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Distribution and Abundance of Submerged Aquatic Vegetation in the Chesapeake Bay: A Scientific Summary

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VEGETATION IN THE CHESAPEAKE BAY: A SCIENTIFIC SUMMARY

by

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Special Report No. 259
in Applied Marine Science and Ocean Engineering

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CONTENTS

List of Figures.	111
List of Tables	iv
1. Introduction.	1
2. Methods	4
3. Present Distribution.	5
4. Past Distribution	9
Historical Trends (1700-1930).	9
Recent Past (1930-1980).	10
The Eelgrass Wasting Disease 1931-1932	10
The Milfoil Problem 1959-1965.	11
The Baywide Problem 1960-1980.	12
1965	15
1965-1970.	15
1970-1975.	18
1975-1980.	28
5. The Atlantic Coast.	30
6. Worldwide Patterns.	32
7. Conclusions	34
8. Literature Cited.	38

LIST OF FIGURES

Number		Page
1	Map of the Chesapeake Bay showing the Lower, Middle and Upper zones.	2
2	Location of regions impacted by Eurasian watermilfoil	13
3	Population fluctuations of watermilfoil compared to the dominant native species	14
4	Distribution of SAV in the Chesapeake Bay - 1965.	16
5	Distribution of SAV in the Chesapeake Bay - 1970.	17
6	Distribution of SAV in the Chesapeake Bay - 1975.	19
7	Trend in SAV occurrence in the Maryland portion of the Chesapeake Bay	21
8	Trends in SAV occurrence in six areas in the Middle Bay zone. . .	23
9	Changes in the distribution and abundance of SAV at the Mumfort Island area in the York River.	24
10	Trends in SAV coverage in the Lower zone of the Chesapeake Bay. .	27
11	Distribution of SAV in the Chesapeake Bay - 1980.	29
12	Pattern of recent changes in the distribution of SAV in the Chesapeake Bay	35
13	Location of sections of the Bay where SAV has experienced the greatest decline	36

LIST OF TABLES

<u>Number</u>		<u>Page</u>
1	Species Associations of SAV in the Chesapeake Bay.	3
2	Numbers of Hectares of Bottom Covered with SAV in the Chesapeake Bay, 1978	6
3	Numbers of Hectares of Bottom Covered with SAV in the Lower Bay Zone, 1971-1980.	7
4	Changes in Harvested Scallops, 1928-1975	11
5	Percent of Sampled Stations Containing SAV in the Maryland Section of the Chesapeake Bay.	20

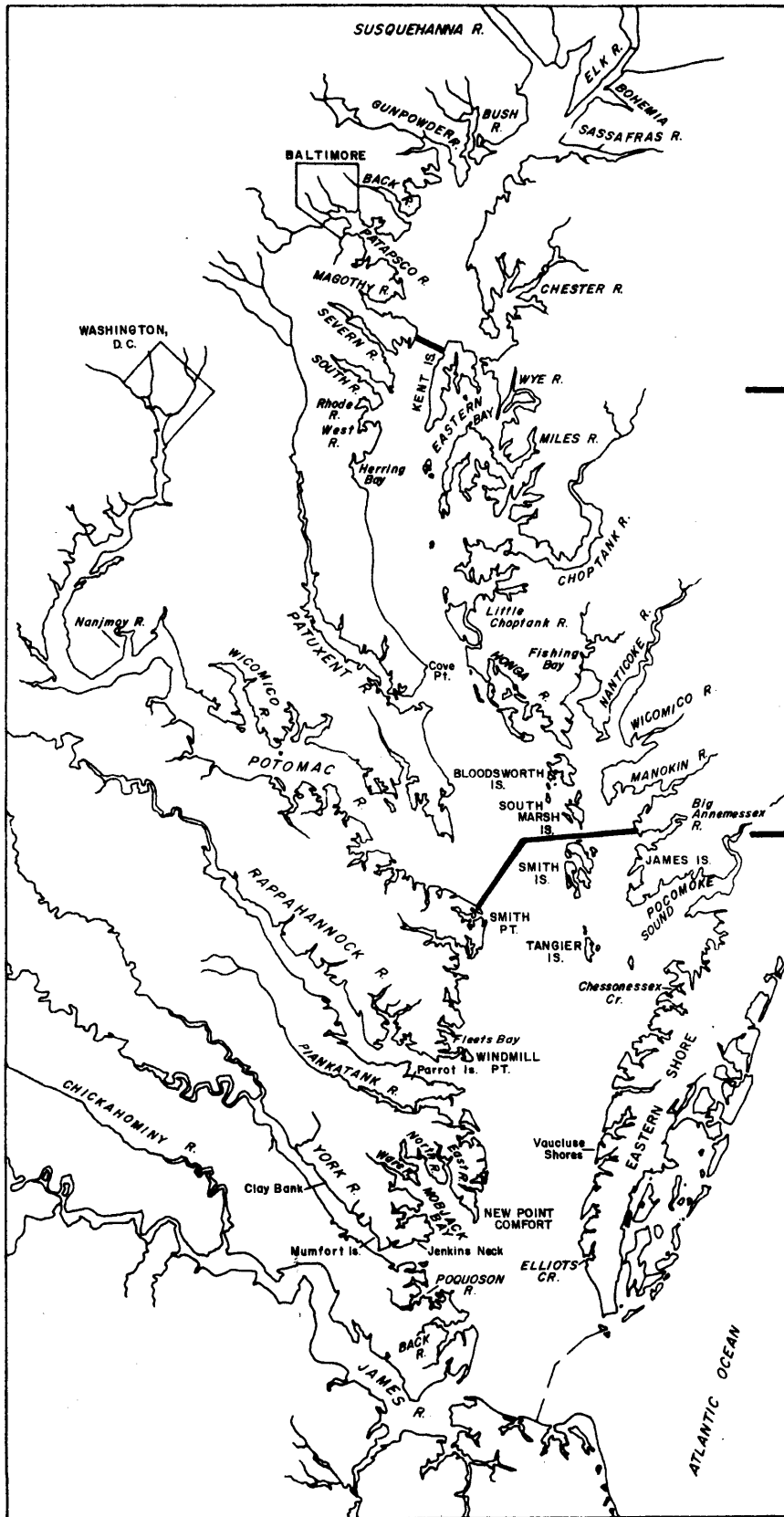
SECTION 1

INTRODUCTION

The Chesapeake Bay, with its extensive littoral zone and broad salinity regime of 0 to 25‰ supports many different species of submerged aquatic vegetation (SAV), (Anderson, 1972; Stevenson and Confer, 1978; Orth, et al., 1979). There are approximately ten species of submerged vascular plants that are abundant within the Bay, with another ten species occurring less frequently. In many areas, more than one species is found in a particular bed of SAV because of the similarity in the physiological tolerances of some of these species. Salinity appears to be the most important factor between regions of the Bay in controlling the species composition of an individual bed of SAV (Stevenson and Confer, 1978), while sediment composition and light regime are important factors in controlling the distribution of SAV within regions of the Bay. All of the species, regardless of the salinity regime, are found in the shallower regions of the Bay's littoral zone and are located in water less than 2 to 3 meters deep (MLW), primarily because of low levels of light occurring below these depths (Wetzel, et al., 1981).

Three associations of SAV can be described in the Chesapeake Bay based on their salinity tolerances as well as their co-occurrence in mixed beds of SAV (Table 1) (Orth, et al., 1979; Stevenson and Confer, 1978). The first association, consisting of Najas guadalupensis (bushy pondweed), Ceratophyllum demersum (coontail), Elodea canadensis (waterweed) and Vallisneria americana (wildcelery), contains species that can tolerate fresh to slightly brackish water and that are found in the upper reaches of the Bay and the tidal freshwater areas of the Bay tributaries. The second association, consisting of Ruppia maritima (widgeon grass), Myriophyllum spicatum (Eurasian watermilfoil), Potamogeton pectinatus (sago pondweed), Potamogeton perfoliatus (redhead grass), Zannichellia palustris (horned pondweed) and Vallisneria americana (wildcelery) is tolerant of slightly higher salinities than the first group. This group is found in the middle reaches of the Bay and its tributaries. The third group, consisting of Zostera marina (eelgrass) and Ruppia maritima (widgeon grass), is tolerant of the highest salinities in the Bay and is found in the lower sections of the Bay and its tributaries.

Since 1978, SAV has been the subject of an intensive research program funded by the U.S. Environmental Protection Agency's Chesapeake Bay Program. SAV was determined to be a high priority area of research in this program because of its high primary productivity and its important role in the Chesapeake Bay ecosystem as a food source for waterfowl, as a habitat and nursery area for many species of commercially important fish and invertebrates, as a shoreline erosion control mechanism and as a nutrient buffer. Most importantly, research was focused on SAV because of the dramatic, baywide decline of all these species in the late 1960's and 1970's.



UPPER

MIDDLE

LOWER

Figure 1. Map of the Chesapeake Bay showing the zonation of the Bay into the Lower, Middle and Upper zones.

TABLE 1. SPECIES ASSOCIATIONS OF SAV IN THE CHESAPEAKE BAY AND ITS TRIBUTARIES
 BASED ON THEIR SALINITY TOLERANCES AS WELL AS THEIR CO-OCCURRENCE
 WITH OTHER SPECIES (COMMON NAME OF EACH SPECIES GIVEN IN PARENTHESIS)

Group 1	Group 2	Group 3
<u>Ceratophyllum demersum</u> (coontail)	<u>Myriophyllum spicatum</u> (Eurasian watermilfoil)	<u>Ruppia maritima</u> (widgeon grass)
<u>Elodea canadensis</u> (common elodea)	<u>Potamogeton pectinatus</u> (sago pondweed)	<u>Zostera marina</u> (eelgrass)
<u>Najas guadalupensis</u> (southern naiad)	<u>Potamogeton perfoliatus</u> (redhead grass)	
<u>Vallisneria americana</u> (wildcelery)	<u>Ruppia maritima</u> (widgeon grass)	
	<u>Vallisneria americana</u> (wildcelery)	
	<u>Zannichellia palustris</u> (horned pondweed)	

One of the main elements of the SAV program was to examine the current distribution and abundance of submerged grasses in the Chesapeake Bay, using aerial photography to map the vegetation. In addition, the historical record of aerial photography was examined for recent evidence (less than 40 years) of alterations in SAV abundance and a biostratigraphic analysis of sediment was performed to detect evidence of longer term (greater than 40 years) alterations in the abundance or species composition of beds of SAV in several locations within the Bay.

SECTION 2

METHODS

The accurate delineation of SAV communities for the purpose of analyzing their distribution and abundance is difficult, especially when the areas of interest may incorporate hundreds of miles of shoreline which are subject to turbid water conditions. These communities are not static but represent dynamic elements whose distribution and abundance can vary in both space and time. Distinct differences in SAV beds can be observed in time frames of less than two months. In order to avoid the problems associated with labor intensive field surveys which provide only a limited view of SAV distribution, remote sensing techniques (aerial photographs) were used to acquire a synoptic view of the existing beds of SAV.

In 1978, the entire shoreline of the Chesapeake Bay and its tributaries, from the Susquehanna Flats to the mouth of the Bay, were flown with light planes equipped with mapping cameras in order to acquire aerial photographs of all existing beds of SAV (see Orth, et al., 1979, and Anderson and Macomber, 1980, for detailed information on methodologies used for this work). Field surveys of selected sites corroborated information observed on the aerial photographs and provided species information.

Data on the past distribution and abundance of SAV in the Bay were acquired from several sources: aerial photographs of the Bay's shoreline and nearshore zone dating back to 1937; reports of field surveys conducted by state and federal laboratories, as well as individual scientists throughout the Bay area; studies on the biostratigraphical analysis of estuarine sediments for seeds and pollen of SAV species (Brush, et al., 1980, 1981); and anecdotal information supplied by watermen, landowners and other interested citizens who had observed changes in the abundance of SAV in numerous areas of the Bay during the last 40 years.

We have organized the discussion of SAV distributions into three zones (Fig. 1). The area between the mouth of the Bay to a line stretching from the mouth of the Potomac River to just above Smith Island will be referred to as the Lower Bay zone; the area between Smith Island and the Chesapeake Bay Bridge at Kent Island will be referred to as the Middle Bay zone; and the area between the Chesapeake Bay Bridge and the Susquehanna Flats will be referred to as the Upper Bay zone. These zones have distinct salinity regimes that will influence the type of SAV community that will grow within each area. The salinity within each zone roughly coincides with the major salinity zones of estuaries: Polyhaline (18-25⁰/oo), Lower zone; Mesohaline (5-18⁰/oo), Middle zone; Oligohaline (0.5-5⁰/oo), Upper zone. Despite the fact that the major rivers (James, York, Rappahannock, Potomac and Patuxent) as well as the smaller tributaries (e.g. Choptank, Chester and Piankatank) of the Bay have their own distinct salinity patterns, the distribution of the grasses in each river will be discussed within the zone where it connects to the Bay proper.

SECTION 3

PRESENT DISTRIBUTION

The results of the 1978 SAV aerial survey and mapping of the entire Bay and its tributaries documented the existence of significant stands of vegetation (Orth, et al., 1979; Anderson and Macomber, 1980). A total of 16,044 hectares (39,629 acres) of bottom was found to be vegetated. Table 2 presents area values for major sections within each zone.

In the Lower Bay zone (Fig. 1) where salinities range from 16-18⁰/oo to 25⁰/oo two species predominated: eelgrass (*Z. marina*) and widgeon grass (*R. maritima*). Horned pondweed (*Z. palustris*) was present but occurred infrequently. In 1978, there were approximately 9400 hectares (23,218 acres) of bottom covered with SAV in this zone. This included 46 hectares of SAV which were found in the Chickahominy River, a fresh to brackish water tributary of James River. These areas ranged from very dense to very sparse in SAV coverage. The largest and most dense grass flats were concentrated in several main regions: (1) along the western shore of the Bay from just north of the James River to the Rappahannock River, especially in the region of the Mobjack Bay; (2) behind protective sandbars along the Bay's Eastern Shore; and (3) the shoal area between Tangier Island and Smith Island. The SAV bed between Tangier and Smith Island was the single, most extensive vegetated area in the entire Bay with a total area coverage of 2394 hectares (5912 acres) or 26% of the total vegetated bottom in the Lower zone and 15% of the total vegetated bottom in the entire Bay.

Aerial photographs taken of the lower Bay in 1980 indicated that the distribution and abundance of SAV in the lower portion of the Bay had decreased by 23% from 1978. This decrease was observed in almost all sections of the lower Bay (Table 3) except for the lower Western Shore where a small increase (9%) occurred. These decreases were observed in many of the smaller beds at upriver sites in some of the smaller tributaries (e.g. Ware, North, East and Severn Rivers in the Mobjack Bay) as well as the offshore deeper sections of several of the larger beds (e.g. off the mouth of the East River in the Mobjack Bay). It was significant to note that in one intensively sampled site in the York River, a general increase in vegetation abundance was observed from 1978 to 1980. Examination of this site revealed that this increase was a result of a large number of seedlings, many with seed coats still evident, that were growing only in the most shallow areas of this location. Subsequent rapid growth and spreading of the seedlings was indicative of the potential importance of seeds to the reestablishment of the vegetation.

TABLE 2. NUMBERS OF HECTARES OF BOTTOM COVERED WITH SUBMERGED AQUATIC VEGETATION IN 1978 FOR DIFFERENT SECTIONS WITHIN THE THREE ZONES IN THE CHESAPEAKE BAY (DATA FROM ORTH, et al. 1979 AND ANDERSON AND MACOMBER, 1980).

Section	Hectares	Zone
1. Susquehanna Flats	110	Upper 2098 hectares
2. Upper Eastern Shore (Elk, Bohemia and Sassafras Rivers)	29	
3. Upper Western Shore (Bush, Gunpowder, Middle, Back and Magothy Rivers and Baltimore Harbor)	484	
4. Chester River	1475	
5. Central Western Shore (Severn, South and West Rivers and Herring Bay)	241	Middle 4546 hectares
6. Eastern Bay (Wye, East and Miles Rivers)	1800	
7. Choptank River (Harris and Broad Creeks, Tred-Avon and Little Choptank Rivers and Trippe Bay)	1740	
8. Patuxent River	3	
9. Middle Western Shore (Herring Bay to mouth of Potomac River)	11	
10. Lower Potomac River Section (Nanjemoy Creek to mouth of Potomac)	541	
11. Middle Eastern Shore (Honga River to Smith Island and includes Fishing Bay, Nanticoke, Wicomico and Manokin Rivers)	210	
12. Tangier Island Complex (includes from Smith Island and Big Annemessex River to Chesconessex Creek)	3759	Lower 9354 hectares
13. Lower Eastern Shore (Chesconessex Creek to Elliots Creek)	1991	
14. Reedville (includes area from Fleets Bay to Great Wicomico River)	364	
15. Rappahannock River (includes Rappahannock and Piankatank Rivers and Milford Haven)	93	
16. New Point Comfort Region	271	
17. Mobjack Bay (includes East, North, Ware and Severn Rivers)	1785	
18. York River (Clay Bank to mouth of York)	157	
19. Lower Western Shore (includes Poquoson and Back Rivers)	925	
20. James River (Hampton Roads area only)	9	

TABLE 3. NUMBERS OF HECTARES OF BOTTOM COVERED WITH SUBMERGED AQUATIC VEGETATION IN 1971, 1974, 1978 AND 1980 FOR DIFFERENT SECTIONS IN THE LOWER BAY ZONE (* INDICATES SECTIONS THAT WERE NOT MAPPED THAT YEAR) (DATA FROM ORTH AND GORDON, 1975; ORTH, et al., 1979; AND UNPUBLISHED DATA)

Section	Year			
	1971	1974	1978	1980
Tangier Island Complex (Includes from Md.-Va. border to Chesconessex Creek)	*	*	2814	2420
Lower Eastern Shore (Chesconessex Creek to Elliots Creek)	*	*	1991	1370
Reedville (Includes area from Windmill Pt. to Smith Pt.)	*	*	364	31
Rappahannock River (Includes Rappahannock and Piankatank Rivers and Milford Haven)	1273	68	93	3
New Point Comfort Region	168	233	271	182
Mobjack Bay (Includes East, North, Ware and Severn Rivers)	1294	1593	1785	1317
York River (Clay Bank to mouth of York)	493	141	157	135
Lower Western Shore (Includes Poquoson and Back Rivers)	1620	1069	925	1008
James River (Hampton Roads area only)	*	7	9	0
TOTAL FOR LOWER BAY ZONE			8409	6466

In the Middle zone of the Bay (Fig. 1), SAV was found to shift from Zostera-Ruppia dominated beds to the lower salinity Potamogeton, Zannichellia, Vallisneria and Myriophyllum beds. This zone contained 4546 hectares (11,229 acres) of bottom covered with SAV in 1978. The greatest concentration of vegetation (77% or 3500 hectares) was located in the Little Choptank River to Eastern Bay area of the eastern shore (Table 2). Only 5% or 227 hectares of the vegetation occurred between the Little Choptank River and Smith Island. An equally small amount (6% or 273 hectares) occurred along the western shore of the Bay from the mouth of the Potomac River to the Chesapeake Bay Bridge and including the South, Severn, Rhode and West Rivers. The Patuxent River had virtually no vegetation with only 3 hectares being observed along the entire length of this river. A small amount (12% or 545 hectares) of the total vegetation in this zone was found in the Potomac River in the vicinity of Nanjemoy Creek, Port Tobacco River, Mathias Point Neck, Mattox and Machodoc Creek, at a distance of 50 to 100 km from the river's mouth. These beds fringe the shoreline on the lower portions of these creeks and the Potomac River proper, and are dominated by P. perfoliatus and V. americana. This was the only vegetation found along the entire length of the Potomac River, except for small pockets of SAV that existed at the heads of several small marsh creeks (Carter and Haramis, 1980; Carter, et al., 1980). In addition, this is the only area of comparable vegetation found

along any of the Bay's major western tributaries (James, York, Rappahannock, Potomac, and Patuxent Rivers). Less intensive surveys in 1979 and 1981 showed only slight decreases from the 1978 distributional patterns to those in 1979 but considerable declines in 1981 were observed throughout the Middle zone of the Bay.

The Upper zone of the Bay (Fig. 1) contained 2098 hectares (5182 acres) of substrate covered with SAV in 1978 (Table 2), with the species association shifting from Group 2 to Group 1 species (Table 1). The Susquehanna Flats had 110 hectares (272 acres) of vegetation in 1978, most of which occurred in scattered beds. This was a very small area when compared to abundance of SAV in the late 1960's and early 1970's. Only two species were present on the Flats in 1978, Eurasian watermilfoil (M. Spicatum) and wildcelery (V. americana), compared with eleven species found by researchers in 1971 (Bayley, et al., 1978). Approximately 23% of the total bottom area covered with SAV in this zone was in the Gunpowder, Middle, Bush and Magothy Rivers located along the western shore, whereas almost no vegetation was present in the Elk, Bohemia and Sassafras Rivers on the eastern shore. About 70% (1469 hectares) of the total bottom area covered with vegetation was present in the Chester River and Eastern Neck area. The Chester River area contained a diverse assemblage of SAV, with seven species recorded during the 1978 survey. Less intensive surveys in 1979 showed little change in the distribution patterns from 1978 but surveys in 1981 indicated considerable declines in this zone.

In summary, the survey of SAV in the Bay in 1978 indicated the presence of many apparently healthy beds in various sections of the Bay. However, there were large sections devoid of almost all vegetation where, in earlier years (1965-1970), luxuriant beds persisted. Tributaries with major reductions of SAV included portions of the York, Rappahannock, Potomac, Patuxent, Choptank, Chester and Piankatank Rivers. SAV populations in other areas along the main stem of the Bay, including the Susquehanna Flats, the area between Smith Point on the Potomac River and Windmill Point on the Rappahannock River and an area between Smith Island and Eastern Bay, which includes many smaller rivers, have also significantly declined. More recent evidence from ground truth surveys and aerial photographs taken from 1978 to 1981 has indicated that this decline has continued in certain areas. This suggests a widespread but complex pattern of recent major decline involving the entire spectrum of SAV communities found in the Bay, from the mouth of the Bay to the Susquehanna Flats at the head of the Bay.

SECTION 4

PAST DISTRIBUTION

A detailed discussion of past trends of SAV distribution and abundance is hindered by the lack of adequate data for many sites over a long period of time. A review of the available historical information indicates that SAV has generally, in the past, been very abundant throughout the Bay. In the last 50 years, however, there have been several distinct periods where SAV in some large portions of the Bay have undergone major fluctuations, although SAV populations have been known to undergo erratic oscillations within small areas (Stevenson and Confer, 1978).

HISTORICAL TRENDS (1700-1930)

The pattern of SAV distribution and abundance in the Bay during this period was determined mostly from indirect evidence, pollen and seed analysis and qualitative observations. Aerial photography, which usually can provide good evidence for the presence of SAV, was not generally available until the late 1930's. If it can be assumed that less urbanization during this period resulted in better water quality throughout the Bay and its tributaries (Heinle, et al., 1980), conditions may have been more favorable for the growth of SAV.

Biostratigraphical analysis of sediments for SAV seeds and pollen from Furnace Bay (Brush, et al., 1980), a small embayment off the Susquehanna Flats, indicated the continuous presence of SAV seeds from the 17th century. However, there appeared to be some changes in species of SAV, e.g., declines of Najas spp., corresponding to changes in land use, such as deforestation. Increased erosion and sedimentation from these practices possibly resulted in more turbid water conditions and, thus, the eventual decline of species less adapted to low light levels.

The Potomac River, the largest estuary in the Bay, historically contained numerous species of SAV which were very abundant. One of the earliest accounts (Seaman, 1875) reported several species (wildcelery, coontail, naiad and elodea) in the vicinity of Washington, D.C. Cumming, et al., (1916) provided a map of the Potomac River below Washington, D.C., which showed the river having a narrow channel and wide shallow margins that he reported to be extensively vegetated with curly pondweed (Potamogeton crispus), wildcelery (V. americana) and coontail (C. demersum). Many other pondweed species were reported from the mouths of tributaries below Washington, D.C. (Hitchcock and Standley, 1919), indicating the widespread presence of SAV species in the tidal portion of the Potomac River.

Eelgrass (*Z. marina*) apparently underwent some decline in the Chesapeake Bay area in the late 19th century although the magnitude of the decline was never quantified. Cottam (1934, 1935) reported that a guide from the Honga River Gunning Club reported on the decline of eelgrass in Dorchester County, Maryland in 1893-94. Cottam also reported an interview with a member of the Maryland Game Commission who commented on the decline of eelgrass in the Chesapeake Bay in 1889 (at the time of the Johnstown Flood) and that it was 25 years before it fully recovered. Cottam also reported on other declines of eelgrass along the East Coast of the U.S., one as early as 1854. From these accounts, it appears that eelgrass had undergone several fluctuations during this period which suggested some irregular, though undefined, perturbations on the system.

In summary then, evidence suggests that in the Bay: (1) SAV was apparently much more widespread during this period than it is today, (2) SAV had been a persistent feature of shallow water habitats during this period, although there may have been some localized shifts in species composition of the beds; and (3) abundance of eelgrass had apparently undergone changes several times.

RECENT PAST (1930-1980)

With an increased awareness of the values of submerged aquatic vegetation due to its importance as a food for waterfowl wintering in the Bay, as well as the observations of major fluctuations in SAV in the Bay and elsewhere, more focus was placed by researchers on the distribution and abundance of SAV during this period. This has led to more quantitative information being available. As a result, a much greater perspective can be obtained for this period. During these last 50 years, there have been two distinct events in which significant changes occurred within individual species of SAV: (1) the eelgrass wasting disease in the 1930's and (2) the watermilfoil (*M. spicatum*) problem in the late 1950's and early 1960's. Even far more dramatic have been the changes in SAV populations in the Bay in the 1960's and 1970's, where, unlike the eelgrass and milfoil events, all species in almost all areas of the Bay have been affected to some degree. The following three sections discuss each of these periods.

The Eelgrass Wasting Disease (1931-1932)

The most documented decline of a species in the Bay was that of eelgrass in the early 1930's. This decline was recorded not only in the Bay area but also along the entire east coast of the U.S. and the west coast of Europe (Cottam 1934, 1935; den Hartog, 1970; Rasmussen, 1977). Indeed, Cottam (1934) commented that, based on information from his surveys of historical records and personal inquiries of fishermen, watermen and scientists, that "in the memory of man there has been no period of scarcity at all comparable to the present one (1931-1932 compared to other past periods)." The extent of the decline in the Chesapeake Bay was never quantified but aerial photographs taken in 1937, five to six years after the height of the decline, were available for almost all of the shoreline

in the lower Bay. A review of many areas in the lower Bay and subsequent mapping of six sites (Orth, et al., 1979) showed areas of bottom in shallow water covered with large amounts of submerged vegetation (it was assumed to be eelgrass based on knowledge of present day patterns and anecdotal information from long-time residents of these areas). All six areas showed subsequent increases in later years up to 1972. Although quantitative information was lacking prior to the wasting disease, we assumed that the vegetation present in 1937 represented partial recovery from the height of the decline in 1931-32. Cottam (1935) confirmed our conclusions from aerial photographs when he reported that the Chesapeake Bay eelgrass was showing "an encouraging change, with a few localized areas fast approaching the normal".

One indication of the magnitude and severity of decline of eelgrass which was experienced not only in the Chesapeake Bay but also along the east coast of the U.S. and the west coast of Europe, was available from the coastal lagoons on Virginia's seaside. These areas contained dense beds of eelgrass which supported a large bay scallop industry. The post-veliger larvae of the scallop require eelgrass as a setting substrate (Gutsell, 1930). Without eelgrass, there could be no scallops because a scallop lives, at the longest, two years, and a change or disappearance of eelgrass would result in rapid shifts of the scallop population. Indeed, this is what happened (Table 4). The commercial fishery that resulted in a harvest of over 14,000 kg/year in the late 1920's and early 1930's completely declined in 1933, over a span of just two years. Eelgrass has never recovered in the seaside bays compared to the Chesapeake Bay and many other areas where it had substantially declined (Cottam and Munro, 1954), nor has the scallop industry ever returned.

TABLE 4. CHANGES IN AMOUNT OF SCALLOPS (SHUCKED MEAT) HARVESTED FROM THE DELMARVA PENINSULA FROM 1928-1975

Year	Harvested scallops (kg shucked meat)
1928	5,050
1929	16,038
1930	25,549
1931	17,170
1932	9,220
1933	0
1934	0
⋮	⋮
1975	0

The Milfoil Problem (1959-1965)

A second major period of extensive SAV fluctuation in the Bay was the large increase in Eurasian watermilfoil (M. spicatum) in the late 1950's

and early 1960's (Bayley, et al., 1978; Stevenson and Confer, 1978). The area affected by the milfoil was restricted to the Upper Bay area and a large section of the Potomac River (Fig. 2). The intolerance of milfoil to high salinity water limited its downward expansion of the Bay, but reasons for its sudden expansion in abundance during this period are not well understood. Until 1955, milfoil was found only sporadically along the Bay, apparently having been introduced from Europe into the United States between 1880 and 1900 (Rawls, 1978). Biostratigraphic evidence substantiated its recent arrival into the Chesapeake Bay (Brush, et al., 1980). Milfoil seeds were found in sections of sediment cores from Furnace Bay near the Susquehanna Flats and dated back only to approximately 1935 even though sediments from the cores had recorded events, including the presence of other SAV species, dating back to 1770.

Milfoil increased baywide from 20,200 hectares (49,000 acres) in 1960 to 40,500 hectares (100,000 acres) in 1961 (Rawls, 1978). In contrast, the 1978 baywide SAV survey found that only 16,000 hectares (39,600 acres) of bottom were covered by all SAV species combined. In creeks along the Potomac River the milfoil reached densities so high that it was considered a nuisance and attempts to eradicate it with applications of 2-4 D were initiated (Rawls, 1978).

The Susquehanna Flats area typified the changes noted during the rapid expansion of milfoil. In 1957, a survey conducted of SAV found that milfoil did not occur at any sampling stations. Subsequently, it was found in 1% of these stations in 1958, 47% in 1959, 82% in 1960 and 89% in 1961 and 1962. After 1962, milfoil declined in the Flats with slight increases in 1966 and 1967. The most serious impact associated with the rapid increase in milfoil was a decline in other native species such as common elodea (*E. canadensis*), naiad (*N. guadalupensis*) and wildcelery (*V. americana*) (Fig. 3). Bayley, et al., (1978) suggested that the decline of native species was due to competitive exclusion by milfoil. As milfoil declined, these native species returned but were found at a lower density and covered less area than prior to the milfoil expansion (Bayley, et al., 1978).

The Baywide Problem (1960-1980)

In the 1960's and 1970's, a number of field surveys, as well as aerial surveys, were conducted to estimate the distribution and abundance of SAV in the Bay. These, when considered with the results of the SAV distribution projects funded by the Bay Program, revealed dramatic results. The combined data showed a pattern of decline of vegetation that included all species in all sections of the Bay and a present abundance of vegetation in the Bay that may be at its lowest level in recorded history.

Because of the importance of SAV for certain species of waterfowl, the impact of this recent decline was first evident in changes in diving duck populations in the Bay (Perry, et al., in press). Two species, in particular, the canvas-back (*Aythya valisineria*) and the redhead (*Aythya americana*), have shown significant population declines in the last 10 years in the Bay despite increases in the overall North American and Atlantic flyway populations. These two duck species have traditionally used SAV as food (Stewart, 1962). The decline in their

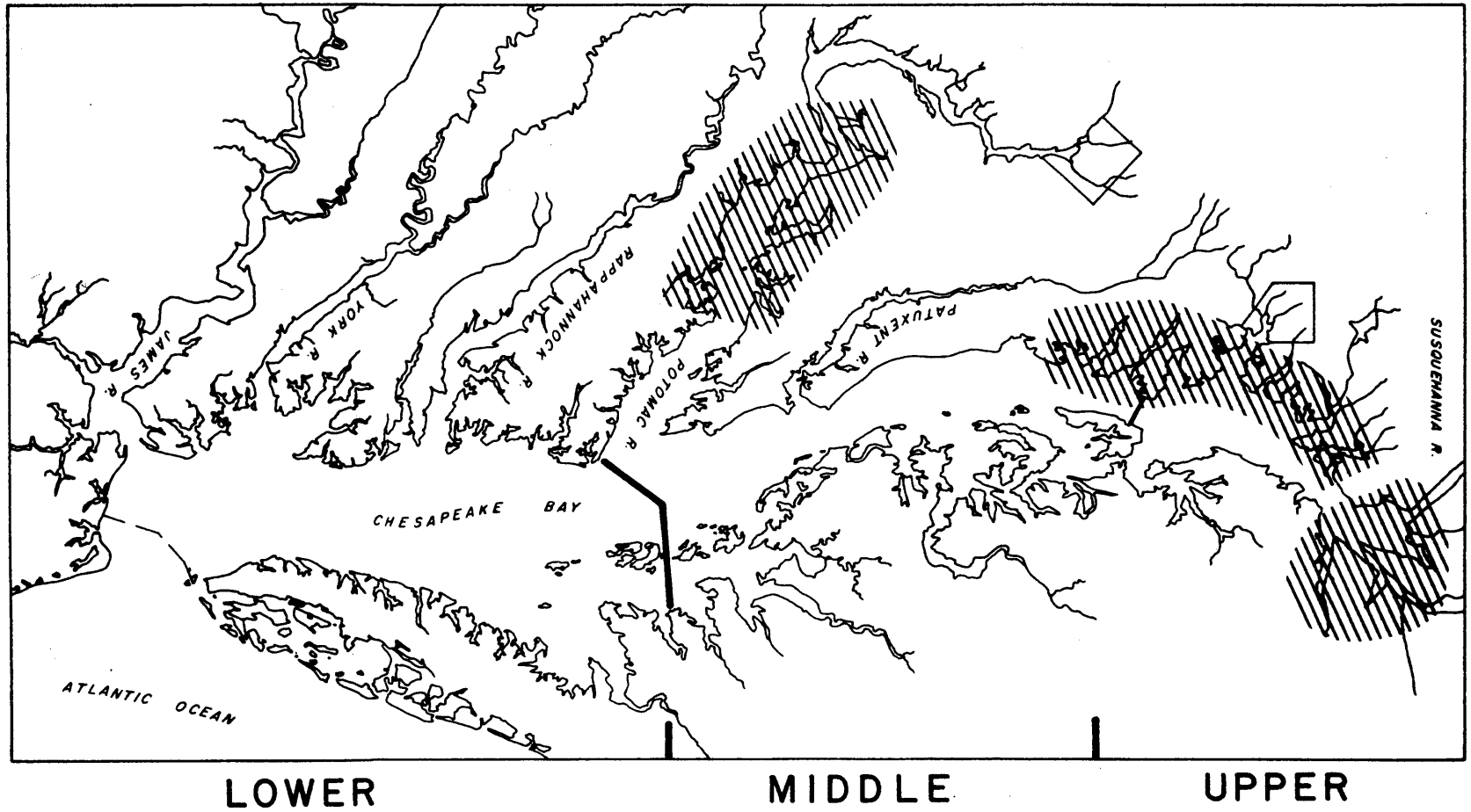


Figure 2. Location of regions (cross-hatching) in the Bay area which were considered to be severely impacted by the growth of Eurasian watermilfoil from 1959-1963.

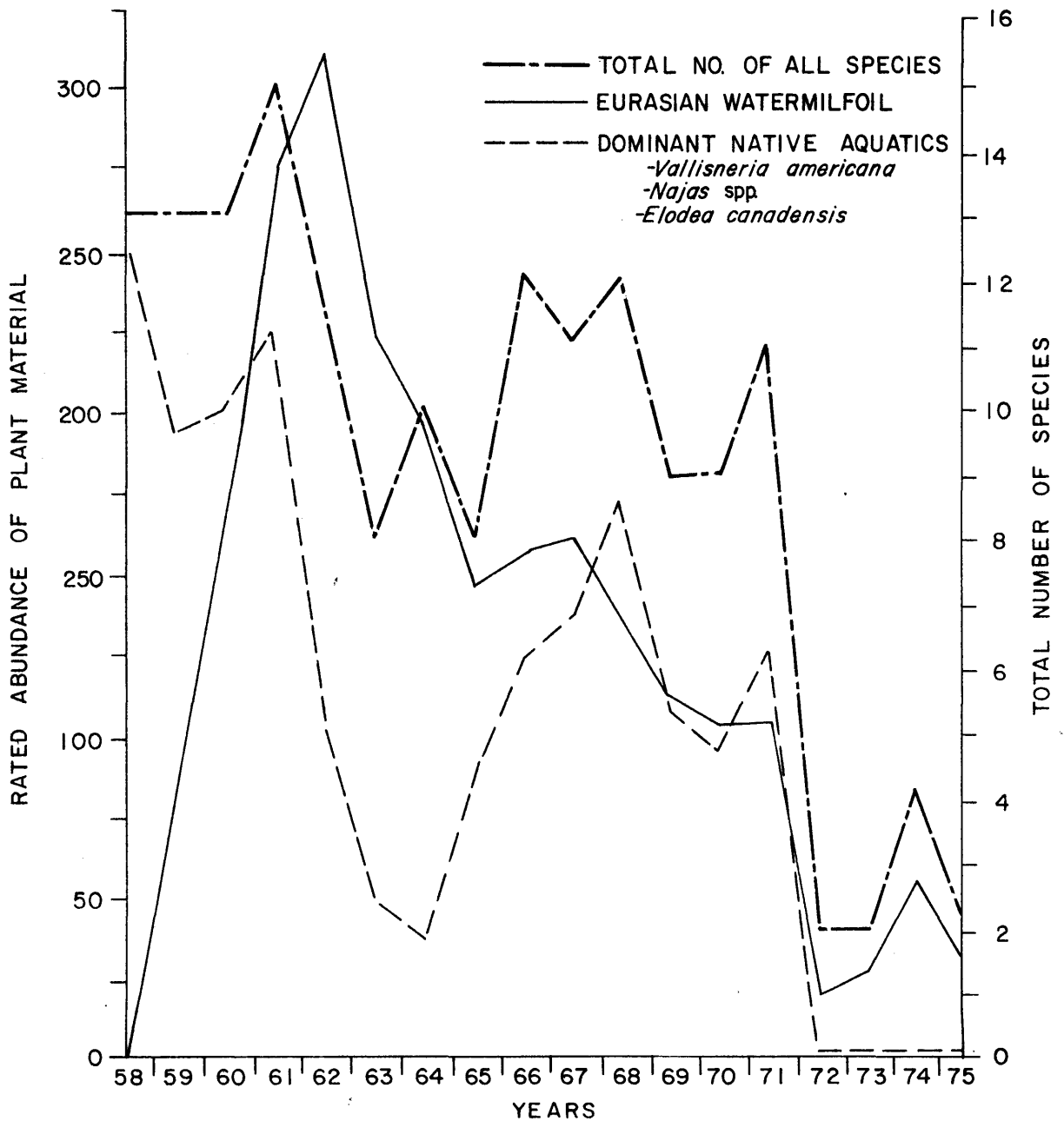


Figure 3. Population fluctuations of watermilfoil compared to the dominant native species and total number of species found on the Susquehanna Flats from 1958-1975 (figure adapted from Bayley, et al., 1978).

preferred food source presumably has led to the decline in the total numbers found in the Bay. Since the SAV decline, canvasbacks have altered their feeding habits to clams whereas the redheads still feed predominantly on vegetation.

To illustrate the major changes that have occurred with SAV in the Bay area in the last 20 years, we have delineated SAV distribution on a baywide basis at 5 year intervals beginning in 1965 and subsequently in 1970, 1975 and 1980 (Figs. 4, 5, 6 and 11). The year 1965 was chosen as a starting point because of (1) lack of complete information for baywide determination prior to 1965, (2) the compounding problem of the explosion in the late 1950's of the Eurasian watermilfoil, which had markedly declined by 1965, and (3) the relatively abundant baywide distribution of SAV during this time that was apparent from archival photographs as well as anecdotal information. Though the scale of the map is small in relation to the generally small size of most SAV areas, the changes that occurred in SAV distribution in each of the 5 year intervals were sufficiently dramatic so as to appear quite distinct in the respective figures. We are aware that the small scale is not suitable for small populations of SAV related to the size of the entire Bay but the overall changes in SAV on a baywide basis are more easily perceived on this size map. Though in some respects the following maps are qualitative, they represented the culmination of a large effort to incorporate whatever quantitative data was available with the most reliable qualitative data. These maps are the first effort to place into perspective the complex changes that have been observed in SAV populations in the last 20 years.

1965--

In 1965 SAV was quite abundant throughout the Bay and in all of the major tributaries (Fig. 4) despite the compounding effects of the milfoil problem in the early 1960's (Bayley, et al., 1978). One area, however, that had been reported to have abundant SAV (Cumming, et al., 1919), but no longer contained any was the freshwater tidal portion of the Potomac River (Carter and Haramis, 1980; Carter, et al., 1980). The SAV of this area apparently declined in the 1930's and had all but disappeared by 1939 (Martin and Uhler, 1939). The lower reaches of the Potomac still contained abundant stands of vegetation in 1965, presumably eelgrass, based on evidence from aerial photographs of the Coan, Yeocomico and Lower Machodoc Rivers and personal accounts of local watermen.

1965-1970--

By 1970, there were still substantial stands of SAV throughout the Bay but evidence indicates some major losses of SAV in several areas had occurred (Fig. 5). Vegetation in the entire Patuxent River had all but completely disappeared (R. Anderson, personal communication) by 1970 with declines being first noted in the mid-1960's. Anecdotal accounts indicated that populations of eelgrass adjacent to the Chesapeake Biological Laboratory at the mouth of the Patuxent River were severely depressed in the late 1960's and gone by 1970. The vegetation in the lower Potomac River evidenced in aerial photographs of the 1960's also was almost completely absent. In addition, vegetation in many of the upriver sections of the Choptank, Chester, Gunpowder and Bush Rivers as well as in the entire Nanticoke and Wicomico Rivers in the Middle and Upper Bay zones were absent or in very reduced abundance (Boynton, personal communication).

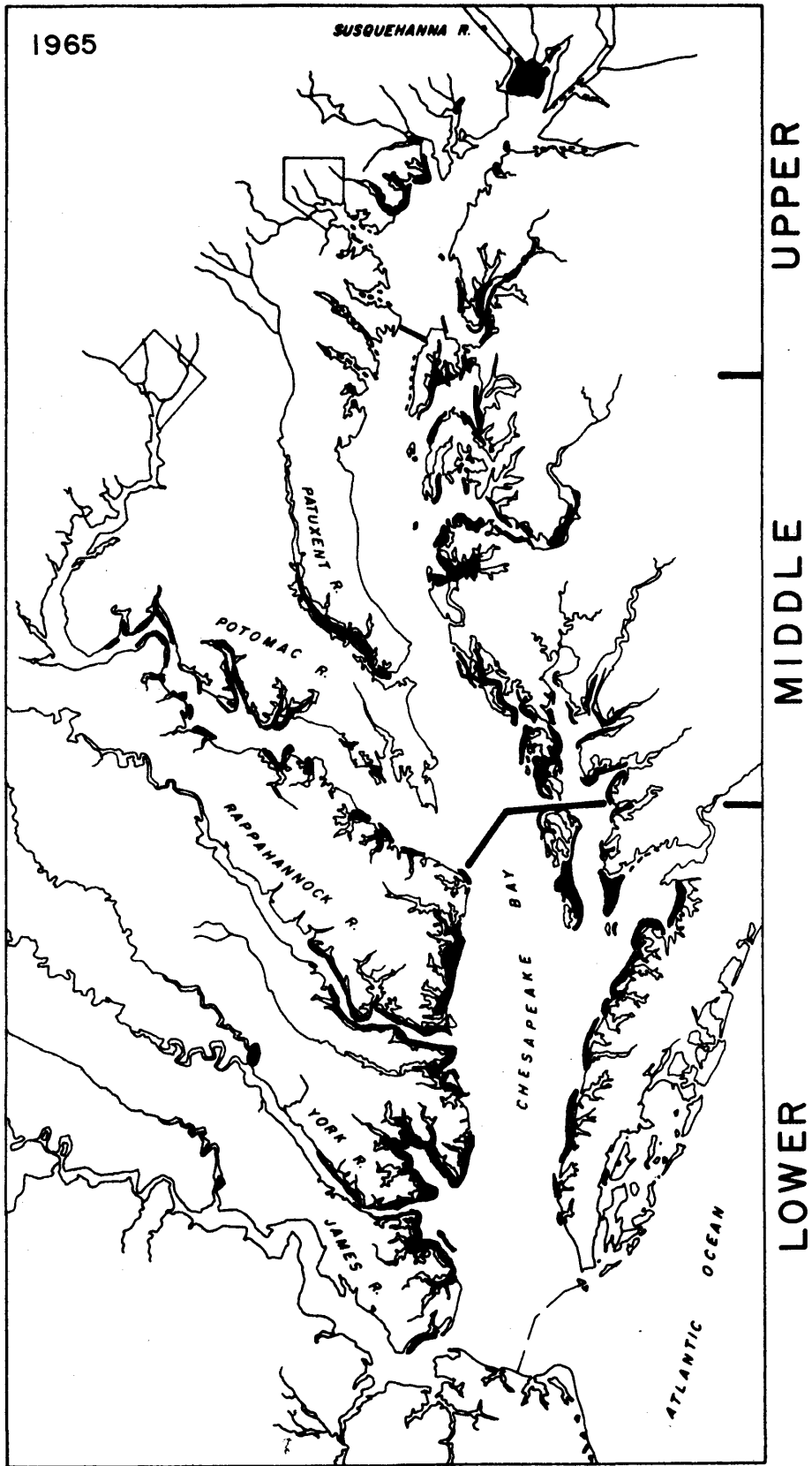


Figure 4. Distribution of SAV in the Chesapeake Bay - 1965.

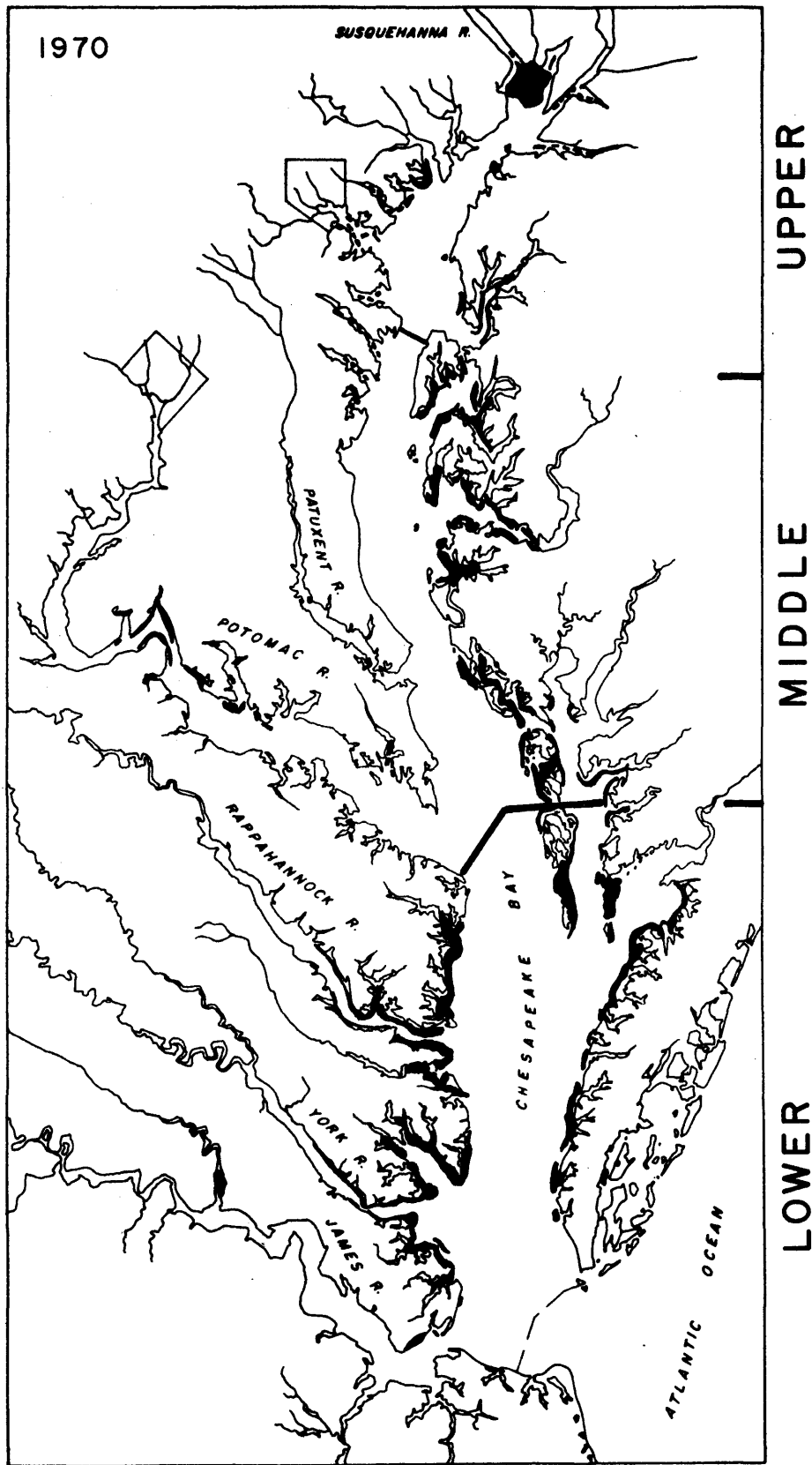


Figure 5. Distribution of SAV in the Chesapeake Bay - 1970.

SAV in some localized areas around the Bay, including the Susquehanna Flats (Bayley, et al., 1978) and the Chester River area (Anderson and Macomber, 1980), had increased in coverage from 1965 to 1970, although not to previous levels. The increase in these years may have been the result of the re-emergence of native SAV species in response to the decline of milfoil (Bayley, et al., 1978).

One of the first significant surveys of the upper Bay during this period was that conducted by Stotts from 1967 to 1969 (1970). Over 1000 transects were sampled from the Virginia - Maryland border to the Susquehanna Flats. The survey findings indicate that the many areas contained significant beds of vegetation especially in the more southern locations, from the Choptank River to Smith Island. Stotts reported however, on large declines of SAV that occurred in July and August in several locations north of the Choptank and that the SAV did not appear as robust as in the more southern areas, indicating that these systems were being stressed by some environmental factors. Examination of aerial photographs taken in September, 1970, shows large beds of vegetation in the same areas where SAV was reported to be abundant by Stotts' survey, especially in the lower reaches of the Chester River, Eastern Bay, Little Choptank River, Honga River and Bloodsworth Island.

In contrast to the declines evidenced during this period in the upstream, low salinity regions of the Bay and its tributaries, the higher salinity regions vegetated with eelgrass and widgeon grass showed as yet little evidence of any deterioration. Aerial photographs document that extremely dense beds characterized much of the shoreline of the lower Bay and its tributaries and many areas showed a continued increase in coverage since the 1930's (Orth and Gordon, 1975; Orth, 1976; Orth, et al., 1979).

1970-1975--

By 1975, the baywide situation for SAV had changed dramatically along the entire length of the Bay proper (Fig. 6). Indeed, the abundance of vegetation in 1975 represented what we feel was, until then, the lowest recorded abundance of vegetation in the Chesapeake Bay and its tributaries as far back as records indicate. The decline of SAV which first began in the mid-1960's and continued to the early 1970's, now was observed in all sections of the Bay with some areas affected more than others. This decline also appeared to accelerate after Tropical Storm Agnes affected the Bay in June, 1972.

Much of the information available for this period for the Upper and Middle Bay zones was from the 644 station survey of SAV by the Maryland Department of Natural Resources and the U.S. Fish and Wildlife Service, conducted once a year in Maryland waters beginning in 1971 (Kerwin, et al., 1977; unpublished files). Their data showed that SAV declined in the surveyed areas between 1971, when 28.5% of the stations were vegetated, and 1973, when 10.5% of the stations were vegetated (Table 2, Fig. 7), and fluctuated at comparatively low levels but at a decreasing rate from 1974 to 1975. The number of major areas with no SAV increased from 4 in 1971 to 11 in 1975, an increase of almost 300% (Fig. 1 and Table 5). This survey also showed that individual sections of the Bay had not exhibited a uniform

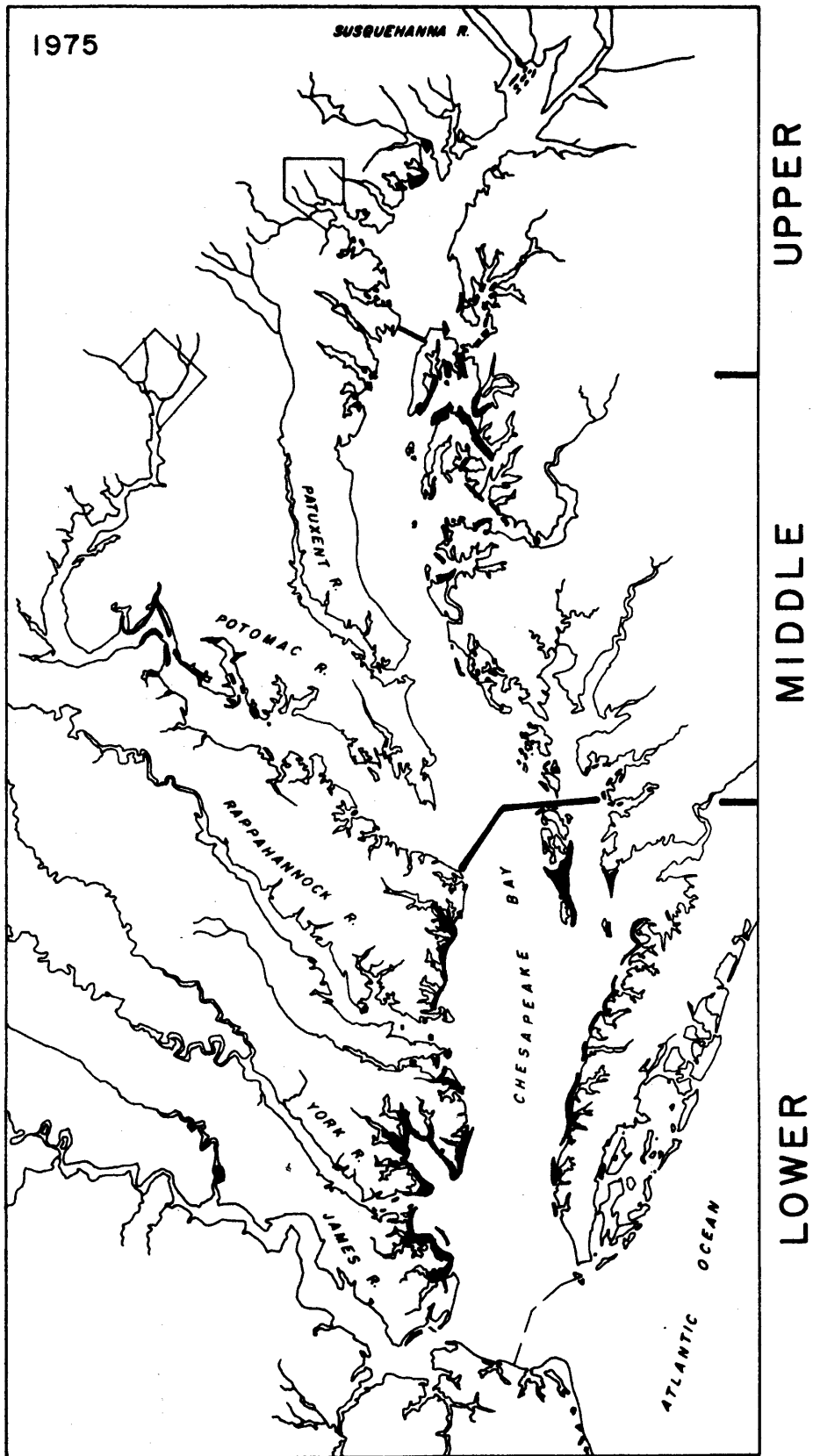


Figure 6. Distribution of SAV in the Chesapeake Bay - 1975.

Table 5. Percent of sampled stations containing submerged aquatic vegetation for various locations in the Maryland section of the Chesapeake Bay (compiled from U.S. Fish and Wildlife Service Migratory Bird and Habitat Research Laboratory (as reported in Stevenson and Confer, 1978) and unpublished files from Maryland's Department of Natural Resources) (**no stations sampled for this location).

River System	Avg. No. of Stations Sampled	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Elk & Bohemia Rivers	15-16	6.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sassafras River	10	30.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Howell & Swan Points	12	16.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Eastern Bay	43-47	34.04	46.51	34.04	36.17	21.74	42.22	28.00	26.10	17.30	34.80
Choptank River	56-60	35.00	39.66	19.30	27.59	1.72	41.07	25.00	28.30	26.70	25.00
Little Choptank River	19	21.05	21.05	0.00	0.00	0.00	15.79	5.00	5.30	5.30	0.00
James Island & Honga River	34	44.12	35.29	2.94	5.88	5.88	8.82	3.00	0.00	0.00	0.00
Honga River	29-30	50.00	40.00	13.33	16.66	10.35	17.24	3.00	3.00	0.00	0.00
Bloodsworth Is.	40-46	37.50	22.73	10.87	11.63	6.98	2.22	4.00	0.00	0.00	2.20
Susquehanna Flats	27-37	44.44	2.70	0.00	13.51	11.11	8.57	11.00	2.70	8.10	0.00
Fishing Bay	24-25	8.00	4.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nanticoke & Wicomico Rivers	30-31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Manokin River	14-15	40.00	46.67	13.33	20.00	7.14	6.67	20.00	0.00	0.00	0.00
Patapsco River	20-21	0.00	5.00	4.76	9.25	**	9.52	14.00	9.50	9.50	0.00
Big & Little Annemessex Rivers	18-20	70.00	60.00	30.00	57.89	33.33	30.00	30.00	15.00	0.00	5.00
Gunpowder & Bush River Headwaters	7-9	11.11	0.00	0.00	0.00	**	0.00	11.00	0.00	11.10	22.20
Pocomoke Sound (Maryland)	20-22	18.18	10.00	4.76	**	15.00	9.09	10.00	4.50	0.00	0.00
Magothy River	12	33.33	0.00	16.67	16.66	**	16.67	25.00	8.30	16.70	16.70
Severn River	13-15	40.00	20.00	26.67	26.67	0.00	46.15	20.00	26.70	20.00	13.30
Back, Middle & Gunpowder Rivers	22	13.64	4.55	4.55	4.55	9.09	4.55	9.00	4.50	4.50	9.10
Curtis & Cove Points	6-21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.30	0.00
South, West & Rhode Rivers	8-10	0.00	0.00	0.00	0.00	0.00	12.50	0.00	0.00	0.00	0.00
Chester River	34-36	61.11	36.11	26.47	23.52	25.00	25.71	38.00	44.40	33.30	38.90
Love & Kent Points	8	0.00	0.00	0.00	12.50	0.00	0.00	0.00	0.00	0.00	0.00
Smith Island (Maryland)	11-17	64.71	45.46	25.00	35.29	22.22	35.29	24.00	5.80	17.60	47.10
Patuxent River	47-50	2.00	4.26	0.00	4.00	0.00	2.04	2.00	2.00	2.00	0.00
Percent of stations vegetated		28.5	21.0	10.5	14.9	8.7	15.0	12.3	9.6	7.9	9.8
Number of stations with no SAV recorded		4	9	12	9	11	8	8	12	13	16

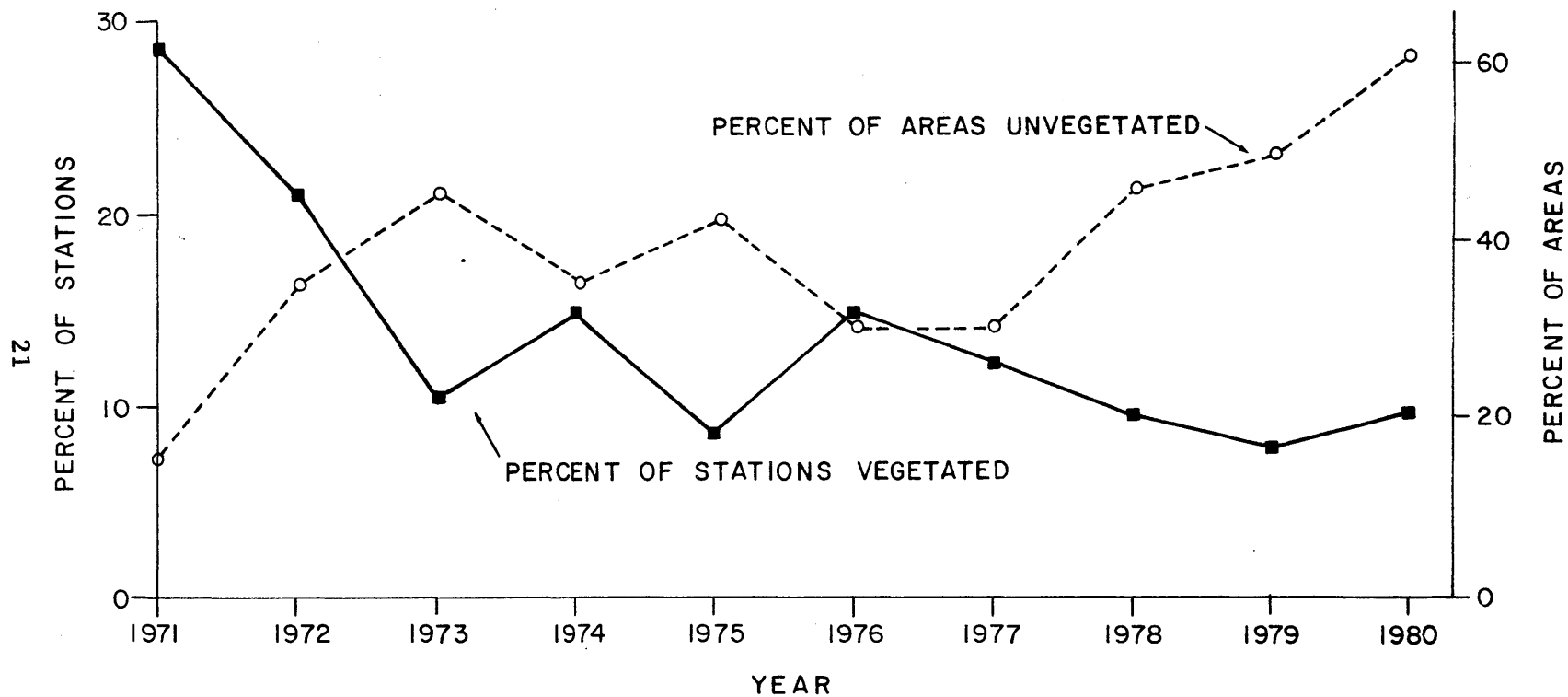


Figure 7. Trend in SAV occurrence in the Maryland portion of the Chesapeake Bay. Values represent the percent of stations with SAV (n = 644 stations) and the percent of unvegetated areas (n = 26 areas) (from Kerwin, et al., 1977; unpublished data from Kerwin, et al., 1977; unpublished data from Maryland's Department of Natural Resources).

trend, but that the head of the Bay and lower Eastern Shore have fared the worst while the middle sections of the Maryland eastern and western shore fared the best.

Large reductions in vegetation were observed in July and August, immediately after Agnes, in many sections of the Upper Bay zone (Fig. 6), principally the Elk, Bohemia, Sassafras, Back, Middle, Magothy and Chester Rivers, Howell and Swan Point, Susquehanna Flats, and the headwaters of the Bush and Gunpowder Rivers (Fig. 6 and Table 5) (Kerwin, et al., 1977). In addition, sections of the Middle Bay zone, primarily those in the northern end, such as the Severn River, appeared to be rapidly denuded of grasses. The species that were most affected were the fresh and brackish water species: coontail (C. demersum), common elodea (E. canadensis), southern naiad (N. guadalupensis), wildcelery (V. americana), sago pondweed (P. pectinatus) and redhead grass (P. perfoliatus) (Table 1).

Vegetation in the Middle and Lower zones of the Bay started to decline in 1973. In the Middle zone, regions affected were: the Choptank and Little Choptank River, James Island, Manokin River, Big and Little Annemessex Rivers, Bloodsworth and Smith Islands. Species affected in these areas included many of the same lower salinity species that were rapidly lost from the Upper Bay section in 1972 as well as the higher saline species, eelgrass and widgeon grass. The decline of SAV at some locations on the lower Eastern Shore where eelgrass and widgeon grass had predominated is shown in Fig. 8.

In the Lower zone, where data was primarily available from detailed aerial photographs (Orth and Gordon, 1975; Orth, et al., 1979), vegetation in the York, Rappahannock and Piankatank Rivers, as well as in many small tributaries, was reduced substantially during this period (Fig. 6).

In order to highlight the changes that occurred with SAV communities in the lower Bay six areas were mapped for historical changes in the distribution and abundance of SAV (Orth, et al., 1979). These changes are shown in detail for one of the sites: Mumfort Island in the York River (Fig. 9). SAV coverage in the lower Bay generally increased at all these sites from the 1930's to 1970 while there was a marked decline beginning around 1970 (Fig. 9 and 10). Our data, especially for the York River, indicated that the decline of SAV occurred in the summer of 1973 as evidenced by the presence of large beds of SAV in April, 1973, that were absent in April, 1974. Comparison of means indicated that there were significant differences between pre-1972 and post-1972 coverages at Parrott Island in the Rappahannock River ($p=0.001$), Mumfort Island in the York River ($p=0.002$), and East River in the Mobjack Bay ($p=0.038$). At Jenkins Neck at the mouth of the York River, where the trend was more gradual, regression analysis indicated a significant decline ($p=0.02$). At Fleets Bay, just above the mouth of the Rappahannock River, regression analysis indicated the decline was significant ($p=0.019$). Only Vaucluse Shores on the Eastern Shore showed no significant decline ($p=0.14$).

Several distinct patterns in the decline of vegetation in the lower Bay are evidenced. First, it appears that losses of vegetation were greatest in all the areas where eelgrass formerly reached its upriver or upbay limits.

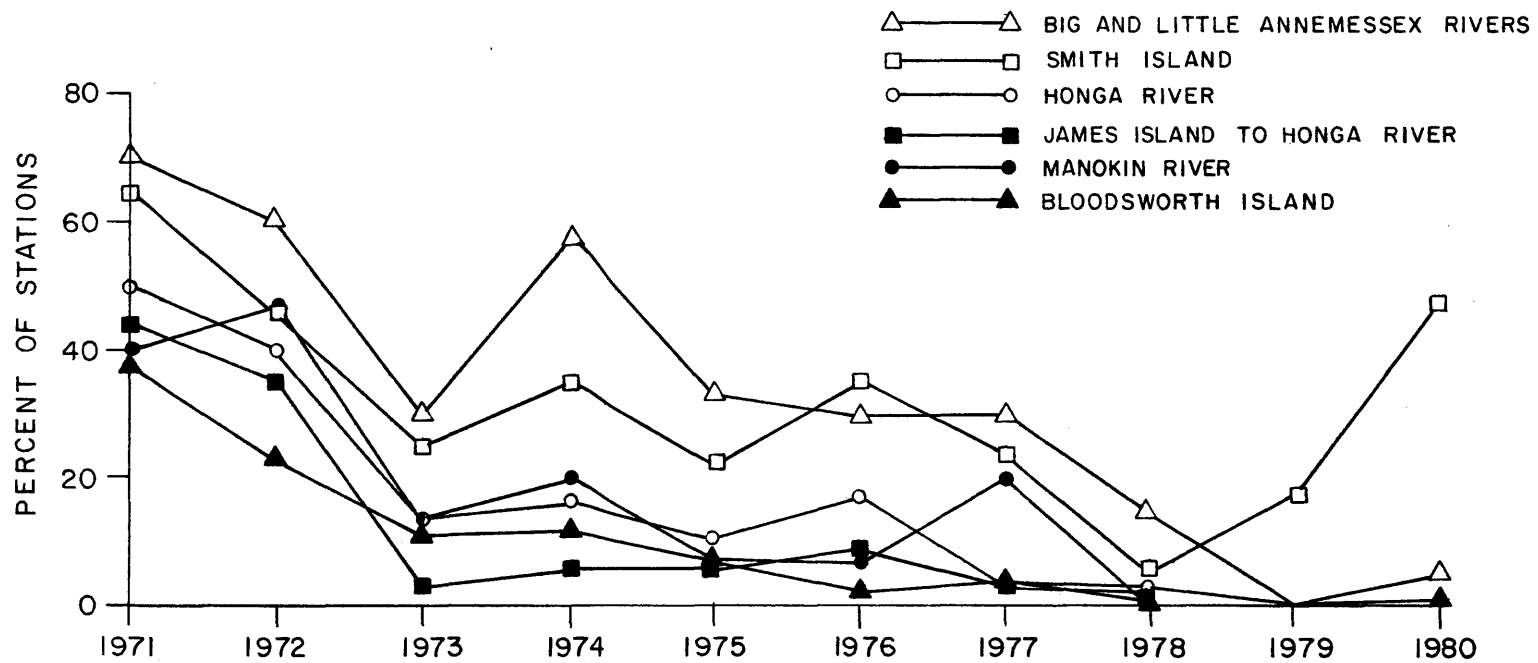


Figure 8. Trends in SAV occurrence in six areas in the Middle bay zone where SAV had markedly declined (data from Kerwin, et al., 1977; unpublished data from Maryland's Department of Natural Resources).

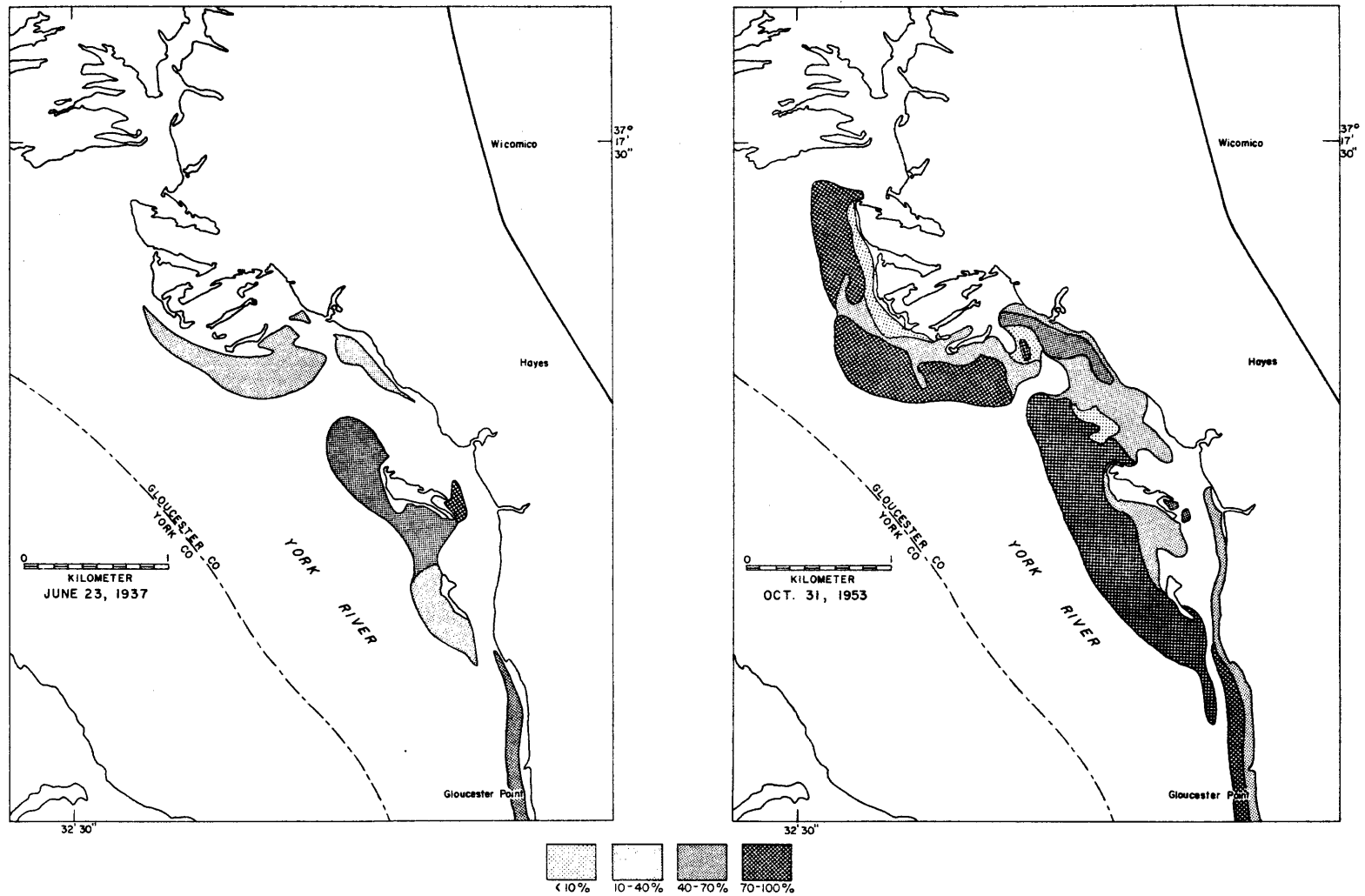


Figure 9. Changes in the distribution and abundance of SAV at the Mumfort Island area in the York River, 1937-1978. Density of SAV shown as very sparse (<10% coverage), sparse (5-40%), moderate (40-70%) or dense 70-100% (data from Orth, et al., 1979).

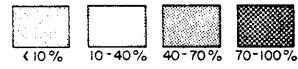
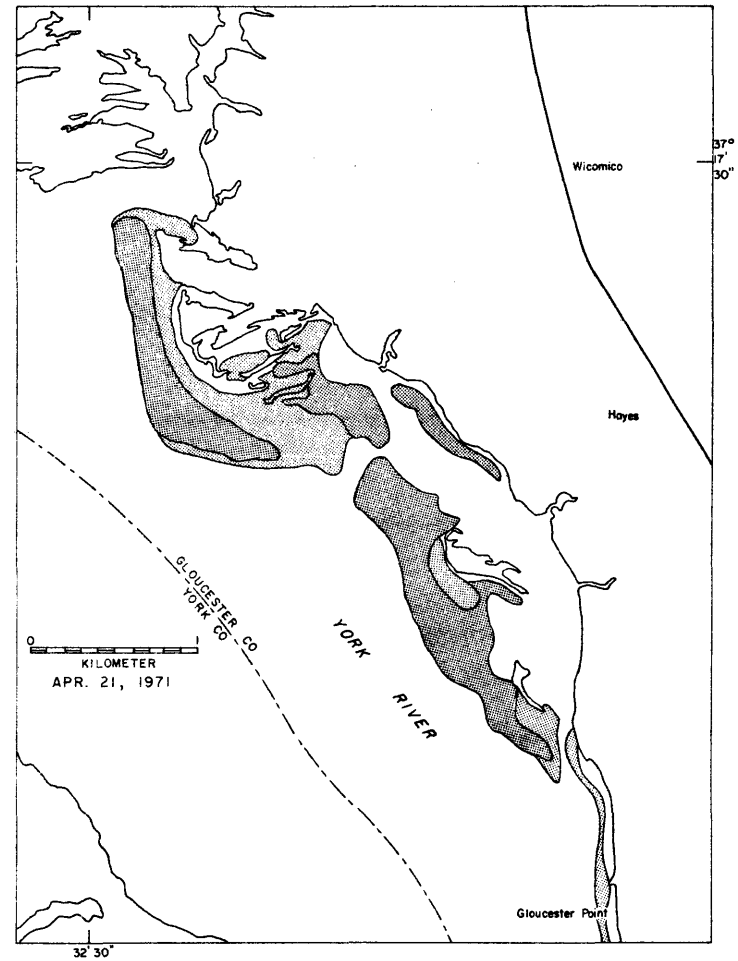
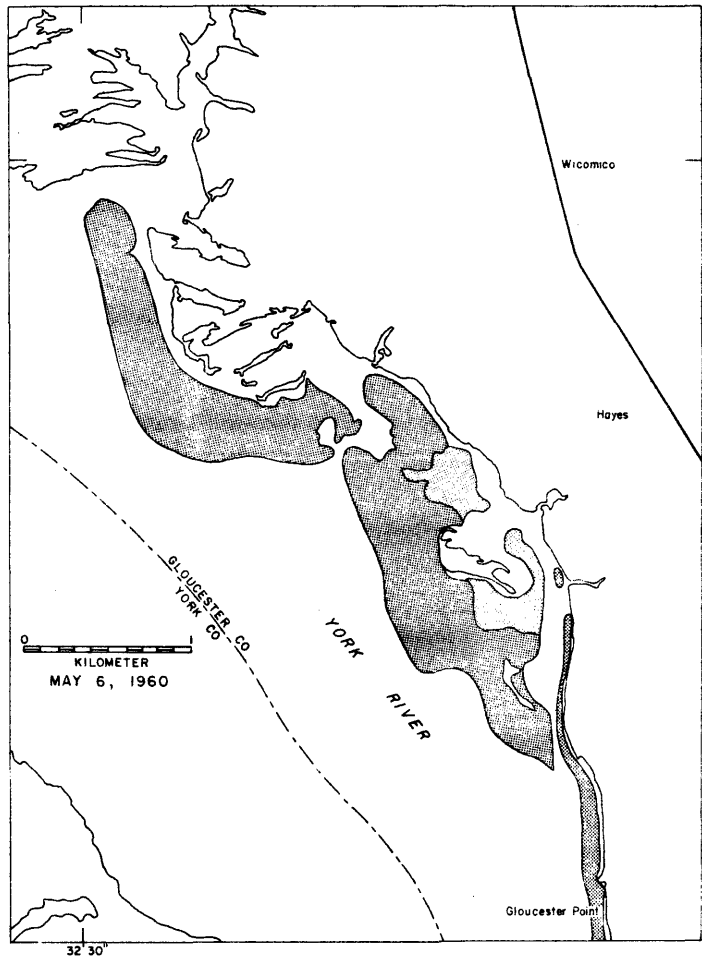


Figure 9. (continued)

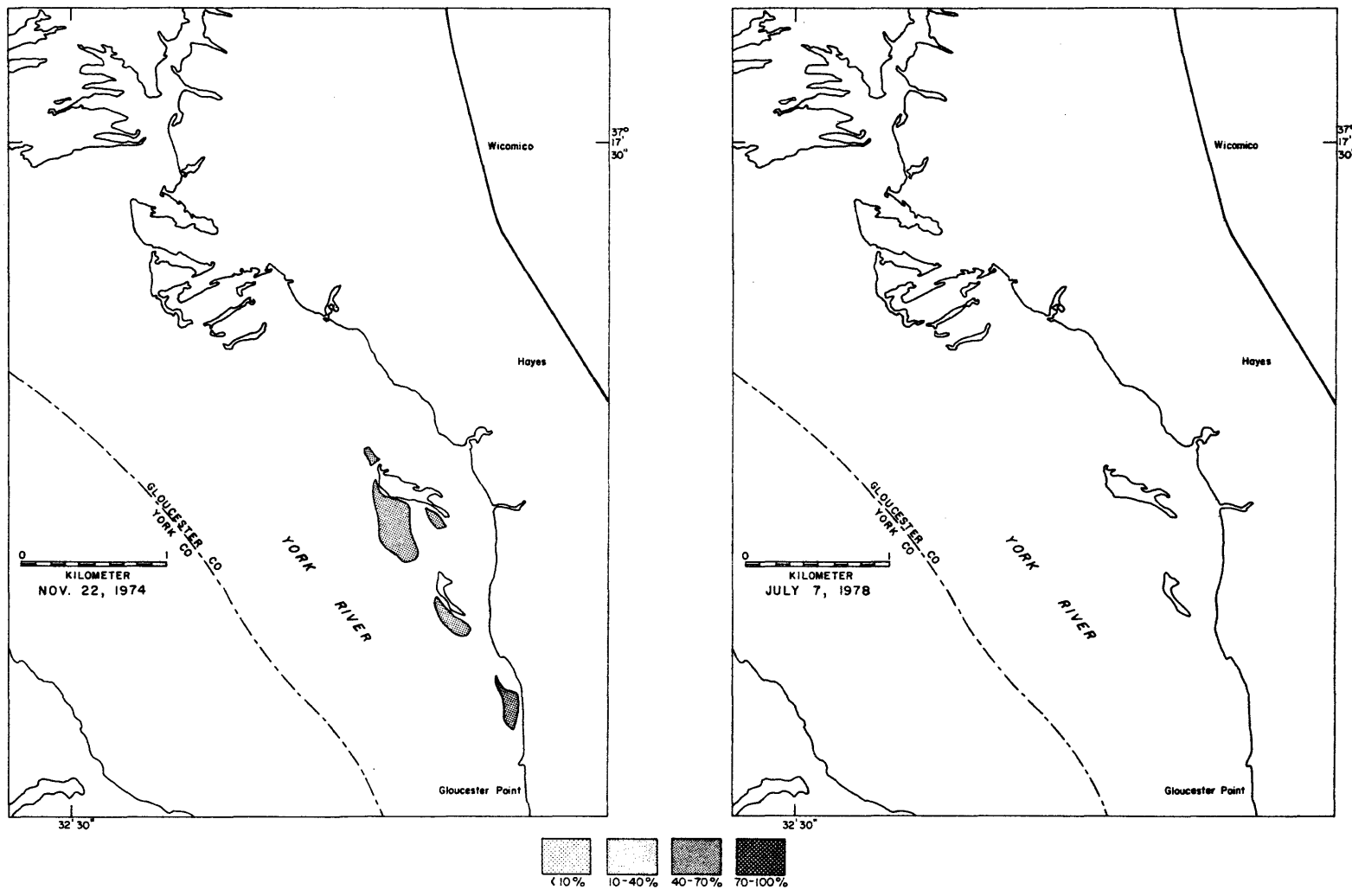


Figure 9. (continued)

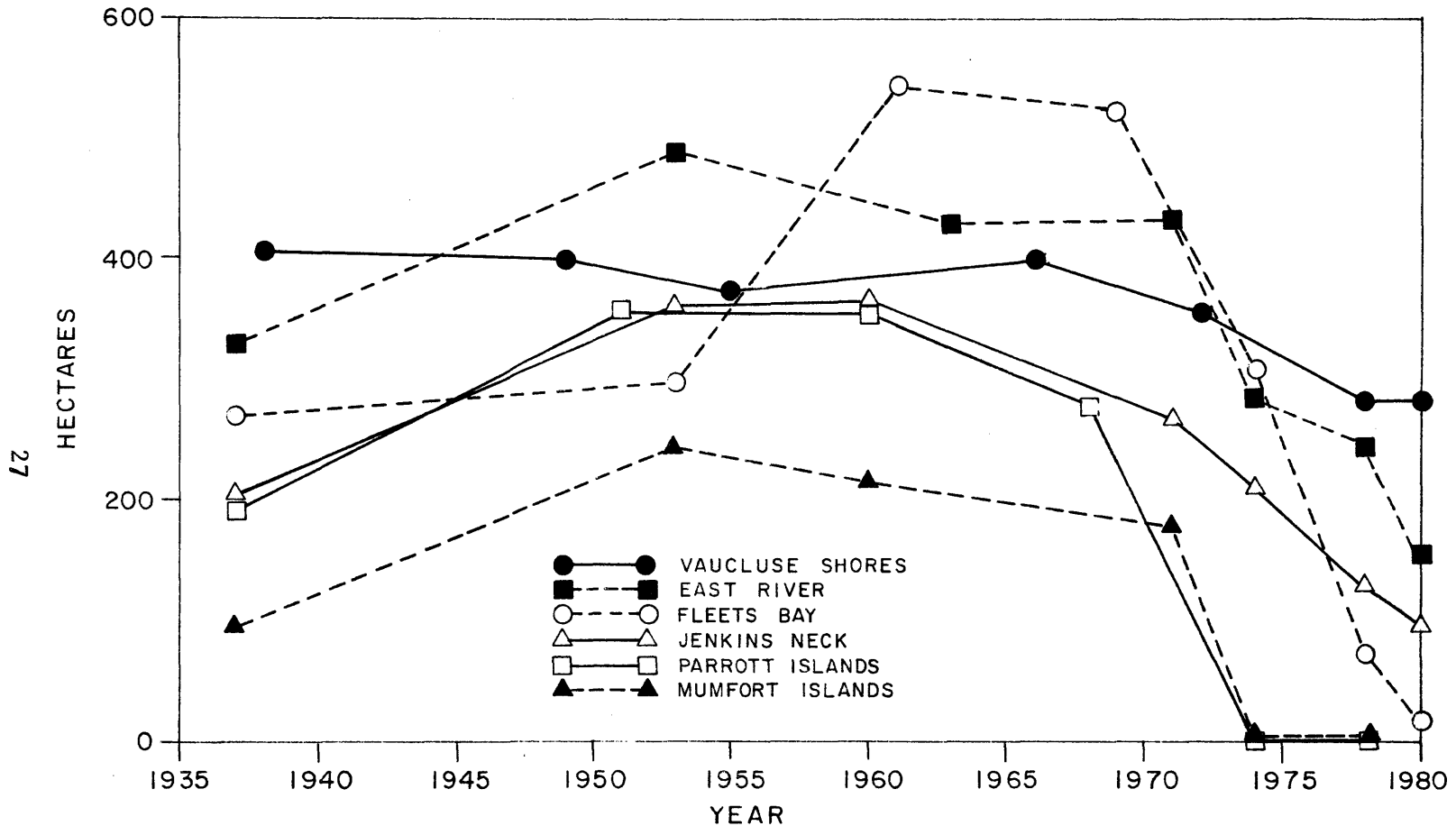


Figure 10. Trends in SAV coverage at six sites in the Lower zone of the Chesapeake Bay (data from Orth, et al., 1979).

For example, eelgrass beds disappeared from the Maryland portion of the Eastern Shore while remaining in the Virginia portion. Along the western shore of the lower Bay SAV beds declined the greatest in the northern areas and least in the southern areas. Within the major tributaries, beds disappeared leaving only some beds at the mouths of these rivers. And in nearly all the small creeks and tributaries where eelgrass beds continued to exist in 1975 the former distribution included areas further upstream. Second, in addition to the upstream-downstream movement it appeared that the vegetation had declined in the deeper offshore sections of the beds rather than the shallower, nearshore areas.

1975-1980--

Between 1975 and 1980, the Baywide status of SAV appeared to be one of a continuing decline in almost all areas of the Bay (Fig. 11). The upper Bay survey by the Maryland Department of Natural Resources continued to show a small percentage of stations vegetated with SAV with a trend toward decreasing levels to 1979 (unpublished data). A small increase was observed in 1980 but this was due to a large increase in vegetated stations at the Smith Island site (Table 5 and Fig. 8). All the sites, where a decline in abundance in the early 1970's from the lower Eastern Shore was observed, except for Smith Island, continued to decline to much lower levels (Fig. 8). Another significant point was the continual increase in the number of areas that contained no SAV. By 1980, 16 areas or 62% of the total areas identified for this survey now contained no SAV, compared with 4 areas or 15% in 1971 (Table 5 and Fig. 7).

In the lower Bay zone, the total for the mapped areas of the western shore from the Rappahannock River to the James River between 1974 and 1978 remained similar (Table 3). Although there were observed declines the losses were offset by some increases in the sizes of some of the grassbeds especially in the Mobjack Bay. The losses were observed in many of the smaller beds that remained in some localities after the 1973-1974 period which had totally disappeared by 1978, and in Fleets Bay, where 76% of the vegetation mapped in 1974 declined by 1978. Between 1978 and 1980, almost all sections of the lower Bay declined where, now in some sections (Rappahannock River and Reedville), almost no SAV remained (Table 3 and Figs. 10 and 11).

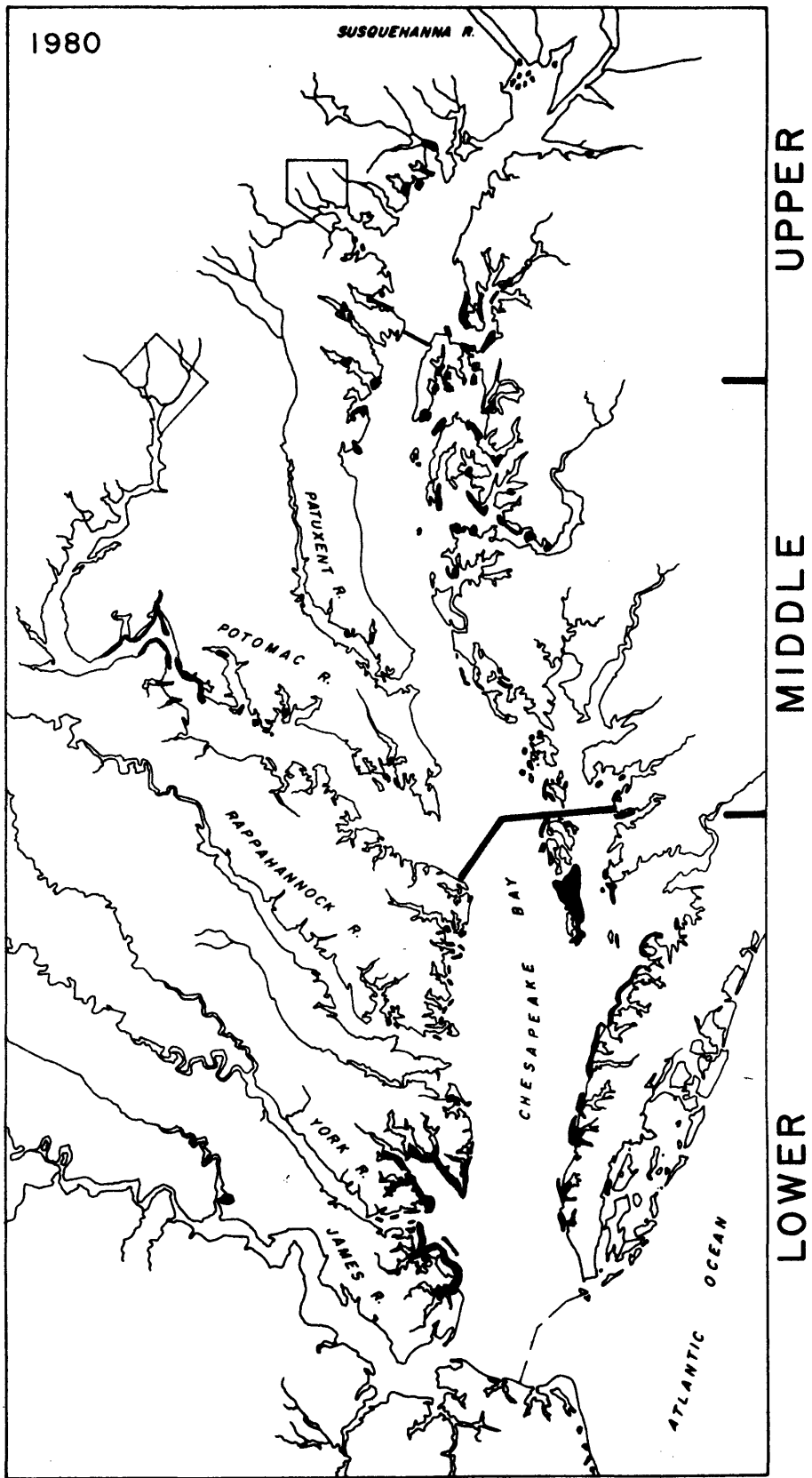


Figure 11. Distribution of SAV in the Chesapeake Bay - 1980.

SECTION 5

THE ATLANTIC COAST

There is little evidence to suggest that there have been recent significant changes in SAV distribution along the east coast of the U.S. comparable to those documented for the Chesapeake Bay. The uniqueness of the Chesapeake Bay estuary with its extensive littoral areas and marked salinity gradient makes comparisons difficult. In addition the only recent interest by the scientific community and management agencies in SAV communities has resulted in little significant work on the historic distribution of SAV in other areas.

Eelgrass is a species that is distributed widely along the coastline, from North Carolina to Nova Scotia in Canada. As mentioned in the previous section, eelgrass populations underwent a dramatic reduction along the east coast of the U.S. in the 1930's. This decline had dramatic effects on waterfowl populations, fisheries and shoreline erosion. Declines in other years was noted by Cottam (1934, 1935) but recovery always followed these declines in most of the reported areas. At present, North Carolina which has extensive beds of eelgrass located within its bays and sounds with few beds found along the tidal rivers, is attempting to determine the present distribution of SAV in the region. Researchers in that area report no apparent widespread changes in eelgrass distribution in the last 10 years (M. Fonseca, G. Thayer, personal communication). There have been localized changes in eelgrass beds but these have been due to physical perturbations by man or other localized disturbances. Davis and Brinson (1976) report on the distribution of SAV's in the Pamlico River but again report no significant, recent changes in their abundance. In South Carolina and Georgia there are, at present, no significant stands of SAV primarily because of the very turbid conditions that exist in the estuaries found there.

North of the Chesapeake Bay there appears to be no SAV in the Delaware Bay at present, and data on whether it ever occurred there are not available. In New Jersey SAV beds which are dominated by eelgrass and widgeon grass are found in the sounds located to the west of the barrier islands (Good, et al., 1978; Macomber and Allen, 1979). There is a lack of historic data on SAV in the region but, again, there is no direct evidence of any large scale changes in the existing beds.

In New York, researchers indicate no reports of significant losses in eelgrass beds in this region. On the contrary, eelgrass appears to be increasing in abundance in this area (Churchill, personal communication).

In Rhode Island, SAV beds persist in many of the small tidal lagoons adjacent to Long Island Sound. These systems still contain abundant vegetation and apparently have not undergone significant recent alterations.

North of Rhode Island, in Massachusetts, Maine and in Canada, there have been no reports of alterations in SAV communities. However, accurate data are lacking because of the fact there are no scientists presently involved in any extensive SAV research program.

In summary, it would appear that the declines in eelgrass or other SAV species in the Bay are not part of an apparent widespread and synchronous loss of vegetation along the East Coast of the U.S., although these conclusions are hampered by lack of comprehensive data on the current and historical distribution of SAV in other areas. It is most likely that the water quality problems affecting the distribution of grasses in the Bay are regional in nature, involving the Bay, its tributaries, and their drainage basins.

SECTION 6

WORLDWIDE PATTERNS

As in the Chesapeake Bay, many coastal and estuarine regions of the world contain varying amounts of shallow water areas that support SAV beds ranging from large, very dense areas in the Caribbean to small, sparse areas in some European countries. The grassbeds around the world occur under a wide range of physical, chemical and biological parameters. Yet, despite these differences, they share a common ground in their functional roles in their respective ecosystems: a habitat and nursery area, food for waterfowl, sediment stabilizer, nutrient buffer and source of detritus. Recent interest in SAV systems worldwide has paralleled the increasing interest in Bay SAV systems from the standpoint of their role and value, but also because their proximity to industrialized areas had led them to become increasingly stressed by man-made perturbations. Recent examples from the Netherlands (Nienhuis and DeBree, 1977; Verhoeven, 1980), England, especially some very pertinent examples from freshwater areas (Wyer, et al., 1977; Eminson, 1978; Phillips, et al., 1978), Wales (Wade and Edwards, 1980), Scotland (Jupp and Spence, 1977), Denmark (Sand-Jensen, 1977; Kiorboe, 1980), France (Peres and Picard, 1975; Maggi, 1973; Verhoeven and Van Vierssen, 1978), Israel (Litav and Agami, 1976), Australia (Cambridge, 1975; Larkum, 1976), Japan (Kikuchi, 1974a, b); and the Virgin Islands (Van Epoel, et al., 1971), have suggested that losses in SAV communities have been highly correlated with changing water quality conditions. In many of the above examples, where SAV has been described as greatly reduced or declining, this reduction has always been associated with decreasing water clarity as a result of increased eutrophication with subsequent increases in epiphytes and phytoplankton due to sewage or agricultural inputs or higher loads of suspended sediments due to dredging or runoff from deforested areas.

On the other hand, increases in water clarity have been shown to result in expansion of SAV. The diking of the Gravelingen estuary in the Netherlands resulted in a salt water lake with reduced currents and no tidal effects. This resulted in a reduced total suspended solid load, and, thus greater light penetration. Subsequently eelgrass increased almost 400% in ten years and was found in water depths of up to five meters, far deeper than before the diking (Nienhuis, 1980).

Large reductions of SAV communities have also been associated with natural causes or diseases. The eelgrass wasting disease of the 1930's that resulted in massive declines of eelgrass along the east coast of the U.S. and west coast of Europe was originally attributed to a disease organism, Labyrinthula, but later attributed to climatological changes in temperature (Rasmussen, 1973, 1977). In Australia, decline of SAV was attributed to migrating sand waves that smothered the grasses (Kirkman, 1978). However,

the more recent declines cited in the literature have been associated with man-induced alterations rather than natural ones.

There are still vast areas of the SAV in many parts of the world, particularly in the Gulf of Mexico, the Caribbean and Australia, areas that are presently not affected by industrial or urban development (one area in southern Florida was estimated to have 500,000 hectares of turtlegrass (Thalassia testudinum) (J. Zieman, personal communications)). However, in those areas where development has occurred, SAV communities have been shown to decline, especially in deeper beds because of the reduction in quantity of light, a pattern that parallels the situation in Bay SAV communities.

SECTION 7

CONCLUSIONS

The period of 1965 to 1980 represented what we feel was an unprecedented decline of SAV in the Chesapeake Bay. Loss of SAV communities was first observed in the late 1960's in the upper Bay areas, and in particular, the Patuxent, lower Potomac River (SAV beds in the freshwater tidal portions had been absent since the 1930's) and the upper reaches of some of the smaller tributaries (e.g. the Chester and Choptank Rivers). By 1970, almost all the vegetation in the Patuxent River and lower Potomac River was gone. The decline of SAV in the Bay accelerated in the early 1970's and had continued through 1980, with the most rapid decline occurring from 1972 to 1974. Several sections in the Bay that once contained abundant SAV had virtually none by 1980 (e.g. the Patuxent, Piankatank and Rappahannock Rivers) while other sections had only small stands remaining (e.g. the Potomac and York Rivers and the Susquehanna Flats). In addition to this trend of SAV populations declining from "up-estuary" to "down-estuary", it appeared that within individual beds the declines occurred first in the areas of greatest depth. The present abundance of all SAV species in the Bay (16,000 hectares) is probably the lowest level recorded in the Bay's history. Figure 12 shows this cumulative pattern of decline over the last 20 years, with the arrows representing the former to present limits of distribution. Fig. 13 outlines these sections of the Bay where SAV has been most severely affected.

SAV in the Bay has experienced other large scale changes in the recent past, although none involving so great a spectrum of species' types. In the 1930's, a decline of SAV involved primarily eelgrass except for the tidal freshwater portion of the Potomac River where all SAV species disappeared. Eelgrass gradually returned to all areas of the Bay but there has been little regrowth of SAV in the upper Potomac. In the late 1950's and early 1960's, the sudden rapid expansion of Eurasian watermilfoil created problems by choking many waterways in sections of the Potomac River, Susquehanna Flats and western tributaries of the upper Bay.

On a much broader latitudinal scale along the entire east coast of the United States and the west coast of Europe, eelgrass populations also declined during the 1930's. This decline was subsequently followed by a gradual return in most areas. Near the Chesapeake Bay, in the shallow lagoons behind the barrier islands of the Delmarva Peninsula, the eelgrass had never recovered. This has drastically affected the scallop industry which was associated with this species of SAV. Regarding the decline of SAV in the 1960's and 1970's in the Chesapeake Bay, there is little evidence yet to suggest that a simultaneous decline occurred with SAV communities in other areas along the east coast of the United States. Reports indicate that on a worldwide basis,

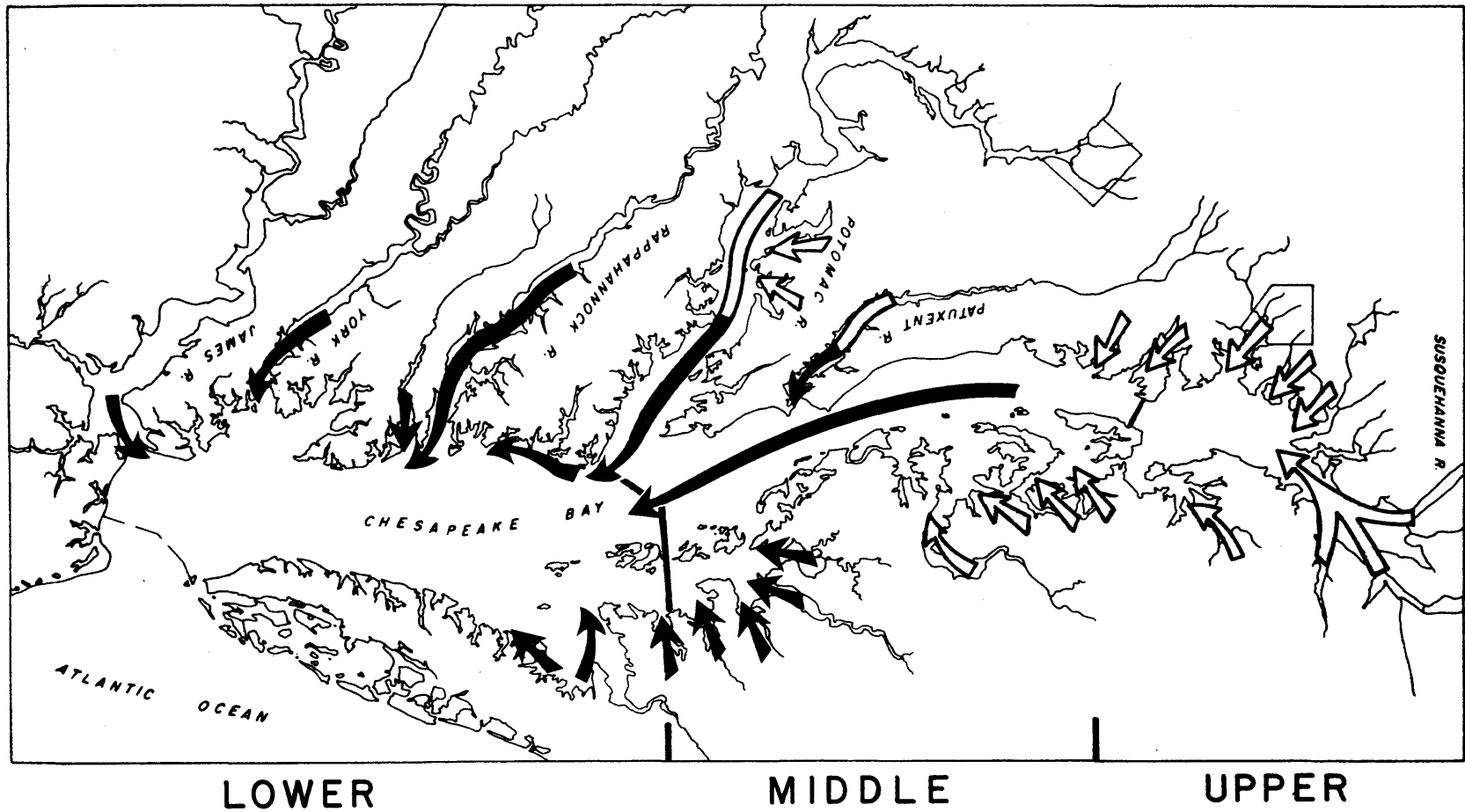


Figure 12. Pattern of recent changes in the distribution of SAV in the Chesapeake Bay. Arrows indicate former to present limits. Solid arrows indicate arrows where eelgrass (*Zostera marina*) dominated. Open arrows indicate other SAV species.

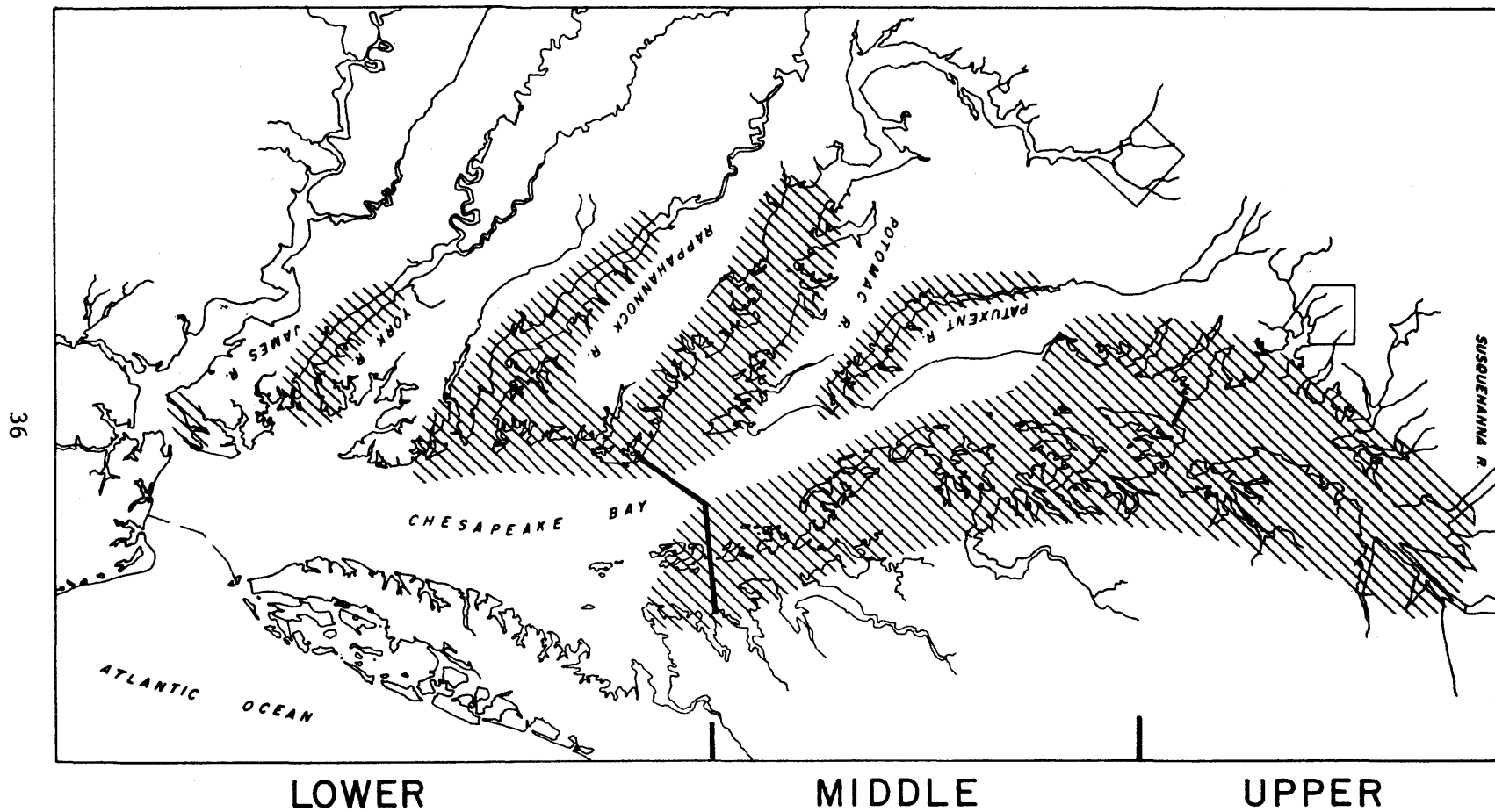


Figure 13. Location of sections of the Bay where SAV has experienced the greatest decline.

despite their abundance in certain areas, SAV communities are becoming increasingly affected by man-induced perturbations, declining in areas where there is extensive industrial and/or urban development.

Given the current situation with the extremely low abundance of SAV in the Bay, a very important question can be raised as to the ability of these systems to return to their previous levels of abundance. Indeed, recovery may not occur because the current levels of SAV are so low or non-existent that natural recruitment via vegetative propagation or seed dispersal may be limited. Recent success with SAV transplantation experiments, moving whole plants into denuded areas in the Potomac River and lower Bay, indicated that these regions may now be capable of supporting SAV (Orth, et al., 1981; V. Carter, personal communication). Thus, transplanting SAV may be a viable method, and in some areas the only way, for the reintroduction of these plant communities.

The future of SAV in the Chesapeake Bay is one of uncertainty. We know that historically there have been several periods of SAV decline in the Bay. The vegetation has returned to some areas while others have remained barren. The pattern of continued decline of SAV in the Bay over the last 20 years suggests a chronic deterioration of water quality. Unless the complex interaction of factors leading to this deterioration can be understood and reversed, SAV communities in many areas may remain a part of the Bay's past.

SECTION 8

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