	•	•	•	0	10.0	15	•	4	•	•	•	0	0.8360	0.1500	0.6860	3	0.1200	0.0100	0.1100	3
1981	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1982	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1983	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1984	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1985	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1986	2.7	1.5	1.2	6	23.5	15	8.5	7	9.6	15.0	•	7	0.3420	0.1500	0.1920	7	0.0400	0.0100	0.0300	7
1987	3.6	1.5	2.1	7	16.0	15	1.0	7	7.5	15.0	•	7	0.5720	0.1500	0.4220	7	0.0380	0.0100	0.0280	7
1988	2.9	1.5	1.4	7	10.0	15	•	7	9.6	15.0	•	7	0.7010	0.1500	0.5510	6	0.0430	0.0100	0.0330	6
1989	4.8	1.5	3.3	7	12.0	15	•	7	3.0	15.0	•	5	1.0520	0.1500	0.9020	7	0.0740	0.0100	0.0640	7
1990	7.3	1.5	5.8	7	13.0	15	•	7	2.7	15.0	•	7	0.8310	0.1500	0.6810	6	0.0460	0.0100	0.0360	7
1991	3.6	1.5	2.1	7	16.0	15	1.0	7	10.3	15.0	•	6	0.6610	0.1500	0.5110	6	0.0380	0.0100	0.0280	7

Med = Median Value for Growing Season
Rqmt = Habitat Requirement
Over = Amount the Median Exceeds Requirement
N = Number of Observations

Sources: Chesapeake Bay Program, 1993a and 1993b.

SAV Growing Season Water Quality Medians By Segment (1970 to 1991)

CBP Segment EE3 - Tangier Sound (Mesohaline)

Year	Kd (l/m) Med	Kd Rqmt	Kd Over	Kd N	TSS (mg/l) Med	TSS Rqmt	TSS Over	TSS N	CHL *a* (ug/1) Med	CHL *a* Rqmt	CHL *a* Over	CHL *a* N	DIN (mg/1) Med	DIN Rqmt	DIN Over	DIN N	DIP (mg/1) Med	DIP Rqmt	DIP Over	DIP N
1970	•	•	•	0	22.0	15	7.0	5	•	•	•	0	•	•	•	0	•	•	•	0
1971	•	•	•	0	24.0	15	9.0	5	•	•	•	0	0.0210	0.1500	•	5	•	•	•	0
1972	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1973	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1974	•	•	•	0	22.0	15	7.0	51	25.5	15.0	10.5	51	0.1950	0.1500	0.0450	51	0.0200	0.0100	0.0100	51
1975	•	•	•	0	26.0	15	11.0	20	16.3	15.0	1.3	20	0.3435	0.1500	0.1935	20	0.0300	0.0100	0.0200	18
1976	2.2	1.5	0.7	17	29.0	15	14.0	12	16.8	15.0	1.8	35	0.0330	0.1500	•	36	0.0300	0.0100	0.0200	36
1977	•	•	•	0	21.0	15	6.0	11	17.5	15.0	2.5	12	0.0982	0.1500	•	12	0.0300	0.0100	0.0200	12
1978	•	•	•	0	40.0	15	25.0	9	7.5	15.0	•	9	0.3480	0.1500	0.1980	6	0.0500	0.0100	0.0400	10
1979	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1980	•	•	•	0	25.2	15	10.2	16	•	•	•	0	0.0652	0.1500	•	16	0.0157	0.0100	0.0057	16
1981	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1982	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1983	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1984	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1985	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0	•	•	•	0
1986	0.9	1.5	•	12	6.5	15	•	12	4.8	15.0	•	12	0.1290	0.1500	•	12	0.0100	0.0100	•	12
1987	1.1	1.5	•	13	9.0	15	•	13	7.5	15.0	•	13	0.0720	0.1500	•	13	0.0060	0.0100	•	13
1988	1.0	1.5	•	14	11.0	15	•	14	8.7	15.0	•	14	0.0640	0.1500	•	13	0.0060	0.0100	•	14
1989	0.9	1.5	•	14	15.5	15	0.5	14	7.8	15.0	•	12	0.0910	0.1500	•	14	0.0070	0.0100	•	14
1990	1.0	1.5	•	14	20.5	15	5.5	14	6.9	15.0	•	13	0.0890	0.1500	•	14	0.0040	0.0100	•	14
1991	1.2	1.5	•	14	20.5	15	5.5	14	7.8	15.0	•	11	0.1040	0.1500	•	13	0.0040	0.0100	•	14

Med = Median Value for Growing Season
Rqmt = Habitat Requirement
Over = Amount the Median Exceeds Requirement
N = Number of Observations

Sources: Chesapeake Bay Program, 1993a, 1993b.

Table C-1. Chesapeake Bay SAV Distribution and Abundance by State in Hectares

Year	Maryland	Virginia	District of Columbia	Delaware	Baywide
1971	•	4901[1]	•	•	(1)
1974	•	3,302[1]	•	•	(1)
1978	8,367	8,530	0	0	16,897
1979	(2)	(2)	•	•	(2)
1980	23	6,411	•	•	6,434
1981	371	7,682	•	•	8,053
1984	5,488	9,940	5	0	15,433
1985	9,638	10,262	74	0	19,974
1986	8,371	10,969	85	0	19,425
1987	9,417	10,750	67	0	20,234
1989	10,278	13,881	88	0	24,247
1990	9,523	14,774	97	0	24,394
1991	9,343	16,265	119	0	25,727
Tier I Goal	24,211	21,702	112	0	46,025
Tier III Target	130,272	116,799	486	102	247,659

(•) = No aerial survey data available for that year.
(1) = Partial aerial survey of Virginia's Chesapeake Bay shoreline; no baywide average data available.
(2) = Aerial photography acquired in 1979 for sections of Maryland and Virginia with only selected areas (4,955 hectares in Maryland and 71 hectares in Virginia) of the survey photography interpreted and mapped.

Sources: Anderson and Macomber, 1980; Batiuk et al., 1992; Chesapeake Bay Program, unpublished data a, b; Orth et al., 1979, 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Gordon, 1975; Orth and Nowak ,1990.

Table C-2. Maryland SAV Distribution and Abundance in Hectares

Year	Density Not Recorded	Density 1	Density 2	Density 3	Density 4	Total
1971	•	•	•	•	•	•
1974	•	•	•	•	•	•
1978	8,360	•	5	2	•	8,367
1979	(1)	•	•	•	•	(1)
1980	•	•	13	7	2	22
1981	•	10	41	307	12	370
1984	•	2,191	658	1,122	1,517	5,488
1985	•	2,375	1,895	2,869	2,499	9,638
1986	•	2,513	1,444	1,723	2,690	8,370
1987	•	2,593	817	1,541	4,466	9,417
1989	•	2,306	1,803	1,430	4,737	10,276
1990	•	2,220	2,015	2,119	3,169	9,523
1991	•	2,010	1,274	2,273	3,786	9,343

(•) = No aerial survey data available for that year or density category.
(1) = Aerial photography was acquired in 1979 for sections of Maryland with only selected areas (4,955 hectares) of the survey photography were interpreted and mapped.

Sources: Anderson and Macomber, 1980; Chesapeake Bay Program, unpublished data a; Orth et al., 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Nowak, 1990.

Table C-3. Virginia SAV Distribution and Abundance in Hectares

Year	Density Not Recorded	Density 1	Density 2	Density 3	Density 4	Total
1971	4,901[1]	•	•	•	•	4,901
1974	3,302[1]	•	•	•	•	3,302
1978	•	911	2,382	4,227	1,011	8,531
1979	(2)	•	•	•	•	(2)
1980	•	365	1,932	2,631	1,483	6,411
1981	•	155	1,207	3,694	2,626	7,682
1984	•	596	2,199	2,732	4,413	9,940
1985	•	829	2,182	3,619	3,633	10,263
1986	•	1,269	2,131	2,023	5,547	10,970
1987	•	1,045	2,478	2,044	5,182	10,749
1989	•	1,023	2,545	2,299	8,013	13,880
1990	•	1,340	3,585	1,867	7,981	14,773
1991	•	1,189	3,568	2,452	9,056	16,265

(•) = No aerial survey data available for that year or density category.
(1) = Partial aerial survey of Virginia's Chesapeake Bay shoreline; does not include Eastern Shore shoreline.
(2) = Aerial photography was acquired in 1979 for sections of Virginia with only selected areas (71 hectares) of the survey photography interpreted and mapped.

Sources: Chesapeake Bay Program, unpublished data a, b; Orth et al., 1979, 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Gordon, 1975; Orth and Nowak, 1990.

Table C-4. District of Columbia SAV Distribution and Abundance in Hectares

Year	Density Not Recorded	Density 1	Density 2	Density 3	Density 4	Total
1971	•	•	•	•	•	•
1974	•	•	•	•	•	•
1978	•	•	•	•	•	•
1979	•	•	•	•	•	•
1980	•	•	•	•	•	•
1981	•	•	•	•	•	•
1984	•	0	3	0	1	4
1985	•	24	34	13	3	74
1986	•	3	20	16	46	85
1987	•	1	1	0	64	66
1989	•	1	2	0	85	88
1990	•	0	3	3	90	96
1991	•	0	9	5	104	118

(•) = No aerial survey data available for that year or density category.

Sources: Orth et al., 1985, 1986, 1987, 1989, 1991, and 1992; Orth and Nowak, 1990.

Appendix D. Maryland Department of Natural Resources SAV Ground Survey Percent Stations Vegetated Data by Chesapeake Bay Program Segment: 1971 to 1990

YEAR	CB1	CB2	CB3	CB4	CB5	EE1	EE2	EE3	ET1	ET2	ET3	ET4	ET5	ET6	ET7	ET8	ET9	LE1
1971	0	0	0	0	0	0	0	100	0	0	0	0	0	0	0	0	0	0
1972	0	0	0		100	-	-	0	0	0	-	-	-	0	0	0	-	-
1973	0	0	4	0	10	37	17	10	0	0	0	29	6	0	0	0		
1974	17	0	0	2	8	40	22	17	0	0	10	31	18	0	0	27	42	7
1975	13	0	14	0	6	24	2	11	0	0	0	25	0	0	0	9	9	25
1976	10	0	8	0	8	46	42	12	0	0	0	26	11	0	0	9	33	4
1977	13	0	0	0	4	31	28	8	0	0	0	46	6	0	0	27	25	3
1978	3	0	12	0	0	29	29	5	0	0	0	46	6	0	0	0	18	0
1979	7	0	8	2	0	14	24	2	14	0	0	36	6	0	0	0	0	4
1980	0	0	15	0	4	38	21	6	0	0	0	36	17	0	0	0	0	0
1981	3	0	8	0	8	5	2	9	0	0	10	14	0	0	0	9	0	0
1982	17	0	0	0	4	4	7	3	0	0	0	0	0	0	0	9	8	0
1983	7	0	5	0	4	20	5	5	0	0	10	11	0	0	0	0	0	0
1984	0	0	0	0	0	7	2	4	14	0	0	25	0	0	0	9	17	0
1985	4	0	17	0	4	19	18	7	0	0	0	14	0	0	0	18	13	0
1986	17	0	8	0	4	10	5	8	0	0	11	11	0	0	0	18	25	0
1987	13	0	0	0	4	47	7	18	0	0	0	50	0	0	0	100	8	4
1988	7	0	0	0	0	-	45	38	0	0	-	-	0	0	0	-	25	7
1989	-	0	22	0	8	0	18	16	0	0	11	11	0	0	0	18	-	-
1990	-	0	0	0	15	2	12	14	0	0	20	0	0	0	0	20	0	0
1991	6	0	0	0	3	9	4	17	0	0	10	8	0	0	0	13	20	0

YEAR	LE2	WT1	WT2	WT3	WT4	WT5	WT6	WT7	WT8	RET1	RET2	TF1	TF2
1971	0	0	0	0	0	0	0	0	0	0	0	0	0
1972	0	0	0	0	0	0	-	-	0	0	0	0	0
1973	0	0	0	14	0	5	29	33	0	0	0	0	0
1974	0	0	0	14	0	10	29	33	0	0	0	0	0
1975	0	0	0	14	0	-	-	-	0	0	0	0	0
1976	0	0	0	14	0	10	29	50	14	0	0	0	0
1977	0	0	25	29	0	14	43	25	0	0	0	0	0
1978	0	0	0	0	0	14	14	33	0	11	0	0	0
1979	0	0	25	14	0	10	29	25	0	0	0	0	0
1980	0	0	50	29	0	0	29	25	0	0	0	0	0
1981	0	0	25	14	0	10	14	8	0	0	0	0	0
1982	0	0	25	0	0	0	0	0	0	7	0	0	0
1983	0	0	25	57	0	5	0	8	0	0	0	0	0
1984	0	0	0	43	0	0	0	0	0	-	-	0	0
1985	0	0	25	43	0	0	29	0	0	-	-	0	0
1986	-	0	0	20	0	0	0	0	0	-	-	0	0
1987	50	0	0	57	0	0	0	0	0	0	-	0	0
1988	60	0	0	0	0	0	0	0	0	0	100	0	71
1989	-	0	0	0	0	0	-	0	0	-	-	0	-
1990	-	0	0	0	0	0	-	0	0	-	-	0	0
1991	0	-	0	0	0	0	8	0	0	0	17	0	17

Source: Chesapeake Bay Program, unpublished data c.

Table E-1. Quartiles of Average Daily Susquehanna River Flow per Month (1950 to 1991)

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1950	4	3	3	4	2	3	2	3	4	4	4	4
1951	4	4	3	3	1	3	3	2	2	1	2	3
1952	4	3	3	3	4	2	2	2	3	1	2	3
1953	4	3	3	2	4	4	2	2	1	1	1	2
1954	1	3	2	2	4	2	1	1	2	3	2	3
1955	3	2	4	1	1	1	1	4	2	5	4	1
1956	1	3	4	4	3	3	4	4	4	3	3	4
1957	3	2	2	4	2	1	1	1	1	1	1	3
1958	3	1	3	4	4	3	4	3	3	3	2	1
1959	3	2	2	3	2	1	1	1	2	3	4	4
1960	3	3	1	4	4	4	3	2	4	2	1	1
1961	1	4	3	4	3	3	2	3	2	1	1	1
1962	3	1	3	4	1	1	1	1	1	3	3	1
1963	2	1	4	1	2	2	1	1	1	1	1	1
1964	3	1	4	3	3	1	1	1	1	1	1	1
1965	1	2	1	2	1	1	1	1	1	2	1	1
1966	1	3	3	1	3	2	1	1	1	2	1	2
1967	2	1	3	2	4	2	2	4	3	4	3	3
1968	1	2	2	1	3	4	3	1	3	2	3	2
1969	2	1	1	2	2	2	2	4	2	1	3	2
1970	1	4	1	4	2	2	4	3	2	3	4	3
1971	2	4	4	2	3	2	1	3	3	2	2	4
1972	3	2	4	3	4	5	5	3	2	2	4	5
1973	4	4	2	3	3	4	3	3	3	3	3	4
1974	4	3	2	3	2	2	4	3	4	3	2	3
1975	4	4	3	1	3	4	3	2	5	5	3	2
1976	3	5	2	1	2	4	4	4	3	5	3	2
1977	1	1	4	3	1	1	3	3	5	5	4	4
1978	4	2	4	3	4	3	2	4	3	2	2	2
1979	5	2	4	2	2	3	2	3	4	5	4	3
1980	2	1	2	4	2	2	2	2	1	1	1	1
1981	1	5	1	1	2	3	3	2	2	4	3	2
1982	2	3	3	3	1	5	3	2	1	1	1	2
1983	1	2	1	4	4	3	3	2	1	2	2	4
1984	1	2	1	2	3	4	4	4	2	2	2	3
1985	2	2	1	1	1	1	2	2	3	3	4	3
1986	3	4	4	2	1	3	3	4	2	3	4	4
1987	2	1	2	3	1	1	3	1	4	3	2	3
1988	2	3	1	1	3	1	2	2	3	2	3	1
1989	2	1	1	2	5	5	5	3	3	4	3	1
1990	3	4	1	1	3	3	4	4	4	5	4	4
1991	4	3	2	1	1	1	1	1	1	1	1	2

Note: Mean monthly flows were categorized according to the quartiles for that month, with a fifth category for extremely high flows. 1 + first quartile (0-25%), 2 = second (25-50% or median), 3 = third (50-75%), 4 = fourth (75%-category), 5 = exceeded 75% + 1.5 times interquartile range (75th percentile - 25th percentile). Data from Conowingo were used.

Table E-2. Quartiles of Average Daily Potomac River Flow per Month (1950 to 1991).

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1950	2	4	2	1	3	3	3	2	5	4	4	4
1951	3	4	2	3	2	4	3	2	2	1	1	2
1952	4	3	3	4	4	2	3	3	4	2	4	3
1953	4	3	4	3	3	3	2	2	2	1	1	1
1954	1	1	2	1	2	1	1	2	2	4	3	3
1955	3	2	4	2	1	3	2	5	4	3	2	1
1956	1	3	2	3	1	2	4	4	3	3	3	3
1957	2	3	1	3	1	1	1	1	1	2	1	3
1958	3	1	3	4	4	2	4	4	2	1	1	1
1959	1	1	1	2	2	3	1	2	1	3	2	2
1960	3	2	2	4	4	4	2	3	3	2	1	1
1961	1	4	4	4	3	2	2	2	2	3	2	2
1962	2	2	4	3	2	2	2	1	1	1	3	1
1963	2	1	4	1	1	2	1	1	1	1	1	2
1964	4	2	4	3	3	1	1	1	1	2	1	2
1965	3	3	3	3	1	1	1	1	1	1	1	1
1966	1	2	1	1	3	1	1	1	4	4	2	2
1967	2	1	4	1	3	1	3	4	3	3	2	4
1968	3	3	3	1	2	3	2	2	2	1	3	1
1969	1	1	1	1	1	1	1	4	4	2	2	2
1970	3	3	1	4	2	2	4	3	1	2	4	4
1971	4	4	2	1	3	4	2	4	4	5	3	4
1972	2	4	3	3	4	5	5	4	3	4	5	5
1973	3	4	2	4	3	4	3	3	3	3	3	4
1974	4	1	1	3	2	4	3	2	3	2	1	4
1975	3	3	3	2	3	3	4	3	5	5	4	2
1976	4	2	1	2	1	2	2	2	2	5	4	2
1977	1	1	3	3	1	1	1	1	1	2	4	4
1978	4	1	4	2	4	2	4	5	3	1	1	3
1979	5	4	4	3	3	4	3	3	5	5	5	3
1980	4	1	2	4	4	3	3	3	1	1	2	1
1981	1	2	1	2	2	4	3	1	3	2	2	1
1982	2	4	3	2	1	5	4	3	2	2	1	2
1983	1	3	3	4	4	3	2	2	1	3	4	4
1984	2	4	4	4	4	1	4	5	3	3	3	3
1985	1	3	1	1	2	3	2	3	2	3	5	4
1986	1	4	3	2	1	1	1	1	1	1	2	3
1987	2	2	2	4	3	1	3	1	4	3	3	3
1988	3	2	1	1	5	2	1	1	2	1	2	1
1989	2	1	2	1	5	4	5	4	4	4	3	1
1990	3	3	1	2	2	3	4	3	3	5	3	3
1991	5	2	3	2	1	•	•	•	•	•	•	•

Note: Mean monthly flows were categorized according to the quartiles for that month, with a fifth category for extremely high flows. 1 + first quartile (0-25%), 2 = second (25-50% or median), 3 = third (50-75%), 4 = fourth (75%-category), 5 = exceeded 75% + 1.5 times interquartile range (75th percentile - 25th percentile). Data from Little Falls were used.