Draft Report

Distribution of Submerged Aquatic Vegetation in the Chesapeake Bay and Tributaries and Chincoteague Bay - 1989

by

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EXECUTIVE SUMMARY

The distribution of submerged aquatic vegetation during 1989 in the Chesapeake Bay, its tributaries, and Chincoteague Bay, was mapped at a scale of 1:24,000 using black and white aerial photography. SAV bed perimeter information was digitized and stored in a computerized data base. Ground truth information was obtained from the U.S. Geological Survey, the U. S. Fish and Wildlife Service, the University of Maryland Horn Point Laboratory, Harford Community College and the College of William and Mary's Virginia Institute of Marine Science/School of Marine Science. Citizen support via the U. S. Fish and Wildlife Service and Chesapeake Bay Foundation, as well as the Maryland Charterboat Association via the Maryland DNR Watermen's Assistance Program, provided additional ground truth information.

In 1989, the Chesapeake Bay had 24.412 hectares of SAV, compared to 20,119 hectares in 1987, with 2,457 (10%), 11,544 (47%) and 10,411 (43%) hectares occurring in the Upper, Middle and Lower Bay zones, respectively (Figs. 1 and 2). Seventy-two percent of the SAV is concentrated in the bay from Barren Island-Honga River to the bay mouth, exclusive of the Potomac River (Fig. 3). Forty-nine percent (11,949 hectares) of the SAV was present along the eastern shore (sections 12, 13, and 14) from the Barren Island-Honga River area to just below Cape Charles (Fig. 3)

In the Upper Bay zone 79% of the SAV was located in the Susquehanna Flats section (1945 hectares). Nine species of SAV were documented by ground truth surveys in this section, with Myriophyllum spicatum being the dominant species. Hydrilla verticillata was found in the Flats but occurred in small isolated beds. In addition to the reduced overall abundance of SAV from 1987, beds were generally much less dense, with 95% of all SAV beds

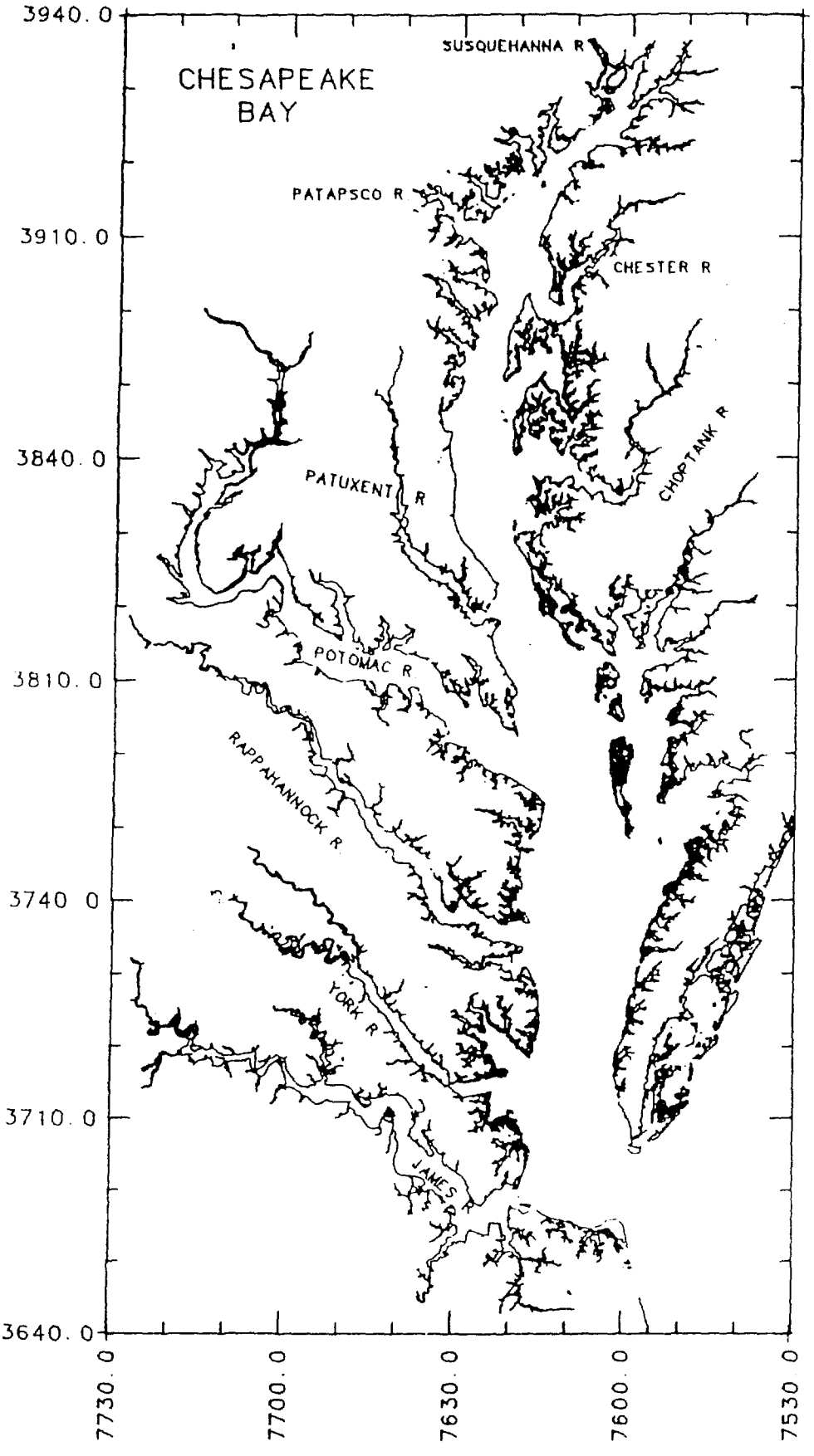

Figure 1. Map of Chesapeake Bay and tributaries with locations of all SAV beds in 1989.

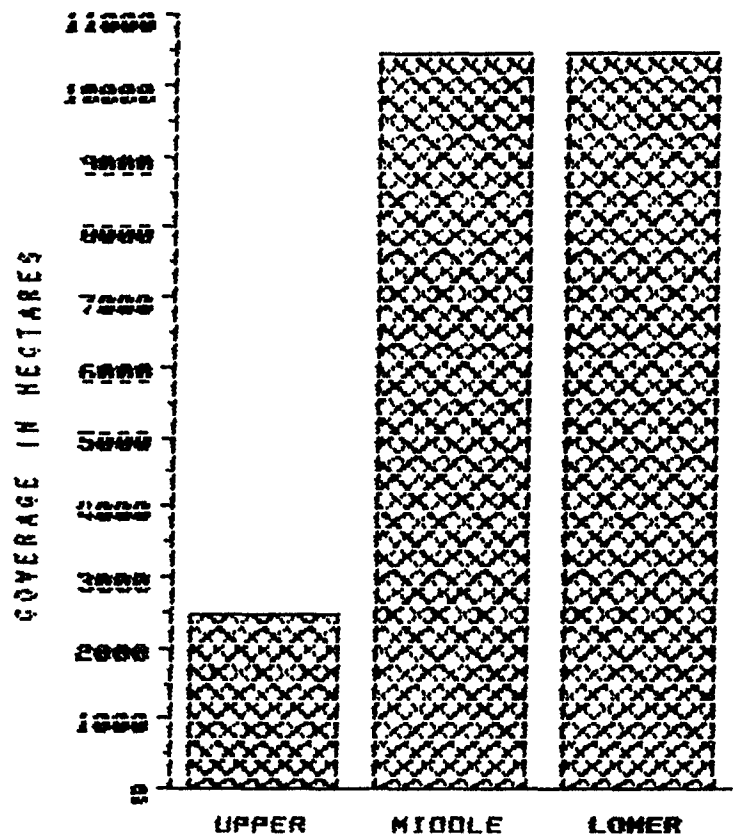

Figure 2. Hectares of SAV in each region of the Chesapeake Bay

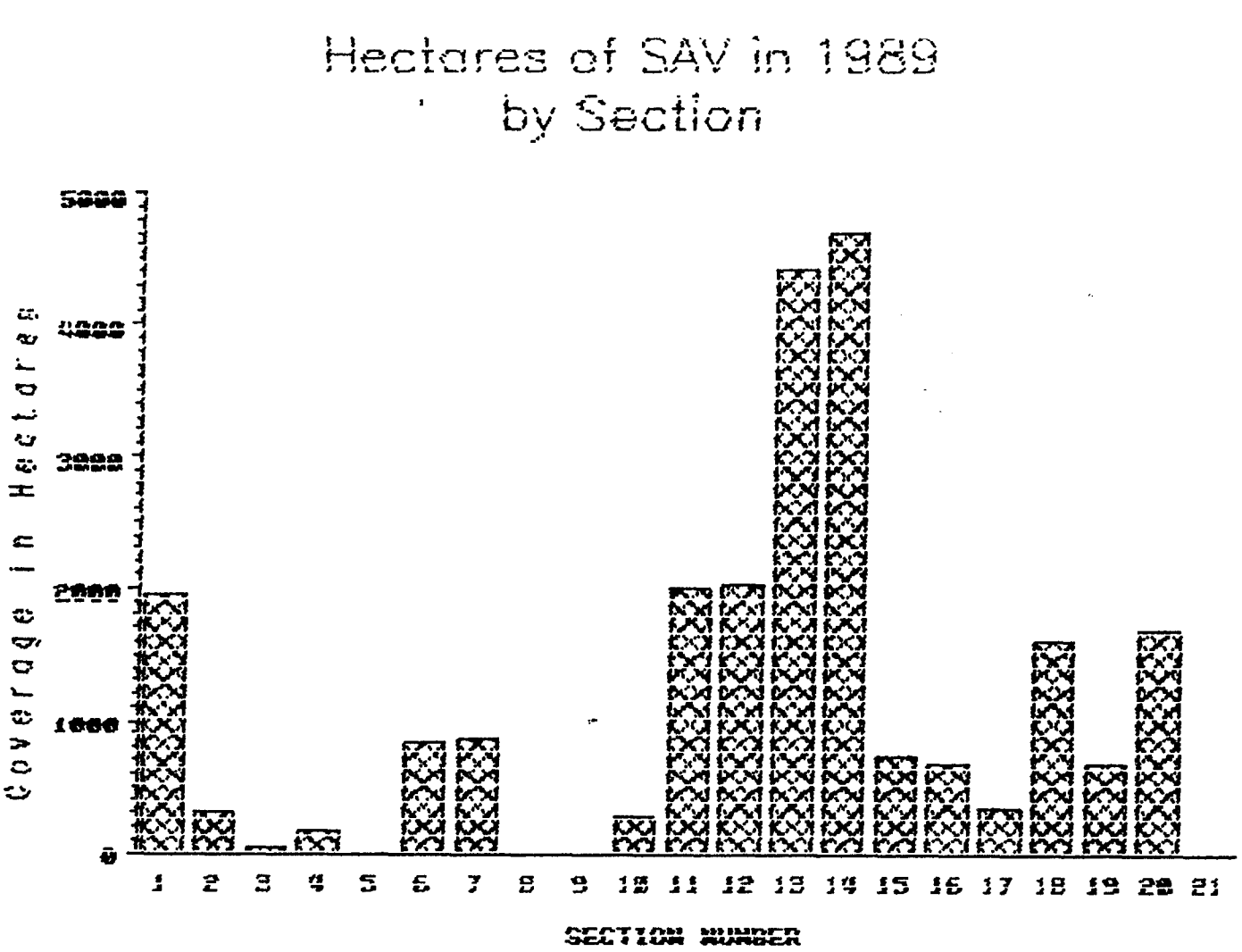

Figure 3. Hectares of SAV in 1989 by section

classified as very sparse, and no beds classified as dense (70-100% coverage). In the Upper Eastern Shore section (307 hectares), SAV was located principally in the Elk and lower Sassafras Rivers, Swan, Stillpond, and Churn Creeks, with many of the same species as reported in the Susquehanna Flats section. In the Upper Western Shore section (38 hectares), SAV was concentrated in Saltpeter and Seneca Creeks, with M. spicatum and Vallisneria americana being most abundant. In the Chester River section (167 hectares), SAV was most abundant adjacent to Eastern Neck and Eastern Neck Island and in the lower Chester River. In this region Ruppia maritima was the most abundant of six species which were reported.

In the Middle Bay Zone, 45% (5,196 hectares) of the SAV was found in the Mid-bay Island Complex, where Ruppia maritima and Zostera marina were present, in particular, the broad shoal area between Smith and Tangier Islands. Eighteen percent (2,035 hectares) of the SAV was present in the Middle Eastern Shore section, primarily in the Barren Island-Honga River area, the Big and Little Annemessex Rivers, and the lower section of the Manokin River, with R. maritima being the dominant species reported for this area. Little or no SAV was mapped or reported from the Central Western Shore, Middle Western Shore, and Patuxent River sections.

The Middle Bay zone also includes the entire Potomac River, where 2,614 hectares of SAV were present in 1989. SAV was concentrated in two distinct zones: 1. the tidal freshwater region (the Upper Potomac River section with 1998 hectares) where H. verticillata remained the numerically dominant species (eight other species were recorded from the USGS and citizen surveys); and 2. the region around the Rt. 301 bridge (the upper portion of the Lower Potomac River section with 616 hectares), including the Nanjemoy and Port Tobacco Creeks, with V. americana and M. spicatum being reported

the most frequently reported species in this area. Although the total abundance of SAV in the upper section increased from 1987 (1,665 hectares), many of the very dense beds from the Woodrow Wilson bridge to just below Piscataway Creek declined. The decline was offset by the large increases in SAV from Quantico Creek to Aquia Creek, along both shores.

SAV was abundant throughout the entire Lower Bay zone except for the James River. Forty-five percent of SAV in the Lower Bay zone was found in the Lower Eastern Shore section, around the Fox Islands and the mouths of major creeks (i.e Cherrystone Inlet, Hungars Creek, Mattawoman Creek, Occahannock Creek, Craddock Creek, Pungoteague Creek and Onancock Creek). Along the western shore, SAV was abundant in Mobjack Bay (15% of SAV in the Lower Bay zone), lower York River, Back River and Drum Island Flats area adjacent to Plum Tree Island. Both R. maritima and Z. marina were abundant throughout this zone. R. maritima continued to increase in abundance in both the Piankatank and Rappahannock Rivers. Z. marina is present in several sections resulting from previously successful transplant efforts.

SAV in Chincoteague Bay was little changed in distribution from 1987, with 2,310 hectares reported in 1989. All of the SAV consisted of R. maritima and Z. marina and was located along the eastern side of the bay behind Assateague Island.

ACKNOWLEDGEMENTS

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Acknowledgement would not be complete without commendation for the groups which provided ground truthing of SAV beds which was used in conjunction with interpretation of the 1989 photography. USF&WS conducted a survey and, with the Chesapeake Bay Foundation (CBF), also organized citizens to report locations and species composition of grassbeds around the bay. In addition, members of the Maryland Charterboat Association were funded by the Md.DNR to participate in the ground truthing program and contributed valuable information on location and species composition of SAV beds in Maryland waters. J. Court Stevenson, Bill Dennison, and Lori Staver of the University of Maryland, Horn Point Environmental Laboratory (HPEL), and Stan Kollar of Harford Community College (HCC) provided ground truth information for certain specific regions of the Maryland portion of the Bay.

Nancy Rybicki, R.T. Anderson and Virginia Carter of the U.S. Geological Survey (USGS) provided ground truth information from the Potomac River. Ken Moore, Sheryl Robertson, Sharon Dewing, Gene Silberhorn, Curtis Harper and Betty Berry (VIMS) provided ground truth information for the lower bay.

The production of this report required the dedication of numerous scientists, technicians, artists, photographers, and others. The following people deserve a note of thanks: Linda Hurley and Kathyrn Reshetiloff, US.F&WS; David Bleil, Md.DNR; Rich Batiuk and Rickie Price, USEPA-Chesapeake Bay Program (CBP); Margaret Podlich (CBF). We are especially grateful to the dedicated VIMS personnel who contributed greatly to the production of this report: Jan Hodges, Jennifer Whiting, and Audrey Warner and Leah Nagey for assistance in data collection and compilation; Pat Barthle for computer programming and computer graphics; Harold Burrell, Kay Stubblefield, Diane Bowers, Silvia Motley, and Billy Jenkins for graphic art work on the SAV maps reproduced in Appendix C, and for figure preparation, photography and printing; Ruth Hershner, Valise Jackson, and Janet Walker for word processing; Pat Hall and David Boughan for computer services. Leigh Medford, Photographic Services, Virginia Department of Transportation; Claud Summers, U.S. Geological Survey (USGS), National Cartographic Information Center (NCIC), Mid-Continent Mapping Center; and Craig Breen, Engineering Media Inc., were helpful in the procurement of high quality topo maps and map copies. Air Photographics, Inc., conducted the aerial photographic missions and was responsible for the high quality photographs.

SECTION 1

INTRODUCTION

Submerged aquatic vegetation (SAV) continues to be one of the important living resources of the Chesapeake Bay receiving considerable attention by bay scientists and managers. The recent signing of an SAV management policy by the governors of Virginia, Maryland, and Pennsylvania, and the mayor of Washington, D. C., and the drafting of an SAV implementation plan, indicate the committment of the bay community to preserving, protecting, and enhancing these important systems.

Monitoring of this resource on an annual basis, one aspect supported by the policy, has revealed the dramatic changes occurring with SAV and has served to provide scientists and managers with a synoptic overview of the current abundance on a baywide basis. SAV communities in the entire Chesapeake Bay and tributaries have been photographed, mapped and the areas of the beds digitized in 1978, 1984, 1985, 1986, 1987, and 1989 while portions of the upper bay were mapped and digitized in 1979 and the lower bay was mapped and digitized in 1980 and 1981 (Orth, et. al., 1979; Anderson and Macomber, 1980; Orth, et. al., 1985, 1986, 1987, and 1989). Numerous SAV ground surveys have been conducted but most have been limited to specific sections. No one ground survey has delineated baywide SAV patterns. Aerial photography has proved to be a useful tool in examining SAV distribution patterns and, when combined with appropriate ground data, has provided an accurate, synoptic picture of baywide SAV distribution. The

goal of the 1989 work was to continue the annual monitoring of SAV on a baywide basis using aerial photographic methods with appropriate ground truth to substantiate presence or absence of SAV in particular sections.

SECTION 2

SAV SPECIES

Ten species of submerged aquatic vegetation are commonly found in the Chesapeake Bay and its tributaries. Zostera marina (eelgrass) is dominant in the lower reaches of the bay. Myriophyllum spicatum (water milfoil), Potamogeton pectinatus (sago pondweed), Potamogeton perfoliatus (redhead grass), Zannichellia palustris (horned pondweed), Vallisneria americana (wild celery), Elodea canadensis (common elodea), 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 (Stevenson and Confer, 1978; Orth et al., 1979; Orth and Moore, 1981, 1983). Ruppia maritima (widgeongrass) is tolerant of a wide range of salinities and is found from the bay mouth to the Susquehanna Flats. Approximately eleven other species are only occasionally found, and when present, occur primarily in the middle and upper reaches of the bay and the tidal rivers (Appendix A). Hydrilla verticillata (hydrilla), presently dominates SAV beds in the tidal freshwater reaches of the Potomac River, although it has declined in abundance since 1987. It has also been reported again in 1989 in the Susquehanna Flats where its growth has not been as widespread as in the Potomac River (Kollar, pers. comm.).

SECTION 3

METHODS

Introduction

Black and white aerial photography at a scale of 1:24,000 was the principal source of information used to assess the distribution and abundance of SAV in the Chesapeake Bay, its tributaries, and Chincoteague Bay in 1989. SAV beds mapped from photographs onto United States Geological Survey (USGS) 7.5 minute topographic quadrangles were then digitized, providing a digital data base for analysis of bed area and location. Ground truth information collected in 1989 was mapped onto the same topographic quadrangles.

Aerial Photography

The 1989 SAV photography was obtained by Air Photographics (Martinsburg, WV) using a Wild RC-20 camera, with a 153 mm (6 inch) focal length Aviogon lens, and Agfa Pan 200 film. The camera was mounted in the bottom fuselage of Air Photographics Piper Aztec, a twin engine reconnaissance aircraft. Photography was acquired at approximately 12,000 feet altitude, yielding a 1:24,000 photographic scale.

Flight lines for photography were predetermined by Air Photographics (and approved by the Principal Investigators) to include all areas known to have SAV, as well as those areas which could potentially have SAV (i.e., all areas where water depths were less than 2 m at mean low water), as well as land features necessary as control points for accurate mapping (Fig. 4).

Flight lines were drawn on 1:250,000 scale USGS maps.

Flight lines were prioritized by major sections and dates of flight windows for aerial photography were specified by the Principal Investigators by contract with Air Photographics. Acquisition of photography was timed to occur at peak standing crop of species known to occur in the sections. In addition, specific areas with significant coverage were given priority. Prior documentation and approval by the funding agencies was required to extend dates of flight windows if necessary. Actual dates of acquisition of photography are noted on each quadrangle map in Appendix C.

General guidelines for mission planning and execution (Table 1) address tidal stage, plant growth, sun elevation, water and atmospheric transparency, turbidity, wind, sensor operation, and plotting. Adherence to these guidelines assured acquisition of photography under nearly optimal conditions for detection of SAV, thus insuring accurate photo interpretation.

Quality assurance and calibration procedures are as follows. The altimeter was calibrated by the Federal Aviation Administration annually. Photographic settings were selected with an automatic exposure control. Sun angle was measured with an indicator on the plane. Flight lines were plotted on 1:250,000 scale maps to allow for overlap of photography. To minimize image degradation due to sun glint, the camera was equipped with a computer controlled intervalometer which established 60% line overlap and 20% sidelap. An automatic bubble level held the camera to within one degree

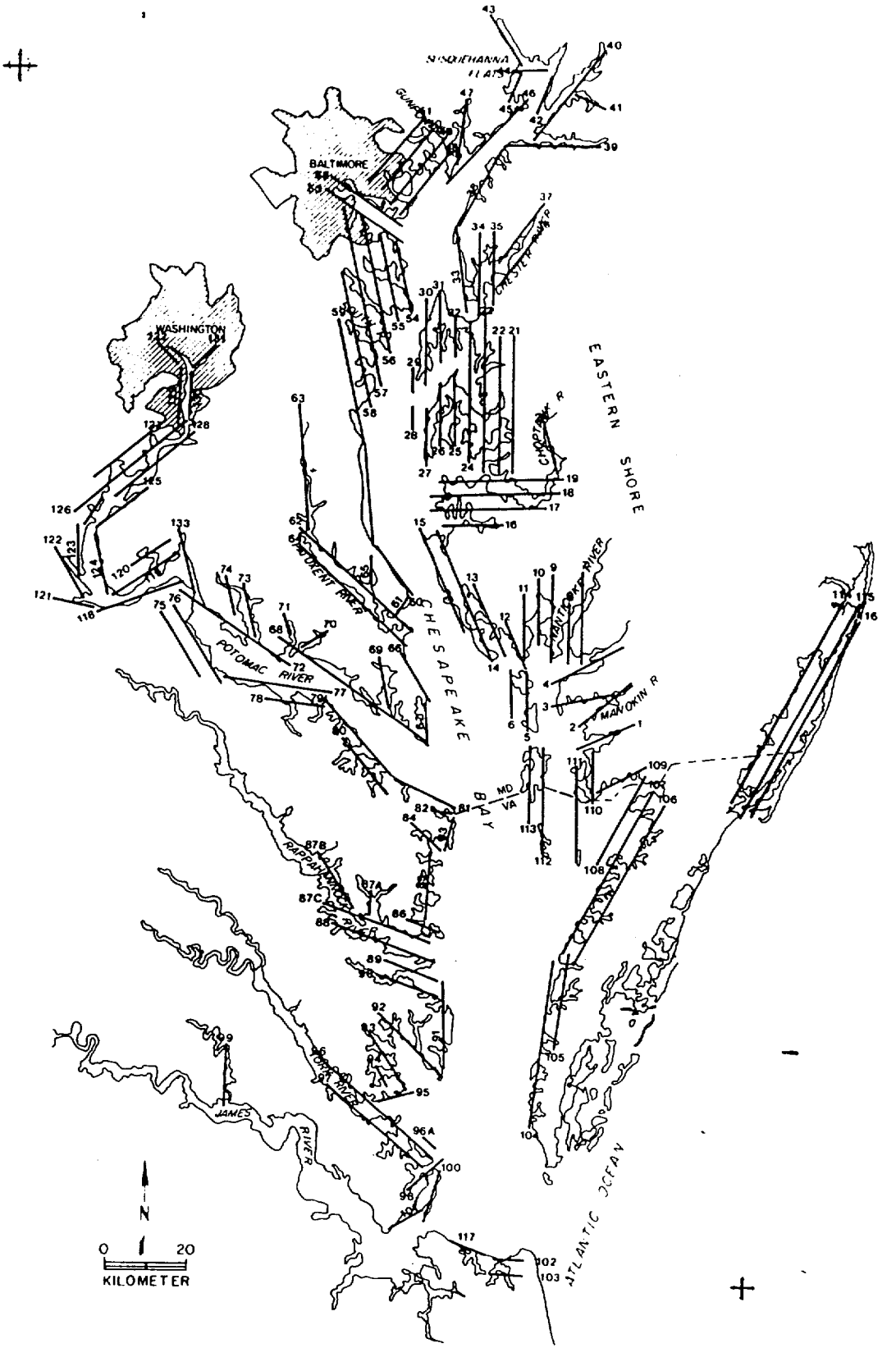

Figure 4. Map of Chesapeake Bay and tributaries with approximate locations of flight lines for 1989 photography.

TABLE 1. GUIDELINES FOLLOWED DURING ACQUISITION OF AERIAL PHOTOGRAPHS.

1. Tidal Stage - Photography was acquired at low tide, +/- 0-1.5 ft., as predicted by the National Ocean Survey tables.

2. Plant Growth - Imagery was acquired when growth stages ensured maximum delineation of SAV, and when phenologic stage overlap was greatest.

3. Sun Angle - Photography was acquired when surface reflection from sun glint did not cover more than 30 percent of frame. Sun angle was generally between 20^{o} and 40^{o} to minimize water surface glitter. At least 60 percent line overlap and 20 percent side lap was used to minimize image degradation due to sun glint.

4. Turbidity - Photography was acquired when clarity of water ensured complete delineation of grass beds. This was visually determined from the airplane to insure that SAV could be seen by the observer.

5. Wind - Photography was acquired during periods of no or low wind. Off-shore winds were preferred over on-shore winds when wind conditions could not be avoided.

6. Atmospherics - Photography was acquired during periods of no or low haze and/or clouds below aircraft. There could be no more than scattered or thin broken clouds, or thin overcast above aircraft, to ensure maximum SAV to bottom contrast.

7. Sensor Operation - Photography was acquired in the vertical mode with less than 5 degrees tilt. Scale/altitude/film/focal length combination permitted resolution and identification of one square meter area of SAV (surface).

8. Plotting - Each flight line included sufficient identifiable land area to assure accurate plotting of grass beds.

tilt. The scale/altitude/film/focal length combination was coordinated to produce two foot resolution. Wind speed was monitored hourly from the flight service available in the region. Under normal operating conditions, flights were usually conducted under wind speeds less than 10 mph. (Above this, wind generated waves stir the bottom sediments which can easily obscure SAV beds in less than one hour.) Pilot experience determined what acceptable level of turbidity would insure complete delineation of SAV beds. At low tide the pilot should have been able to distinguish bottom features such as SAV or algae. When turbid conditions prevailed photography did not commence. Cloud cover did not exceed 5% of the area covered by the camera frame. Determination of cloud cover was based on pilot experience. Records of this parameter were kept in a flight notebook. Every attempt was made to acquire photographs with no cloud cover below 12,000 feet. A thin haze layer above 12,000 feet was generally acceptable. Experience has shown that the optimal conditions given above generally occur two to three days following passage of a cold front when winds have shifted from north-northwest to south and moderated to less than 10 mph. Where possible, and within the guidelines given for prioritizing and executing the photography, flights were planned to coincide with these atmospheric conditions.

Exposed film was processed by Air Photographics. A contact print was produced for each exposed frame. Each photograph was labeled with date of acquisition as well as flight line number. Film and photographs were stored under appropriate environmental conditions to prevent degradation of the product.

Mapping Process

This study utilized USGS 7.5 minute topographic quadrangle maps as a basis for mapping SAV beds from aerial photography, for digitizing the SAV beds, and for compiling SAV bed area measurements. Figure 5 gives locations of topographic quadrangles in the study area which includes all regions with potential for SAV growth. Most quadrangles are sequentially numbered for efficient access to data. The name corresponding to each quadrangle in Figure 5 is listed in Table 2.

Photo interpretation to identify and delineate SAV beds utilized all available information including knowledge of aquatic grass signatures on film, distribution of SAV in 1989 from aerial photography, 1989 ground truth information, and aerial site surveys. USGS published 7.5 minute topographic quadrangle masters (1:24,000 scale) printed by the Mid-continent Mapping Center of the USGS on stable transparent mylar were used as base maps. Identical copies of these base maps were made at the same scale on stable transparent mylar by the Virginia Department of Highways using a diazo process. SAV from the 1989 aerial photographs was mapped onto these diazo copies of USGS topographic quadrangles. Delineation of SAV bed boundaries onto the topgraphic quadrangle maps was facilitated by superimposing the photographic print with the appropriate mylar quadrangle on a light table. SAV boundaries were then traced directly onto the mylar quadrangle with a pencil. Where minor scale differences were evident between a photograph and a quadrangle, or where significant shoreline erosion or accretion had occurred since USGS publication of a map, either a best fit was obtained or shoreline changes were noted on the quadrangle.

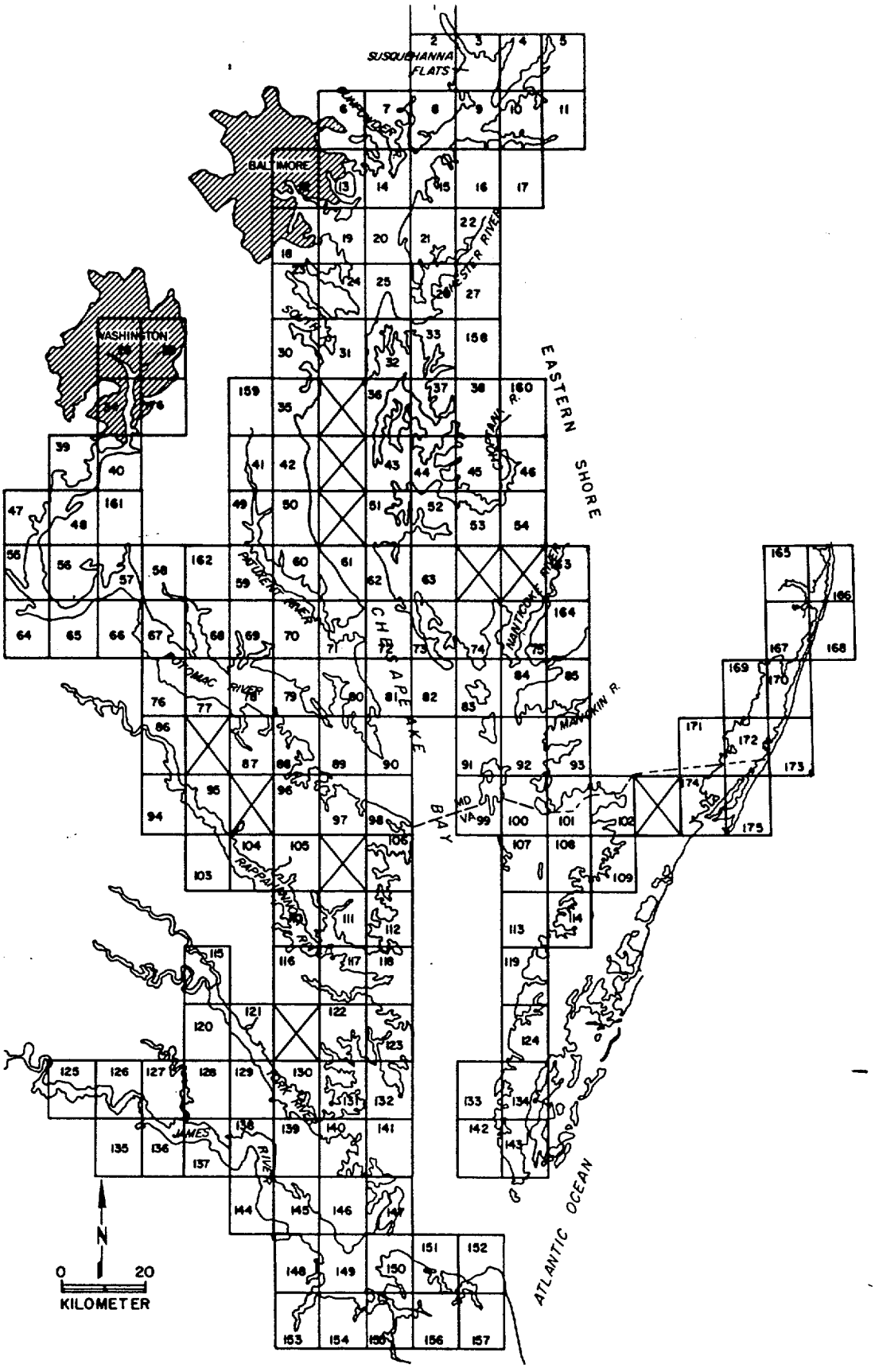

Figure 5. Location of USGS topographic quadrangles in the Chesapeake Bay, its tributaries and Chincoteague Bay.

TABLE 2. LIST OF USGS 7.5 MINUTE QUADRANGLES IN CHESAPEAKE BAY AND CHINCOTEAGUE BAY SAV STUDY AREAS AND CORRESPONDING CODE NUMBERS (SEE FIG. 5 FOR LOCATION OF QUADRANGLES. THOSE TOPOGRAPHIC QUADRANGLES WITH SAV BEDS CAN BE FOUND IN APPENDIX C).

1. Conowingo Dam, Md.-Pa.
2. Aberdeen, Md.
3. Havre de Grace, Md.
4. North East, Md.
5. Elkton, Md.
6. White Marsh, Md.
7. Edgewood, Md.
8. Perryman, Md.
9. Spesutie, Md.
10. Earleville, Md.
11. Cecilton, Md.
12. Baltimore East, Md.
13. Middle River, Md.
14. Gunpowder Neck, Md.
15. Hanesville, Md.
16. Betterton, Md.
17. Galena, Md.
18. Curtis Bay, Md.
19. Sparrows Point, Md.
20. Swan Point, Md.
21. Rock Hall, Md.
22. Chestertown, Md.
23. Round Bay, Md.
24. Gibson Island, Md.
25. Love Point, Md.
26. Langford Creek, Md.
27. Centreville, Md.
28. Washington West, Md.-D.C.-Va.
29. Washington East, D.C.-Md.
30. South River, Md.
31. Annapolis, Md.
32. Kent Island, Md.
33. Queenstown, Md.
34. Alexandria, Va.-D.C.-Md.
35. Deale, Md.
36. Claiborne, Md.
37. St. Michaels, Md.
38. Easton, Md.
39. Fort Belvoir, Va.-Md.
40. Mt. Vernon, Md.-Va.
41. Lower Marlboro, Md.
42. North Beach, Md.
43. Tilghman, Md.
44. Oxford, Md.
45. Trappe, Md.
46. Preston, Md.
47. Quantico, Va.-Md.
48. Indian Head, Va.-Md.
49. Benedict, Md.
50. Prince Frederick, Md.
51. Hudson, Md.
52. Church Creek, Md.
53. Cambridge, Md.
54. East New Market, Md.
55. Widewater, Va.-Md.
56. Nanjemoy, Md.
57. Mathias Point, Md.-Va.
58. Popes Creek, Md.
59. Mechanicsville, Md.
60. Broomes Island, Md.
61. Cove Point, Md.
62. Taylors Island, Md.
63. Golden Hill, Md.
64. Passapatanzy, Md.-Va.
65. King George, Va.-Md.
66. Dahlgren, Va.-Md.
67. Colonial Beach North, Md.-Va.
68. Rock Point, Md.
69. Leonardtown, Md.
70. Hollywood, Md.
71. Solomons Island, Md.
72. Barren Island, Md.
73. Honga, Md.
74. Wingate, Md.
75. Nanticoke, Md.
76. Colonial Beach South, Va.-Md.
77. Stratford Hall, Va.-Md.
78. St. Clements Island, Va.-Md.
79. Piney Point, Md.-Va.
80. St. Marys City, Md.
81. Point No Point, Md.
82. Richland Point, Md.
83. Bloodsworth Island, Md.
84. Deal Island, Md.
85. Monie, Md.
86. Champlain, Va.
87. Machodoc, Va.
88. Kinsale, Va.-Md.
89. St. George Island, Va.-Md.
90. Point Lookout, Md.

TABLE 2. (continued)

91.	Kedges Straits, Md.	134.	Cheriton, Va.
92.	Terrapin Sand Point, Md.	135.	Savedge, Va.
93.	Marion, Md.	136.	Claremont, Va.
94.	Mount Landing, Va.	137.	Surry, Va.
95.	Tappahannock, Va.	138.	Hog Island, Va.
96.	Lottsburg, Va.	139.	Yorktown, Va.
97.	Heathsville, Va.-Md.	140.	Poquoson West, Va.
98.	Burgess, Va.-Md.	141.	Poquoson East, Va.
99.	Ewell, Md.-Va.	142.	Elliotts Creek, Va.
100.	Great Fox Island, Va.-Md.	143.	Townsend, Va.
101.	Crisfield, Md.-Va.	144.	Bacons Castle, Va.
102.	Saxis, Va.-Md.	145.	Mulberry Island, Va.
103.	Dunnsville, Va.	146.	Newport News North, Va.
104.	Morattico, Va.	147.	Hampton, Va.
105.	Lively, Va.	148.	Benns Church, Va.
106.	Reedville, Va.	149.	Newport News South, Va.
107.	Tangier Island, Va.	150.	Norfolk North, Va.
108.	Chesconessex, Va.	151.	Little Creek, Va.
109.	Parksley, Va.	152.	Cape Henry, Va.
110.	Urbanna, Va.	153.	Chuckatuck, Va.
111.	Irvington, Va.	154.	Bowers Hill, Va.
112.	Fleets Bay, Va.	155.	Norfolk South, Va.
113.	Nandua Creek	156.	Kempsville, Va.
114.	Pungoteague, Va.	157.	Princess Anne, Va.
115.	West Point, Va.	158.	Wye Mills, Md.
116.	Saluda, Va.	159.	Bristol, Md.
117.	Wilton, Va.	160.	Fowling Creek, Md.
118.	Deltaville, Va.	161.	Port Tobacco, Md.
119.	Jamesville, Va.	162.	Charlotte Hall, Md.
120.	Toano, Va.	163.	Mardela Springs, Md.
121.	Gressitt, Va.	164.	Wetipquin, Md.
122.	Ware Neck, Va.	165.	Selbyville, Md.
123.	Mathews, Va.	166.	Assawoman Bay, Md.
124.	Franktown, Va.	167.	Berlin, Md
125.	Westover, Va.	168.	Ocean City, Md.
126.	Charles City, Va.	169.	Public Landing, Md.
127.	Brandon, Va.	170.	Tingles Island, Md.
128.	Norge, Va.	171.	Girdle Tree, Md.-Va.
129.	Williamsburg, Va.	172.	Boxiron, Md.-Va.
130.	Clay Bank, Va.	173.	Whittington Point, Md.-Va.
131.	Achilles, Va.	174.	Chincoteague West, Va.
132.	New Point Comfort, Va.	175.	Chincoteague East, Va.
133.	Cape Charles, Va.	176.	Anacostia, D.C.-Md.

In addition to delineating SAV bed boundaries, an estimate of percent cover within each bed was made visually in comparison with an enlarged Crown Density Scale similar to those developed for estimating of forest tree crown cover from aerial photography (Fig. 6). Bed density was classified into one of four categories based on a subjective comparison with the density scale. These were: 1, very sparse (<10% coverage); 2, sparse (10 to 40%); 3, moderate (40 to 70%); or 4, dense (70-100%). Either the entire bed or subsections within the bed were assigned a number (1 to 4) corresponding to the above density categories. Additionally, each distinct SAV unit (bed or bed subsection) was assigned an identifying two letter designation unique to its map. Subsections of beds were further identified as being part of a contiguous bed by the addition of two letters unique to each contiguous bed. These contiguous bed descriptions aid in the tracking of a single bed between quad sheets as well as the analysis of those beds that had to be separated due to variation in SAV density.

SAV Perimeter Digitization and Area Calculation

The perimeters of all SAV beds mapped from the aerial photography were digitized in a clockwise direction using a Numonics Model 2400/2200 DigiTablet Graphics Analysis System having a resolution of .001 inches (.00254 cm) and an accuracy of .005 inches (.0127 cm). Coordinates were transmitted to a PRIME 9955 computer for area calculations and data manipulation via software developed at VIMS. Each SAV bed was digitized at least four times and the area reported as a mean of three.

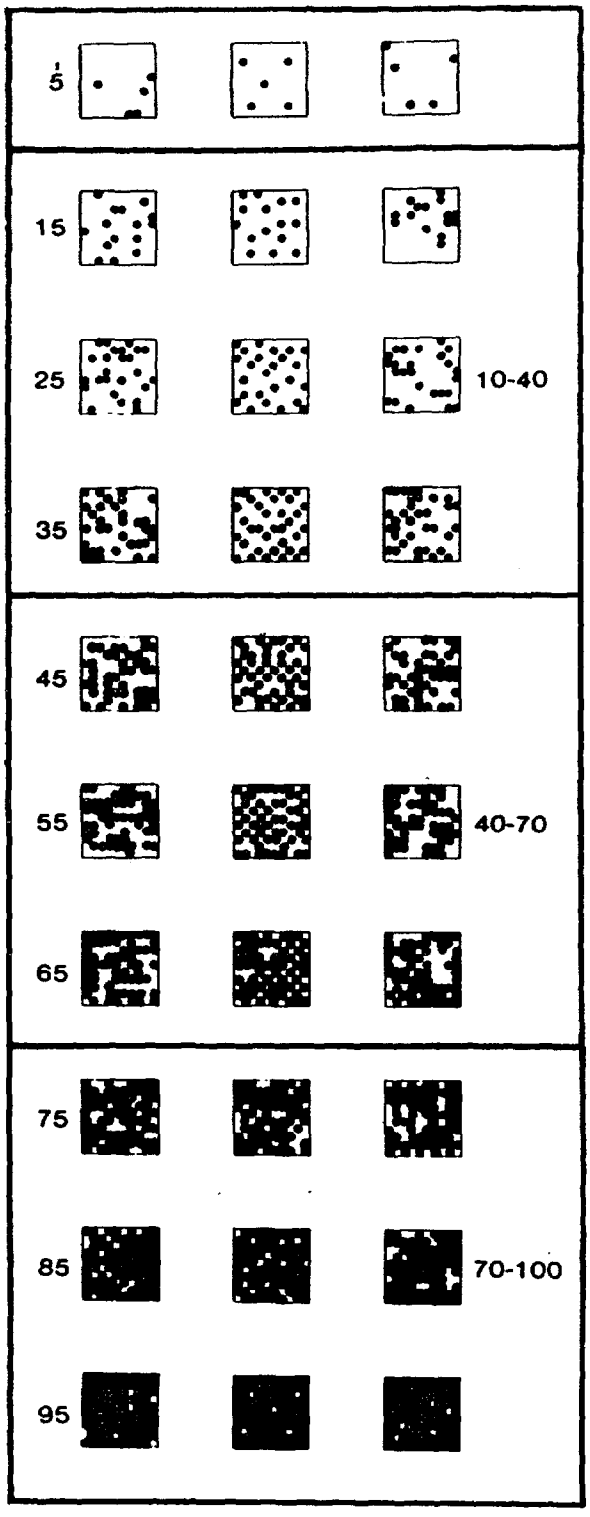

Figure 6. Crown density scale used for determining density of SAV beds: (1) Very sparse, 0-10%; (2) Sparse, 10-40%; (3) Moderate, 40-70%; (4) Dense, 70-100%.

The perimeter of each SAV bed was defined by a polygon with a linear data point density of 127 per chart inch (50 per cm, 5 meter ground resolution). The total number of points defining any SAV bed is dependent on overall bed size. The SAV bed perimeter was stored as X and Y coordinates in centimeters from the quadrangle origin (lower left corner).

Any 'island' within a polygon (digitized SAV perimeter) was disregarded as long as a line was drawn from the outside of the polygon to the 'island' and the resulting polygon was digitized in a clockwise direction. The line connecting the 'island' polygon to the larger surrounding polygon was drawn in by the digitizer operator.

SAV bed area in square centimeters on the chart was calculated via the following equation:

$$A = 1/2 \left| (X_1 * Y_2 - X_2 * Y_1) + (X_2 * Y_3 - X_3 * Y_2) + \ldots + (X_n * Y_1 - X_1 * Y_n) \right|$$

where X_n and Y_n are the nth digitized perimeter points in centimeters. The area is then converted from square centimeters on the chart to square meters on the ground. This is done via the following conversion based on a chart scale of 1:24000:

$$A_g(m^2 \text{on ground}) = A_c(cm^2 \text{on chart}) * 57600\ (m^2 \text{on ground} / cm^2 \text{on chart})$$

where A_g is the area on the ground of each SAV bed and A_c is the area on the chart. The area on the ground is then stored for later use.

Tests of Precision and Accuracy

Prior to each digitization session, the Numonics instrument was checked manually against a digitizing standard. After a map had been secured to the digitizing tablet, the standard was secured to the map and digitized four times. The information from digitizing the standard was transmitted to the beginning of the SAV bed Perimeter File on the PRIME computer. This same procedure was followed at the end of each digitizing session. When this file was processed by the computer, the digitized area of each standard was compared to the known area of the standard. If a variation between the known and the mean of the observed areas exceeded 1.0% a warning was printed advising the operator to check the digitizing system. In addition, checks were made with respect to the absolute location of the digitizing standard as secured to the map. A comparison was made between the location of the standard before and after the digitizing session. If the absolute location differed by more then 0.10 cm another warning to check the system was printed. Any movement in absolute location can be indicative of digitizer instrument drift or chart movement during the digitization session. These checks assure that the final calculated bed locations are as accurate as possible.

Maximum accuracy was maintained by exclusively using mylar topographic quadrangles rather than paper ones which can change scale as a function of changes in air temperature and humidity in the digitizer room .

Calculation of SAV Bed Mean Area and Choice of Representative SAV Bed

Every SAV bed mean area was the result of at least four independent digitizations of the outline of each SAV bed. The computer made an area calculation of each replication and the 3 bed outlines or perimeters most similar in terms of area were then used for the calculation of a mean area. The perimeter defining the area most similar to the mean area was then saved by the computer program as the representative perimeter for this specific SAV bed. Representative perimeters for all 1989 SAV beds were later converted to Latitude and Longitude and a copy of each on computer tape was then cent to the EPA Chesapeake Bay Program. The areas used in the mean area calculation do not by contract requirements have a range in excess of 5% of the mean area. All bed areas having an error rate in excess of 5% are flagged by the VIMS quality assurance quality control computer program for additional error assesment. In fact, the VIMS error rate is normally less than 1%.

A complete outline of the digitization procedure can be found in the quality assurance project plan for the 1989 submerged aquatic vegetation, distribution and abundance survey of the Chesapeake and Chincoteague Bays (available from the EPA Chesapeake Bay Program Office).

Standard Operating Procedures for Quality Assurance/Quality Control

Standard operating procedures (SOPs) were developed to facilitate orderly and efficient processing of the 1989 SAV maps and the SAV bed perimeter computer files produced from them, and to comply with the need for consistency, quality assurance and quality control. SOPs developed include:

a detailed procedure outlining 46 steps for digitization of SAV maps; a 47 step checklist for editing SAV perimeter computer files to insure completeness and accuracy; a digitizer log in which all operations were recorded and dated, and which was used to guide and record editing operations; and a flow chart used to track progress of all operations including all changes in file names. Examples of these SOPs are in the quality assurance project plan for the 1987 submerged aquatic vegetation, distribution and abundance survey of the Chesapeake and Chincoteague Bays.

Conversion of SAV Perimeter Points from X,Y Centimeters to Latitude and Longitude

Before SAV perimeter information was to be exported to the EPA Bay Program, the perimeter points had to be converted from X,Y centimeters to the more generally applicable latitude and longitude. This is done via a three step two dimensional linear interpolation between the four corner points of every quadrangle. At the start of digitization of every chart, the location of each corner point in X,Y cm and in latitude and longitude is recorded at the head of the data file. The corners are numbered:

1 = lower left corner or chart origin

2 = upper left corner

3 = upper right corner

4 = lower right corner

These corner points are then used to convert each individual X,Y perimeter point to latitude and longitude. If additional files are needed

for a given chart, a new set of corner points are digitized and stored at the head of these files.

The steps for the conversion of from X,Y cm to lat. and long. are:

1. Transpose each X,Y perimeter point from the original, non orthogonal (not at right angles) chart axes defined by the original four corner points to a new set of orthogonal chart axes and defined by a new set of four corner points.

2. Calculate centimeter to lat. and long. linear conversion factors from the transposed chart corner points via:

```
XCONV = 0.125 / (XCORNERPOINT(4) - XCORNERPOINT(1))
YCONV = 0.125 / (YCORNERPOINT(2) - YCORNERPOINT(1))
```

Where : XCONV is the X cm to lat,lon conversion factor.
YCONV is the Y cm to lat,lon conversion factor.
0.125 is a constant representing the distance in decimal degrees latitude or longitude between each successive chart corner point.
XCORNERPOINT(#) is the X value in centimeters of the numbered chart corner point.
YCORNERPOINT(#) is the Y value in centimeters of the numbered chart corner point.

3. Perform linear conversions from orthogonal X,Y cm perimeter point to latitude and longitude via the following equations:

YLAT = YCHART(1) + (YPORTH * YCONV)

XLON = XCHART(1) - (XPORTH * XCONV)

WHERE : YLAT is the new Y point in decimal degrees latitude.

XLON is the new X point in decimal degrees longitude.

YCHART(#) is the latitude of the chart corner point.

XCHART(#) is the longitude of the chart corner point.

YPORTH is the Y perimeter point in cm from the orthogonal chart coordinate system.

XPORTH is the X perimeter point in cm from the orthogonal chart coordinate system.

These new Lat,Lon perimeter points are then stored in a special EPA submission file for VIMS SAV Data. The submission file structure is fully documented in the VIMS 1987 QA project plan.

Organizational Provinces for Analysis and Discussion

Discussion of the distribution of SAV in the Chesapeake Bay and tributaries has been organized into three zones as established by Orth and Moore (1982). The area between the mouth of the bay to a line stretching from the mouth of the Potomac River at Smith Point in Virginia to approximately 3 nautical miles south of Tangier Island then extending to the eastern side of the bay to an area just south of the mouth of the Little Annemessex River is referred to as the Lower Bay zone (Fig. 7).

The area between the south shore of the Little Annemessex River and the south shore of the Potomac River to the Chesapeake Bay bridge at Kent Island

is referred to as the Middle Bay zone. The area between the Chesapeake Bay bridge and the Susquehanna Flats is referred to as the Upper Bay zone. The salinity within each zone roughly coincides with the major salinity zones of estuaries: polyhaline (18-25°/oo), Lower zone; mesohaline (5-18°/oo), Middle zone; oligohaline (0.5-5°/oo), Upper zone. Although the major rivers and smaller tributaries of the bay have their own salinity regimes, the distribution of SAV in each river is discussed within the zone where it connects to the bay proper.

In addition, 21 major sections of the bay are identified for more detailed discussion of SAV distribution (Fig. 7, Table 3). These sections, which were first delineated for the 1984 survey (Orth, et. al, 1985) and had been slightly modified for the 1987 survey, denote relatively distinct parts of the bay and its tributaries that are readily identifiable from a map. The section boundaries used for analysis and discussion of the 1989 SAV distribution and abundance data are those used for the 1987 report. Sections 1 through 4 are located in the Upper Bay zone. Sections 5 through 13 are located in the Middle Bay zone, and sections 14 through 21 are located in the Lower Bay zone. Appendix B gives the latitude and longitude of the boundary points of each Chesapeake Bay section in decimal degrees. SAV distribution in Chincoteague Bay is presented and discussed as a separate section.

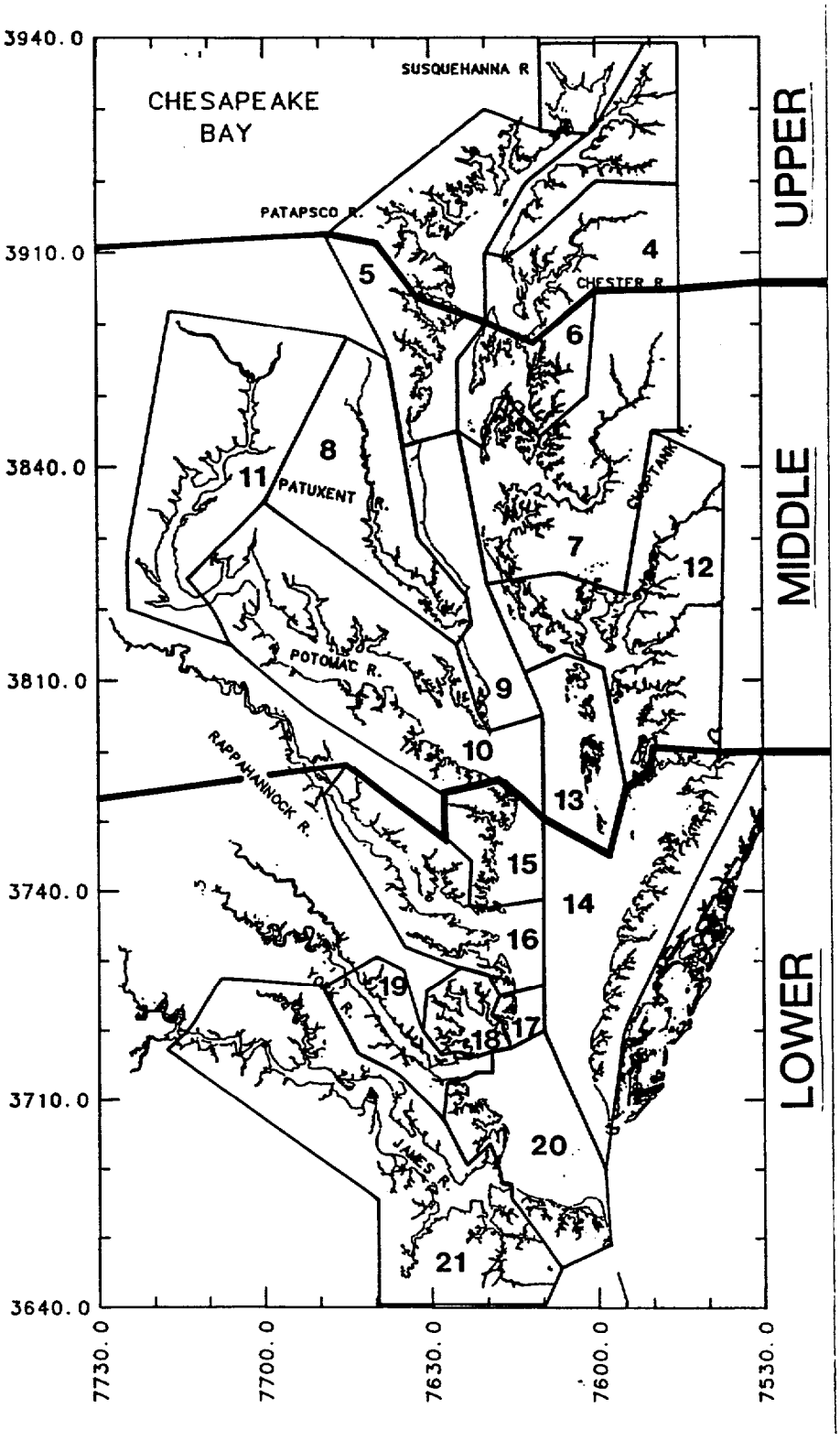

Figure 7. Location of upper, middle and lower zones of the Chesapeake Bay and the 21 major sections used for delineation of SAV distribution patterns. (See Table 3 and Appendix B for exact boundary positions.)

TABLE 3. AREA DESCRIPTION FOR EACH OF 21 MAJOR SECTIONS OF THE CHESAPEAKE BAY SAV STUDY AREA.**

Section 1. Susquehanna Flats - all areas between and including Spesutie Island and Turkey Point at the mouth of the Elk River to include the Northeast River.

Section 2. Upper Eastern Shore - all areas in the Elk, Bohemia and Sassafras Rivers, and SAV in areas on the eastern shore above the Swan Point quadrangle.

Section 3. Upper Western Shore - all areas south of Spesutie Island and north of the bay bridge to include the Bush, Gunpowder, Middle, Patapsco and Magothy Rivers.

Section 4. Chester River - includes all of the Chester River, Eastern Neck, areas north of the bay bridge on Kent Island and south of Swan Point, and to include SAV on the Swan Point quadrangle.

Section 5. Central Western Shore - all areas south of the bay bridge and north of Holland Point on Herring Bay to include the Severn, South and West Rivers and Herring Bay.

Section 6. Eastern Bay - all areas south of the bay bridge on Kent Island and north of Tilghman Island from Green Marsh Point to include the Wye, East and Miles Rivers, Crab Alley Bay, Prospect Bay and Poplar, Jefferson and Coaches Islands.

Section 7. Choptank River - all areas south of Tilghman Island from Green Marsh Point and north of Taylor Island to include the Choptank and Little Choptank Rivers.

Section 8. Patuxent River - all areas in the Patuxent River.

Section 9. Middle Western Shore - all areas south of Holland Point at Herring Bay and north of Point Lookout on the Potomac River but not the mouth of the Patuxent River.

Section 10. Lower Potomac River - all areas between the mouth of the Potomac River to a line extending from Maryland Point on the north shore, just above Nanjemoy Creek, to Somersett Beach on the south shore.

Section 11. Upper Potomac River - all areas from upriver limit of the Lower Potomac River Section to Chain Bridge at Washington D.C.

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continued

TABLE 3.** (continued)

Section 12. Middle Eastern Shore - all areas south of Taylor Island and north of a line bisecting Cedar Island to include the Big and Little Annemessex Rivers, Fishing Bay, and the Honga, Nanticoke, Wicomico and Manokin Rivers.

Section 13. Mid-bay Island Complex - all areas in and adjacent to Bloodsworth, South Marsh, Smith and Tangier Islands.

Section 14. Lower Eastern Shore - all areas south of a line bisecting Cedar Island and located just above the Maryland-Virginia line to Fisherman's Island.

Section 15. Reedville - includes the area between Windmill Point on the Rappahannock River, and Smith Point at the mouth of the Potomac River.

Section 16. Rappahannock River Complex - includes the entire Rappahannock River, Piankatank River and Milford Haven area.

Section 17. New Point Comfort Region - includes the area fronting the bay from the lighthouse at New Point Comfort north to, but not including, the bay entrance to Milford Haven.

Section 18. Mobjack Bay Complex - includes the East, North, Ware and Severn Rivers, the north shore of the Mobjack Bay from New Pt. Comfort lighthouse to the North River, and north of a line bisecting the large shoal area around the Guinea Marsh area.

Section 19. York River - all areas along the north shore from Clay Bank to the Guinea Marsh area and south of a line bisecting the large shoal area around the Guinea Marsh area, and along the south shore to include the north shore of Goodwin Island.

Section 20. Lower Western Shore - includes all areas south of Goodwin Island to Broad Bay off Lynnhaven Inlet, excluding the James River.

Section 21. James River - all SAV in the James River including the Chickahominy River.

**- Sections 12, 13, 14, 18, 19, and 20 were given new boundaries for the 1987 report which also changed the delineation of the three major zones. These new boundaries have been retained for the 1989 report. (See report for these changes and see Figure 7 and Appendix B for boundary locations).

Ground Truth and Other Data Bases

Ground truthing was accomplished by cooperative efforts of a number of agencies and individuals. Although incomplete for most areas, ground truthing confirmed the existence of some SAV beds mapped from 1989 aerial photography, located a few SAV beds not visible from the photography, and provided species data for many of these beds.

For those areas in Virginia waters where aerial photographic evidence of SAV beds was inconclusive, photo-verification was accomplished by ground truthing. Observations were principally made from small boats and by divers snorkeling over areas indicated from the photographs. In several river systems included in this survey (York, Piankatank and Rappahannock) where VIMS researchers transplanted SAV (principally eelgrass), transplant sites also were examined carefully by divers for any extant SAV. Citizen Field Observation data (compiled by the F&WS) were also added to the Virginia maps in Appendix C. In addition, a great deal of ground truth information could be extrapolated from earlier studies (Orth et al., 1979; Orth and Moore, 1982) since SAV beds in this region contain primarily one or two species and have not undergone drastic fluctuations since the first bay-wide survey in 1978.

In Maryland, ground truth data were obtained in 1989 by the USGS Potomac River study, two SAV research and transplanting projects, a F&WS survey, and the Citizen and Charterboat Captain volunteer surveys (both data sets compiled by the F&WS). The field study in the Potomac River by the USGS from D.C. to the 301 bridge near Morgantown, Md. used shoreline surveys

to document the distribution of SAV in the tidal Potomac River and transition zone.

The USGS conducted shoreline surveys in the tidal freshwater portion of the river and tributaries, specifically the majority of the reach between D.C. and Indian Head (quads 40, 34, 28, and 48), from June to August, and, in selected locations further south to Aquia Creek (quad 55), in October of 1989. These surveys were done by boat, using rakes to collect samples to determine presence or absence of SAV. Plants were identified by species and the proportion of each was estimated for vegetated areas. Each vegetated area with species proportions was referenced on USGS 7.5 minute topo maps. The transition zone was surveyed in August for SAV by spot-checking using rakes as described above. Specifically, spot checking was done in the Port Tobacco and Nanjemoy Creek quads. Data from these surveys were transferred to the SAV distribution maps in Appendix C.

>The F&WS personnel surveyed selected locations by boat using rakes to collect samples to determine presence or absence of SAV. Plants collected were identified to species when possible. SAV sitings were referenced on USGS 7.5 minute topo maps along with the sitings reported by the Citizen and Chaterboat Captain surveys. Data from these surveys were transferred to the SAV distribution maps in Appendix C.

>One SAV transplanting project being conducted on the Susquehanna Flats by Stan Kollar of Harford Community College (HCC) provided data in the form of species presence by percentage, primarily by visual estimates. Species locations from these data were added to the SAV maps in Appendix C.

A SAV research group at University of Maryland Horn Point Environmental Laboratory (HPL) headed by Court Stevenson also provided ground truth data.

Maps of their study sites on the Choptank River were annotated on the maps for this report (Appendix C) indicating the species reported for 1989.

In addition to the scientific surveys, private citizens participated in identifying SAV beds by checking areas in the bay for SAV. Two groups were responsible for looking for SAV under the sponsorship of separate organizations. The Maryland Charterboat Association participated in the baywide effort, funded by the Maryland Department of Natural Resources (DNR) Watermen's Assistance Program. Boat captains were provided with reduced SAV quadrangle maps to aid in location of SAV beds and with data sheets on which to record information on each SAV bed identified. Sampling of SAV sites was undertaken at low tide. Samples were taken by hand, net or rake. Plants were identified as to species onsite or placed in zip-lock plastic bags and sent to the DNR for identification. (See maps, Appendix C, for these data.)

Private citizens volunteered to assist in the SAV ground survey under guidance of the United States Fish and Wildlife Service (F&WS) and the Chesapeake Bay Foundation (CBF). This program entailed identifying and recording the location of SAV in the bay. Volunteers were recruited through press releases, newsletters and personal letters. Volunteers, provided with an identification guide of SAV, reduced 1987 SAV maps, and data sheets, visited numerous sites around the bay. Each volunteer was asked to identify the location where SAV was sighted, as well as water conditions, how many and which kind of species, grass bed size, percentage area covered, and location description. All information from the Charterboat Captain's survey and Citizen's survey was submitted to Linda Hurley and Kathy Reshetiloff (F&WS) for processing. Species locations were mapped in Appendix C.

Ground survey information was included on the SAV distribution and abundance maps in Appendix C to show positions of the survey stations in

relation to the beds of SAV mapped from the aerial photographs. Each survey was designated by a unique symbol to identify the different methods. In most cases, the symbols on the SAV maps (Appendix C) have been enlarged and offset from the actual sampling point to avoid confusion with the mapped SAV bed. Where species information was available, it was included on the map unless it was redundant.

SECTION 4

RESULTS

Data Presentation

SAV distribution data are presented by topographic quadrangle (Table 4), by section and zone (Table 5), and by quadrangles within a section (Table 6). Topographic quadrangle maps annotated with all SAV beds are presented in Appendix C, while individual bed areas for each quadrangle are given in Appendix D.

1989 SAV distribution data and species occurrences are first discussed relative to the Upper, Middle, and Lower Bay zones, respectivley. The 21 sections of the Chesapeake Bay, and Chincoteague Bay, are then discussed individually and the data compared to results from the 1987 study of distribution and abundance.

TABLE 4. TOTAL AREA OF SAV IN HECTARES BY TOPOGRAPHIC QUADRANGLES FOR 1978, 1984, 1985, 1986 AND 1987.

	QUADRANGLE	1978	1984	1985	1986	1987	1989
1.	Conowingo Dam, Md.-Pa.	-	-	0	0	-	0
2.	Aberdeen, Md.	-	0	6.34	5.77	4.18	0.66
3.	Havre de Grace, Md.	803.67	1741.85	1605.81	1977.42	1857.89	1835.92
4.	North East, Md.	5.62	13.31	29.46	6.95	5.99	105.51
5.	Elkton, Md.	0.75	0	0	0	0	5.01
6.	White Marsh, Md.	-	0	0	0	0	0
7.	Edgewood, Md.	10.48	49.81+	6.31	+++	0.52	0
8.	Perryman, Md.	-	2.01	4.64	0	2.93	0
9.	Spesutie, Md.	0.84	411.38	439.96	369.54	379.65	187.86
10.	Earleville, Md.	4.67	3.47	11.60	9.72	4.69	97.87
11.	Cecilton, Md.	-	0	0	0	0	0
12.	Baltimore East, Md.	-	0	0	0	0	0
13.	Middle River, Md.	90.06	0	74.80	+++	22.04	3.61
14.	Gunpowder Neck, Md.	200.71	183.99+	132.99	+++	90.54	34.55
15.	Hanesville, Md.	9.31	5.48	10.10	7.70	42.35	12.66
16.	Betterton, Md.	6.40	5.74	12.89	8.40	19.81	1.09
17.	Galena, Md.	1.46	11.88	0.61	10.91	7.57	2.79
18.	Curtis Bay, Md.	33.40	0	0	0	0	0
19.	Sparrows Pt., Md.	10.52	0	5.56	0	#	0
20.	Swan Point, Md.	29.86	18.65	10.25	3.33	1.60	5.24
21.	Rock Hall, Md.	127.25	30.13	14.71	5.97	5.31	19.16
22.	Chestertown, Md.	12.31	0	1.92	0	0	0
23.	Round Bay, Md.	137.15	0	0	0	0	0
24.	Gibson Island, Md.	139.45	7.61	16.07	4.09	0.26	0
25.	Love Point, Md.	11.81	0	3.94	0	0	0
26.	Langford Creek, Md.	1255.20	599.72	586.06	294.89	499.17	138.91
27.	Centreville, Md.	38.75	0	0	0.52	1.45	0
28.	Washington West, Md.-DC-Va.	-	0++	0	0	0	0
29.	Washington East, DC-Md.	-	0	0	0	0	0
30.	South River, Md.	15.14	0	0	0	#	0
31.	Annapolis, Md.	27.15	0	0.28	0.12	#	0

TABLE 4. (continued)

	QUANDRANGLE	1978	1984	1985	1986	1987	1989
32.	Kent Island, Md.	513.68	26.28	48.36	30.80	322.50	327.06
33.	Queenstown, Md.	492.10	89.45	97.9	36.57	216.74	128.32
34.	Alexandria, Va.-DC-Md.	-	160.40	512.70	495.80	470.96	368.43
35.	Deale, Md.	61.51	0	2.43	0.57	#	0
36.	Claiborne, Md.	421.08	52.25	346.69	165.06	136.89	381.67
37.	St. Michaels, Md.	366.09	11.14	223.91	64.03	231.60	172.45
38.	Easton, Md.	1.19	0	14.33	0	0	0
39.	Fort Belvoir, Va.-Md.	-	0.91	1.73	7.16	19.35	63.48
40.	Mt. Vernon, Md.-Va	-	420.34	857.81	1080.23	1056.79	334.65
41.	Lower Marlboro, Md.	-	0	0	0	0	0
42.	North Beach, Md.	-	0	18.88	0	#	0
43.	Tilghman, Md.	478.15	6.87	253.74	37.48	85.45	231.10
44.	Oxford, Md.	562.96	23.25	329.10	51.91	5.51	95.94
45.	Trappe, Md.	64.75	0	33.16	0	#	0
46.	Preston, Md.	-	0	0	0	0	0
47.	Quantico, Va.-Md.	-	0	6.67	19.23	46.27	533.16
48.	Indian Head, Va.-Md.	-	0++	0.21	7.51	17.59	184.02
49.	Benedict, Md.	1.58	0	0	4.23	1.27	0
50.	Prince Frederick, Md.	-	0	0	0	0	0
51.	Hudson, Md.	377.08	4.42	229.75	193.59	167.74	331.38
52.	Church Creek, Md.	208.94	9.00	322.63	141.52	49.46	18.99
53.	Cambridge, Md.	48.96	0	0	0	#	0
54.	East New Market, Md.	-	0	0.75	0	#	0
55.	Widewater, Va.-Md.	-	4.59	38.21	39.36	39.17	466.59
56.	Nanjemoy, Md.	28.03	30.92	106.68	102.74	108.45	149.61
57.	Mathias Pt., Md.-Va.	194.12	121.11	228.66	210.70	284.18	346.70
58.	Popes Creek, Md.	-	0	0	0	#	6.20
59.	Mechanicsville, Md.	13.62	0	0	7.59	2.08	0
60.	Broomes Island, Md.	4.94	4.37	24.71	4.14	20.20	0
61.	Cove Pt., Md.,	2.97	3.75	2.46	0.74	4.62	0.48
62.	Taylors Island, Md.	-	8.55	47.53	12.38	47.47	16.17

TABLE 4. (continued)

	QUANDRANGLE	1978	1984	1985	1986	1987	1989
63.	Golden Hill, Md.	-	0.42	10.90	1.07	2.53	2.49
64.	Passapatanzy, Md.-Va.	-	0	0	0	0	0
65.	King George, Va.-Md.	2.25	13.44	22.15	22.95	16.10	52.25
66.	Dahlgren, Va.-Md.	8.32	2.67	1.97	2.41	14.29	65.33
67.	Colonial Beach N, Md.-Va.	87.44	25.63	15.66	18.42	17.79	28.46
68.	Rock Pt., Md.	22.85	0	0.27	0	0	0
69.	Leonardtown, Md.	2.44	0	0	0	0	0
70.	Hollywood, Md.	-	0	0	1.33	4.97	0
71.	Solomons Island, Md.	10.54	0.76	15.52	2.63	8.33	2.96
72.	Barren Island, Md.	-	0	264.99	177.17	269.81	394.52
73.	Honga, Md.	126.94	5.05	178.58	194.48	632.04	773.50
74.	Wingate, Md.	2.64	8.81	97.99	90.83	171.97	369.30
75.	Nanticoke, Md.	-	0	0	0	0	5.02
76.	Colonial Beach S., Va.-Md.	61.95	11.26	0	0	0	0
77.	Stratford Hall, Va.-Md.	5.53	2.16	0	0	0	0
78.	St. Clements Is., Va.-Md.	0.13	0	0	0	0	0
79.	Piney Point, Md.-Va.	-	-	0.51	1.51	0	0
80.	St. Marys City, Md.	-	-	19.01	16.66	10.48	0
81.	Point No Point, Md.	-	-	16.50	0	0	0
82.	Richland Pt., Md.	0.73	0.38	24.28	3.76	42.46	24.03
83.	Bloodsworth Island, Md.	66.07	18.29	285.53	385.28	555.76	686.76
84.	Deal Island, Md.	3.01	0	16.65	60.48	60.24	27.38
85.	Monie, Md.	9.15	0	1.93	18.69	24.60	17.84
86.	Champlain, Va.	-	-	0	-	-	0
87.	Machodoc, Va.	-	-	0	0	0	0
88.	Kinsale, Va.-Md.	-	-	0	0	0	0
89.	St. George Island, Va.-Md.	-	-	8.82	6.91	5.73	2.84
90.	Point Lookout, Md.	-	-	5.76	0.58	0	0
91.	Kedges Straits, Md.	156.09	366.42	474.91	637.99	693.37	781.29
92.	Terrapin Sand Point, Md.	314.48	187.00	180.48	209.35	93.26	218.22
93.	Marion, Md.	289.33	0	200.29	243.13	160.14	202.27

TABLE 4. (continued)

	QUANDRANGLE	1978	1984	1985	1986	1987	1989
94.	Mount Landing, Va.	-	-	-	-	-	-
95.	Tappahannock, Va.	-	-	-	-	-	-
96.	Lottsburg, Va.	-	-	-	0	-	0
97.	Heathsville, Va.-Md.	-	-	-	0	0	0
98.	Burgess, Va.-Md.	-	-	-	0	0	0
99.	Ewell, Va.-Md.	1483.30	2308.58	2129.67	2324.36	2012.93	2423.93
100.	Great Fox Is., Va.-Md.	540.65	807.81	1074.25	1362.12	1089.95	1381.80
101.	Crisfield, Va.-Md.	7.48	113.01	79.22	180.46	123.22	202.04
102.	Saxis, Va.-Md.	-	-	-	-	0	2.08
103.	Dunnsville, Va.	-	-	-	-	-	-
104.	Morattico, Va.	-	-	0	-	0	0
105.	Lively, Va.	-	-	0	-	0	0
106.	Reedville, Va.	230.40	108.56	51.17	71.28	87.99	157.88
107.	Tangier Island, Va.	405.06	614.44	613.55	651.89	499.15	696.00
108.	Chesconessex, Va.	482.54	808.61	827.28	920.15	911.70	972.11
109.	Parksley, Va.	80.35	264.80	241.16	318.28	235.80	320.19
110.	Urbanna, Va.	-	-	-	-	36.16	200.66
111.	Irvington, Va.	5.31	9.33	8.26	7.50	97.34	245.43
112.	Fleets Bay, Va.	133.23	155.45	120.91	132.88	235.67	334.59
113.	Nandua Creek, Va.	184.86	345.10	350.51	375.97	378.70	406.24
114.	Pungoteague, Va.	401.63	716.76	691.94	706.23	696.73	795.06
115.	West Point, Va.	-	-	-	-	-	-
116.	Saluda, Va.	-	-	-	-	0	19.08
117.	Wilton, Va.	10.43	0	0	-	26.75	43.07
118.	Deltaville, Va.	59.43	6.62	0.70	0.52	18.88	81.06
119.	Jamesville, Va.	406.04	367.36	327.20	404.46	419.53	496.41
120.	Toano, Va.	-	-	-	-	-	-
121.	Gressitt, Va.	-	-	-	-	-	0
122.	Ware Neck, Va.	256.00	203.15	171.91	168.59	194.32	278.08
123.	Mathews, Va.	63.88	30.32	37.39	37.03	58.08	110.18
124.	Franktown, Va.	504.49	395.26	419.66	441.77	392.70	435.85

TABLE 4. (continued)

	QUANDRANGLE	1978	1984	1985	1986	1987	1989
125.	Westover, Va.	-	-	-	-	-	-
126.	Charles City, Va.	-	-	-	-	-	-
127.	Brandon, Va.	-	-	-	++++	0	0
128.	Norge, Va.	46.48	46.48**	46.48**	13.66**	0**	0
129.	Williamsburg, Va.	-	-	-	-	-	-
130.	Clay Bank, Va.	-	-	-	-	0	0
131.	Achilles, Va.	797.92	741.50	710.16	702.91	755.41	963.57
132.	New Point Comfort, Va.	1096.31	1092.71	1154.55	1155.33	1048.89	1264.93
133.	Cape Charles, Va.	321.42	308.32	329.48	255.33	266.42	271.66
134.	Cheriton, Va.	85.20	55.99	63.58	72.74	73.50	73.21
135.	Savedge, Va.	-	-	-	-	-	-
136.	Claremont, Va.	-	-	-	-	-	-
137.	Surry, Va.	-	-	-	-	-	-
138.	Hog Island, Va.	-	-	-	-	-	-
139.	Yorktown, Va.	1.92	0.23	0.21	0.28	0.98	1.58
140.	Poquoson West, Va.	210.44	216.93	237.70	235.96	290.53	412.40
141.	Poquoson East, Va.	516.63	687.16	784.53	762.30	752.42	994.67
142.	Elliotts Creek, Va.	44.58	14.48	8.41	19.91	9.43	15.90
143.	Townsend, Va.	42.70	4.80	17.72	14.42	11.97	12.55
144.	Bacons Castle, Va.	-	-	-	-	-	-
145.	Mulberry Island, Va.	-	-	-	-	-	-
146.	Newport News North, Va.	-	-	-	-	0	-
147.	Hampton, Va.	218.25	233.15	287.10	270.40	283.99	304.05
148.	Benns Church, Va.	-	-	-	-	-	-
149.	Newport News South, Va.	1.87	0	0	-	0	0
150.	Norfolk North, Va.	-	-	-	-	0	0
151.	Little Creek, Va.	-	0	0	-	0	0
152.	Cape Henry, Va.	*	37.87	36.76	43.31	40.50	36.46
153.	Chuckatuck, Va.	-	-	-	-	-	-
154.	Bowers Hill, Va.	-	-	-	-	-	-
155.	Norfolk South, Va.	-	-	-	-	-	-

TABLE 4. (continued)

	QUANDRANGLE	1978	1984	1985	1986	1987	1989
156.	Kempsville, Va.	-	-	-	-	-	-
157.	Princess Anne, Va.	-	-	-	-	-	0
158.	Wye Mills, Md.	-	-	1.10	-	-	0
159.	Bristol, Md.	-	-	2.08	0	#	0
160.	Fowling Creek, Md.	-	-	0	0	-	0
161.	Port Tobacco, Md.	-	-	0	1.10	5.64	12.09
162.	Charlotte Hall, Md.	-	-	0	0	0	0
163.	Mardela Springs, Md.	-	-	0	0	0	0
164.	Wetipquin, Md.	-	-	0	0	0	0
165.	Selbyville, Md.	-	-	-	-	0	0
166.	Assawoman Bay, Md.	-	-	-	-	0	0
167.	Berlin, Md.	-	-	-	-	7.06	4.98
168.	Ocean City, Md.	-	-	-	-	8.42	3.45
169.	Public Landing, Md.	-	-	-	-	0	0
170.	Tingles Island, Md.	-	-	-	852.47	1020.60	820.88
171.	Girdle Tree, Md.-Va.	-	-	-	-	0	0
172.	Boxiron, Md.-Va.	-	-	-	687.95	664.94	653.90
173.	Whittington Point, Md.-Va.	-	-	-	189.94	207.90	161.77
174.	Chincoteague West, Va.	-	-	-	0	0	0
175.	Chincoteague East, Va.	-	-	0	403.57	401.00	665.66
176.	Anacostia, D.C.-Md.	-	-	-	-	#	0
	TOTAL SAV - Chesapeake Bay	16,622.40	15,399.70	19,390.64	19,165.44	20,119.39	26,537.09
	TOTAL SAV - Chincoteague Bay				2,133.93	2,309.91	2,310.52

TABLE 4. (continued)

NOTES:
- \- Indicates quadrangle not photographed and assumed to have no SAV.
- 0 Indicates quadrangle photographed and no SAV noted.
- * Area not flown in 1978 but most likely had SAV in 1978 based on data collected in subsequent years.
- ** Area not photographed in 1984 or 1985. We made the assumption that the 1984 and 1985 distributions would be similar to the 1978 distribution. Area was photographed and mapped in 1986. Area was photographed in 1987 and was known to have SAV in 1987 but was not mapped because SAV beds were too narrow and obscured by the shoreline at 1:24000 scale. In 1987 ground truthing revealed narrow beds fringing the shoreline of small tributaries of the Chickahominy River (see map, Appendix C).
- \+ Information on SAV distribution taken from 1983 aerial photographs provided by Willie Burton of Martin Marietta Corp.
- ++ Presence of SAV beds not detected from 1984 aerial photography. Information provided by Virginia Carter of the USGS for the 1984 Potomac River Shoreline Survey indicated presence of SAV.
- +++ Aerial photography unavailable in 1986, therefore, SAV acreage data not collected. SAV presence verified by ground truth surveys. See 1986 SAV report (Orth, et. al., 1987) for discussion of Section 2, Upper Eastern Shore, and Section 3, Upper Western Shore, in Results, and maps in APPENDIX C.
- ++++ Aerial photography unavailable in 1986, therefore, SAV acreage data not collected. SAV presence verified by ground truth surveys. See 1986 SAV report (Orth, et. al., 1987) for discussion of Section 21, James River, in Results.
- # Presence of SAV beds not detected from 1987 aerial photography. Information provided by Linda Hurley of the USF&WS indicated presence of SAV.

TABLE 5. NUMBERS OF HECTARES OF BOTTOM COVERED WITH SUBMERGED AQUATIC VEGETATION IN 1989 FOR SECTIONS WITHIN THE THREE ZONES OF THE CHESAPEAKE BAY AND IN CHINCOTEAGUE BAY. (Section boundaries redefined for 1987 report. See Figure 7, Table 3 and Appendix B for boundary locations.)

Zone		Section	AREA (HECTARES)
Upper	1.	Susquehanna Flats	1945
	2.	Upper Eastern Shore	307
	3.	Upper Western Shore	38
	4.	Chester River	167
		Zone Total	2,457
Middle	5.	Central Western Shore	0
	6.	Eastern Bay	834
	7.	Choptank River	862
	8.	Patuxent River	3
	9.	Middle Western Shore	0
	10.	Lower Potomac River	269
	11.	Upper Potomac River	1998
	12.	Middle Eastern Shore	2035
	13.	Mid-Bay Island Complex	4415
		Zone Total	10,416
Lower	14.	Lower Eastern Shore	4718
	15.	Reedville	738
	16.	Rappahannock River Complex	669
	17.	New Point Comfort Region	344
	18.	Mobjack Bay Complex	1589
	19.	York River	679
	20.	Lower Western Shore	1670
	21.	James River	4
		Zone Total	10,411
		TOTAL SAV FOR CHESAPEAKE BAY	23,285
		TOTAL SAV FOR CHINCOTEAGUE BAY	2,310

TABLE 6. NUMBER OF SQUARE METERS OF SAV IN 1989 FOR EACH QUADRANGLE CONTAINED WITHIN THE 21 SECTIONS OF THE CHESAPEAKE BAY AND FOR CHINCOTEAGUE BAY. MAP CODE NUMBERS FROM TABLE 2 IN PARENTHESES.

SECTION	QUADRANGLE	AREA	
Susquehanna Flats - 1	Conowingo Dam (1)	0	
	Aberdeen (2)	6,603	
	Havre de Grace (3)	18,355,110	
	North East (4)	0	
	Elkton (5)	0	
	Perryman (8)	0	
	Spesutie (9)	1,087,980	
	Earleville (10)	0	
		19,449,600	sq.m
		1,944.96	hectares
		4,806.00	acres
Upper Eastern Shore - 2	North East (4)	1,055,036	
	Elkton (5)	50,136	
	Perryman (8)	0	
	Spesutie (9)	790,515	
	Earleville (10)	978,678	
	Cecilton (11)	0	
	Gunpowder Neck (14)	0	
	Hanesville (15)	126,610	
	Betterton (16)	10,860	
	Galena (17)	27,884	
	Swan Point (20)	0	
	Rock Hall (21)	30,621	
		3,070,340	sq.m
		307.03	hectares
		758.68	acres
Upper Western Shore - 3	White Marsh (6)	0	
	Edgewood (7)	0	
	Perryman (8)	0	
	Spesutie (9)	0	
	Baltimore East (12)	0	
	Middle River (13)	36,118	
	Gunpowder Neck (14)	345,544	
	Hanesville (15)	0	
	Curtis Bay (18)	0	
	Sparrows Point (19)	0	
	Swan Point (20)	0	
	Round Bay (23)	0	
	Gibson Island (24)	0	

continued

TABLE 6. (continued)

Upper Western Shore - 3 (continued)		
	Love Point (25)	0
		381,662 sq.m
		38.17 hectares
		94.31 acres
Chester River - 4	Betterton (16)	0
	Galena (17)	0
	Swan Point (20)	54,409
	Rock Hall (21)	160,956
	Chestertown (22)	0
	Love Point (25)	0
	Langford Creek (26)	1,389,220
	Centreville (27)	0
	Kent Island (32)	0
	Queenstown (33)	69,034
		1,671,619 sq.m
		167.16 hectares
		413.06 acres
Central Western Shore - 5	Curtis Bay (18)	0
	Round Bay (23)	0
	Gibson Island (24)	0
	South River (30)	0
	Annapolis (31)	0
	Deale (35)	0
	North Beach (42)	0
		0 sq.m
		0 hectares
		0 acres
Eastern Bay - 6	Annapolis (31)	0
	Kent Island (32)	3,270,651
	Queenstown (33)	1,214,291
	Claiborne (36)	2,206,638
	St. Mighaels (37)	1,646,711
	Easton (38)	0
	Tilghman (43)	0
	Oxford (44)	0
		8,338,291 sq.m
		833.83 hectares
		2,060.39 acres

continued

TABLE 6. (continued)

Choptank River - 7	Claiborne (36)	1,607,895
	St. Michaels (37)	77,222
	Easton (38)	0
	Tilghman (43)	2,311,106
	Oxford (44)	959,387
	Trappe (45)	0
	Preston (46)	0
	Hudson (51)	3,313,613
	Church Creek (52)	189,937
	Cambridge (53)	0
	East New Market (54)	0
	Taylors Island (62)	161,654
	Golden Hill (63)	0
	Fowling Creek (160)	0
		8,620,814 sq.m
		862.08 hectares
		2,130.20 acres
Patuxent River - 8	Deale (35)	0
	Lower Marlboro (41)	0
	North Beach (42)	0
	Benedict (49)	0
	Prince Frederick (50)	0
	Mechanicsville (59)	0
	Broomes Island (60)	0
	Cove Point (61)	4,774
	Hollywood (70)	0
	Solomons Island (71)	29,595
	Bristol (159)	0
		34,369 sq.m
		3.44 hectares
		8.49 acres
Middle Western Shore - 9	North Beach (42)	0
	Prince Frederick (50)	0
	Hudson (51)	0
	Broomes Island (60)	0
	Cove Point (61)	0
	Taylors Island (62)	0
	Solomons Island (71)	0
	Barren Island (72)	0
	St. Marys City (80)	0
	Point No Point (81)	0
	Richland Point (82)	0

continued

TABLE 6. (continued)

Middle Western Shore - 9 (continued)		
	Point Lookout (90)	0
		0 sq.m
		0 hectares
		0 acres
Lower Potomac River - 10	Nanjemoy (56)	1,496,092
	Mathias Point (57)	0
	Popes Creek (58)	61,980
	Mechanicsville (59)	0
	King George (65)	147,912
	Dahlgren (66)	653,267
	Colonial Beach North (67)	284,566
	Rock Point (68)	0
	Leonardtown (69)	0
	Hollywood (70)	0
	Solomons Island (71)	0
	Colonial Beach South (76)	0
	Stratford Hall (77)	0
	St. Clements Island (78)	0
	Piney Point (79)	0
	St. Marys City (80)	0
	Machodoc (87)	0
	Kinsale (88)	0
	St. George Island (89)	28,413
	Point Lookout (90)	0
	Lottsburg (96)	0
	Heathsville (97)	0
	Burgess (98)	0
	Port Tobacco (161)	17,165
	Charlotte Hall (162)	0
		2,689,395 sq.m
		268.94 hectares
		664.55 acres
Upper Potomac River - 11	Washington West (28)	0
	Washington East (29)	0
	Alexandria (34)	3,684,402
	Fort Belvoir (39)	634,809
	Mt. Vernon (40)	3,346,106
	Quantico (47)	5,331,638

continued

TABLE 6. (continued)

Upper Potomac River - 11 (continued)			
	Indian Head (48)	1,840,078	
	Widewater (55)	4,666,420	
	Nanjemoy (56)	0	
	Mathias Point (57)	0	
	Passapatanzy (64)	0	
	King George (65)	374,853	
	Dahlgren (66)	0	
	Port Tobacco (161)	103,741	
		19,982,044	sq.m
		1,998.20	hectares
		4,937.56	acres
Middle Eastern Shore - 12	Taylors Island (62)	0	
	Golden Hill (63)	24,915	
	Barren Island (72)	3,945,341	
	Honga (73)	7,734,319	
	Wingate (74)	3,693,344	
	Nanticoke (75)	50,162	
	Richland Point (82)	240,230	
	Bloodsworth Island (83)	782,931	
	Deal Island (84)	273,837	
	Monie (85)	178,368	
	Terrapin Sand Point (92)	118,467	
	Marion (93)	2,022,714	
	Great Fox Island (100)	1,287,101	
	Crisfield (101)	474,794	
	Mardela Springs (163)	0	
	Wetipquin (164)	0	
		20,351,720	sq.m
		2,035.17	hectares
		5,028.91	acres
Mid-Bay Island Complex - 13	Richland Point (82)	0	
	Bloodsworth Island (83)	6,085,111	
	Deal Island (84)	0	
	Kedges Straits (91)	0	
	Terrapin Sand Point (92)	2,063,632	
	Ewell (99)	24,239,832	
	Great Fox Is. (100)	5,314,487	

continued

TABLE 6. (Continued)

Mid-Bay Island Complex - 13 (continued)			
	Tangier Island (107)	6,441,425	
		44,144,480	sq.m
		4,414.45	hectares
		10,908.10	acres
Lower Eastern Shore - 14	Great Fox Island(100)	7,215,881	
	Crisfield (101)	1,436,282	
	Saxis (102)	20,770	
	Tangier Island (107)	518,920	
	Chesconessex (108)	9,721,160	
	Parksley (109)	3,201,754	
	Nandua Creek (113)	4,062,116	
	Pungoteague (114)	7,951,006	
	Jamesville (119)	4,964,022	
	Franktown (124)	4,358,882	
	Cape Charles (133)	2,716,648	
	Cheriton (134)	732,115	
	Elliotts Creek (142)	158,984	
	Townsend (143)	125,531	
		47,184,056	sq.m
		4,718.41	hectares
		11,659.18	acres
Reedville - 15	Heathsville (97)	0	
	Burgess (98)	0	
	Reedville (106)	1,578,771	
	Irvington (111)	2,454,316	
	Fleets Bay (112)	3,345,897	
		7,378,984	sq.m
		737.90	hectares
		1,823.35	acres
Rappahannock River Complex - 16	Tappahannock (95)	0	
	Dunnsville (103)	0	
	Morattico (104)	0	
	Lively (105)	0	
	Urbanna (110)	2,006,669	
	Irvington (111)	2,454,482	
	Fleets Bay (112)	1,212	
	Saluda (116)	190,787	
	Wilton (117)	430,680	
	Deltaville (118)	810,605	
	Ware Neck (122)	0	

continued

TABLE 6. (continued)

Rappahannock River Complex - 16 (continued)			
	Mathews (123)	797,847	
		6,692,292	sq.m
		669.23	hectares
		1,653.66	acres
New Point Comfort Region - 17	Mathews (123)	0	
	New Point Comfort (132)	3,440,852	
		3,440,852	sq.m
		344.09	hectares
		850.23	acres
Mobjack Bay Complex - 18	Ware Neck (122)	2,780,668	
	Mathews (123)	303,972	
	Achilles (131)	6,706,823	
	New Point Comfort (132)	6,102,371	
		15,893,832	sq.m
		1,589.38	hectares
		3,927.37	acres
York River - 19	Toano (120)	0	
	Gressitt (121)	0	
	Williamsburg (129)	0	
	Clay Bank (130)	0	
	Achilles (131)	2,929,100	
	New Pt. Comfort (132)	3,104,722	
	Hog Island (138)	0	
	Yorktown (139)	15,826	
	Poquoson West (140)	740,234	
	Poquoson East (141)	0	
		6,789,882	sq.m
		678.99	hectares
		1,677.78	acres
Lower Western Shore - 20	Poquoson West (140)	3,382,530	
	Poquoson East (141)	9,946,190	
	Elliotts Creek (142)	0	
	Newport News North (146)	0	
	Hampton (147)	3,002,001	
	Norfolk North (150)	0	

continued

TABLE 6. (continued)

Lower Western Shore - 20 (continued)		
	Little Creek (151)	0
	Cape Henry (152)	364,698
	Kempsville (156)	0
	Princess Anne (157)	0
		16,695,418 sq.m
		1,669.54 hectares
		4,125.44 acres
James River - 21	Toano (120)	0
	Westover (125)	0
	Charles City (126)	0
	Brandon (127)	0
	Norge (128)	0
	Williamsburg (129)	0
	Savedge (135)	0
	Claremont (136)	0
	Surry (137)	0
	Hog Island (138)	0
	Yorktown (139)	0
	Bacons Castle (144)	0
	Mulberry Island (145)	0
	Newport News North (146)	0
	Hampton (147)	38,602
	Benns Church (148)	0
	Newport News South (149)	0
	Norfolk North (150)	0
	Little Creek (151)	0
	Chuckatuck (153)	0
	Bowers Hill (154)	0
	Norfolk South (155)	0
	Kempsville (156)	0
		38,602 sq.m
		3.86 hectares
		9.54 acres

continued

TABLE 6. (continued)

Chincoteague Bay	Berlin (167)	49,775
	Ocean City (168)	34,490
	Public Landing (169)	0
	Tingles Island (170)	8,208,322
	Girdle Tree (171)	0
	Boxiron (172)	6,538,884
	Whittington Point (173)	1,617,859
	Chincoteague West (174)	0
	Chinoteague East (175)	6,655,878
		23,105,204 sq.m
		2,310.52 hectares
		5,709.29 acres

DISCUSSION

In 1989, the Chesapeake Bay had 24.412 hectares of SAV, compared to 20,119 hectares in 1987, with 2,457 (10%), 11,544 (47%) and 10,411 (43%) hectares occurring in the Upper, Middle and Lower Bay zones, respectively (Figs. 1 and 2). Seventy-two percent of the SAV is concentrated in the bay from Barren Island-Honga River to the bay mouth, exclusive of the Potomac River (Fig. 3). Forty-nine percent (11,949 hectares) of the SAV was present along the eastern shore (sections 12, 13, and 14) from the Barren Island-Honga River area to just below Cape Charles (Fig. 3)

In the Upper Bay zone 79% of the SAV was located in the Susquehanna Flats section (1945 hectares). Nine species of SAV were documented by ground truth surveys in this section, with Myriophyllum spicatum being the dominant species. Hydrilla verticillata was found in the Flats but occurred in small isolated beds. In addition to the reduced overall abundance of SAV from 1987, beds were generally much less dense, with 95% of all SAV beds classified as very sparse, and no beds classified as dense (70-100% coverage). In the Upper Eastern Shore section (307 hectares), SAV was located principally in the Elk and lower Sassafras Rivers, Swan, Stillpond, and Churn Creeks, with many of the same species as reported in the Susquehanna Flats section. In the Upper Western Shore section (38 hectares), SAV was concentrated in Saltpeter and Seneca Creeks, with M. spicatum and Vallisneria americana being most abundant. In the Chester River section (167 hectares), SAV was most abundant adjacent to Eastern Neck

and Eastern Neck Island and in the lower Chester River. In this region Ruppia maritima was the most abundant of six species which were reported.

In the Middle Bay Zone, 45% (5,196 hectares) of the SAV was found in the Mid-bay Island Complex, where Ruppia maritima and Zostera marina were present, in particular, the broad shoal area between Smith and Tangier Islands. Eighteen percent (2,035 hectares) of the SAV was present in the Middle Eastern Shore section, primarily in the Barren Island-Honga River area, the Big and Little Annemessex Rivers, and the lower section of the Manokin River, with R. maritima being the dominant species reported for this area. Little or no SAV was mapped or reported from the Central Western Shore, Middle Western Shore, and Patuxent River sections.

The Middle Bay zone also includes the entire Potomac River, where 2,614 hectares of SAV were present in 1989. SAV was concentrated in two distinct zones: 1. the tidal freshwater region (the Upper Potomac River section with 1998 hectares) where H. verticillata remained the numerically dominant species (eight other species were recorded from the USGS and citizen surveys); and 2. the region around the Rt. 301 bridge (the upper portion of the Lower Potomac River section with 616 hectares), including the Nanjemoy and Port Tobacco Creeks, with V. americana and M. spicatum being reported the most frequently reported species in this area. Although the total abundance of SAV in the upper section increased from 1987 (1,665 hectares), many of the very dense beds from the Woodrow Wilson bridge to just below Piscataway Creek declined. The decline was offset by the large increases in SAV from Quantico Creek to Aquia Creek, along both shores.

SAV was abundant throughout the entire Lower Bay zone except for the James River. Forty-five percent of SAV in the Lower Bay zone was found in the Lower Eastern Shore section, around the Fox Islands and the mouths of

major creeks (i.e Cherrystone Inlet, Hungars Creek, Mattawoman Creek, Occahannock Creek, Craddock Creek, Pungoteague Creek and Onancock Creek). Along the western shore, SAV was abundant in Mobjack Bay (15% of SAV in the Lower Bay zone), lower York River, Back River and Drum Island Flats area adjacent to Plum Tree Island. Both R. maritima and Z. marina were abundant throughout this zone. R. maritima continued to increase in abundance in both the Piankatank and Rappahannock Rivers. Z. marina is present in several sections resulting from previously successful transplant efforts.

SAV in Chincoteague Bay was little changed in distribution from 1987, with 2,310 hectares reported in 1989. All of the SAV consisted of R. maritima and Z. marina and was located along the eastern side of the bay behind Assateague Island.

1. SUSQUEHANNA FLATS

There were 1945 hectares (4806 acres) of SAV in the Susquehanna Flats section in 1989 (Tables 4-6; Fig. 8; Appendix C, Maps 2, 3, and 9) compared to 2219 hectares mapped in 1987. In addition to the reduced overall abundance of SAV from 1987, beds were generally much less dense (95% of the beds are classified as very sparse, and no beds were classified as dense). SAV beds were located principally in two main areas: 1. very sparse to moderate fringing beds in the Susquehanna River consisting primarily of M. spicatum, with P. pectinatus, C. demersum, V. americana, H. dubia, and N. guadalupensis in lesser amounts from Spencer Island to the river mouth at Havre de Grace on the west side, and to Stump Point at the mouth of Mill Creek on the north side; and 2. a large area of very sparse SAV located in the broad shoal area at the river mouth. This broad shoal consisted

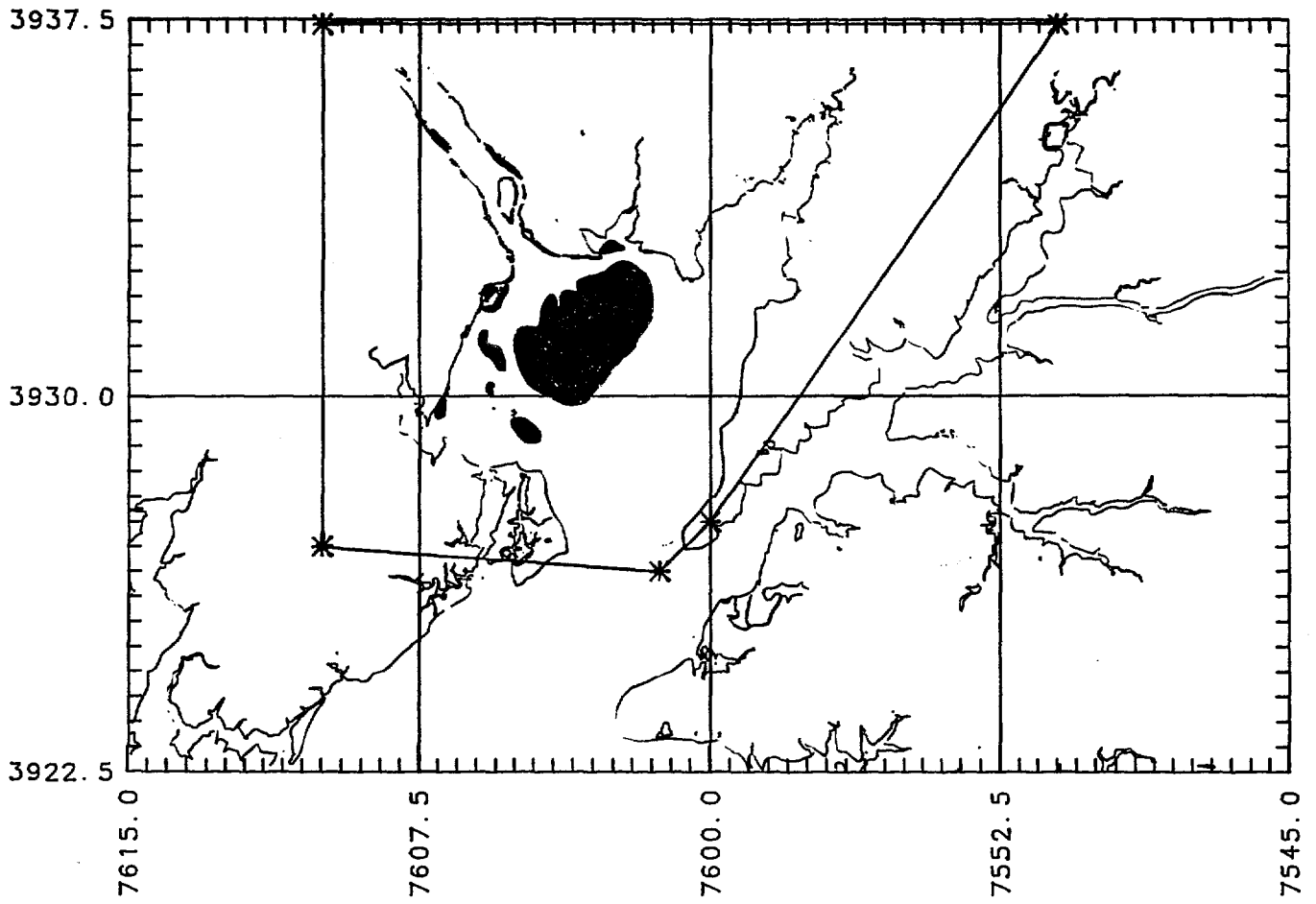

Figure 8. Distribution of SAV in Susquehanna Flats (Section 1).

primarily of small patches of M. spicatum, with P. pectinatus, V. americana, C. demersum and N. guadalupensis.

A total of nine species (M. spicatum, H. dubia, V. americana, H. verticillata, C. demersum, P. pectinatus, N. guadalupensis, P. perfoliatus, and Najas spp.) have been reported either by Stan Kollar of Harford Community College or the Citizen or Charterboat Captains surveys. SAV beds consisted of up to five species, with M. spicatum being dominant. H. dubia, V. americana, H. verticillata and C. demersum also occurred in significant abundance. SAV remains virtually absent from Mill Creek, Furnace Bay, Northwest River, Swan Creek, Spesutie Island and western Elk Neck.

2. UPPER EASTERN SHORE

There were 307 hectares (759 acres) of SAV mapped for the Upper Eastern Shore section in 1989 (Tables 4-6; Fig. 9; Appendix C, Maps 4, 5, 9, 10, 15, 16, 17, and 21), compared to 103 hectares mapped for 1987, consisting of very sparse (35% of the total) to sparse (63% of the total), small beds. Principal locations of beds were in the Elk River, Swan Creek, lower Sassafras River, Stillpond Creek, and the mouth of Churn Creek. Very little SAV was mapped in the Bohemia River and along the mainstem of the bay from Stillpond Creek to Swan Point. This section has contained relatively little SAV since the baywide SAV survey began in 1978, although, historically, this section has contained abundant SAV.

M. spicatum and V. americana were the two most commonly reported species, with seven other species (H. verticillata, C. demersum, P. pectinatus, E. canadensis, Z. palustris, P. crispus, and R. maritima) reported in lesser amounts as determined by the Citizen and Charterboat

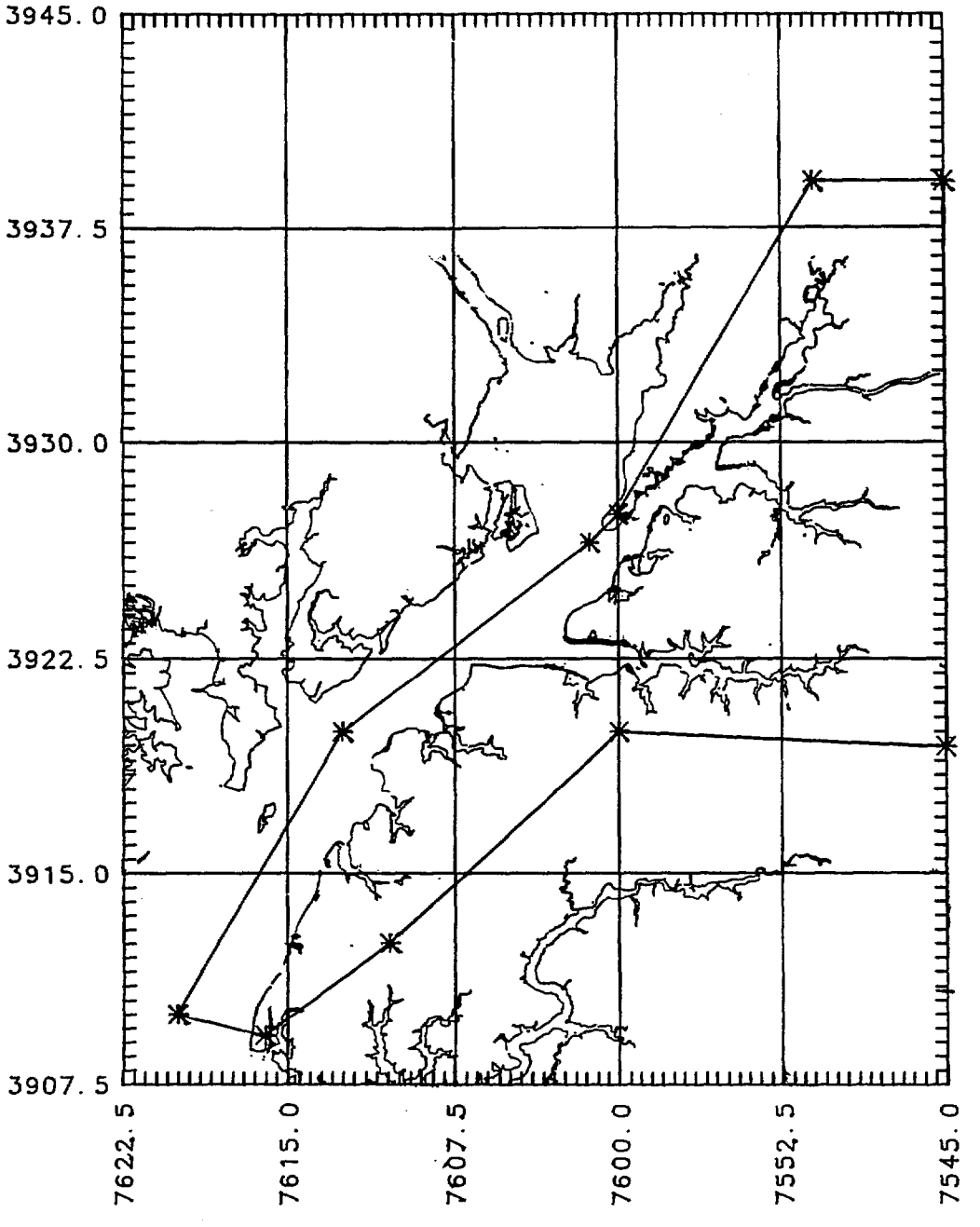

Figure 9. Distribution of SAV in Upper Eastern Shore (Section 2).

Captains surveys.

3. UPPER WESTERN SHORE

There were 38 hectares (94 acres) of SAV mapped from the aerial photographs in 1989 for the Upper Western Shore section (Tables 4-6; Fig. 10; Appendix C, Maps 13 and 14) compared to 117 hectares in 1987. SAV beds were concentrated in Saltpeter and Seneca Creeks. Very little or no SAV was reported in the Back, Patapso, Bush, Gunpowder, Middle, and Magothy Rivers.

M. spicatum, E. canadensis, Z. palustris, P. pectinatus, and C. demersum were reported by the Citizen and Charterboat Captains surveys (maps 7, 18, 19, 23, and 24).

4. CHESTER RIVER

There were 167 hectares (413 acres) of SAV in the Chester River section in 1989 (Tables 4-6; Fig. 11; Appendix C, Maps 20, 21, 26, and 33) compared to 515 hectares in 1987. Most of the SAV was located adjacent to Eastern Neck and Eastern Neck Island, and in the Chester River. Additional beds are found in Rock Hall Harbor, The Haven, Swan and Huntingfield Creeks, located above Eastern Neck on the Chesapeake Bay.

Six species of SAV were reported from this section in 1989 by the Citizen, Charterboat Captains, and U. S. Fish and Wildlife surveys (maps 21 and 26). R. maritima and P. perfoliatus were by far the most commonly reported species in this section with P. pectinatus, M. spicatum, E. canadensis, and Z. palustris being reported less frequently.

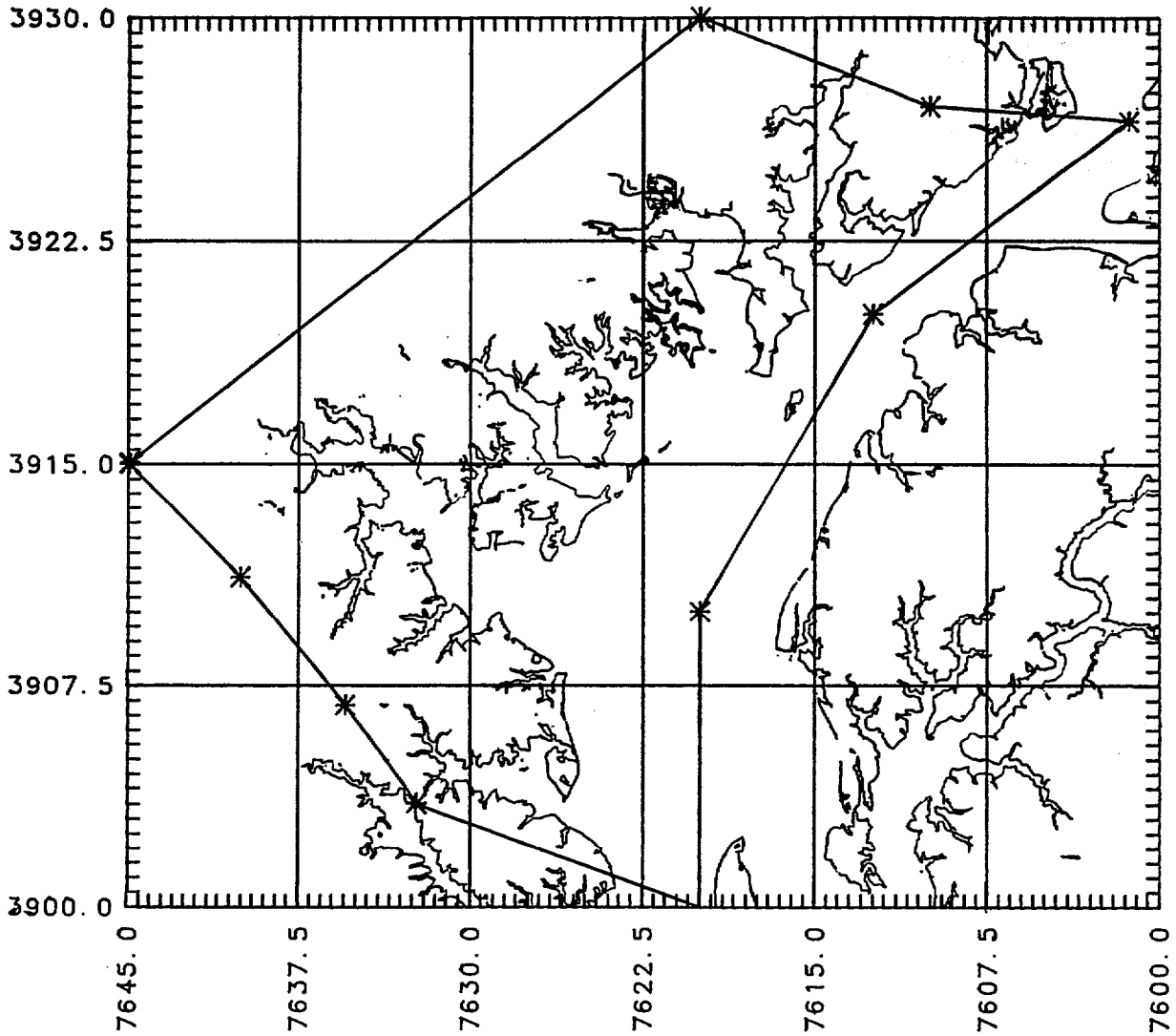

Figure 10. Distribution of SAV in Upper Western Shore (Section 3).

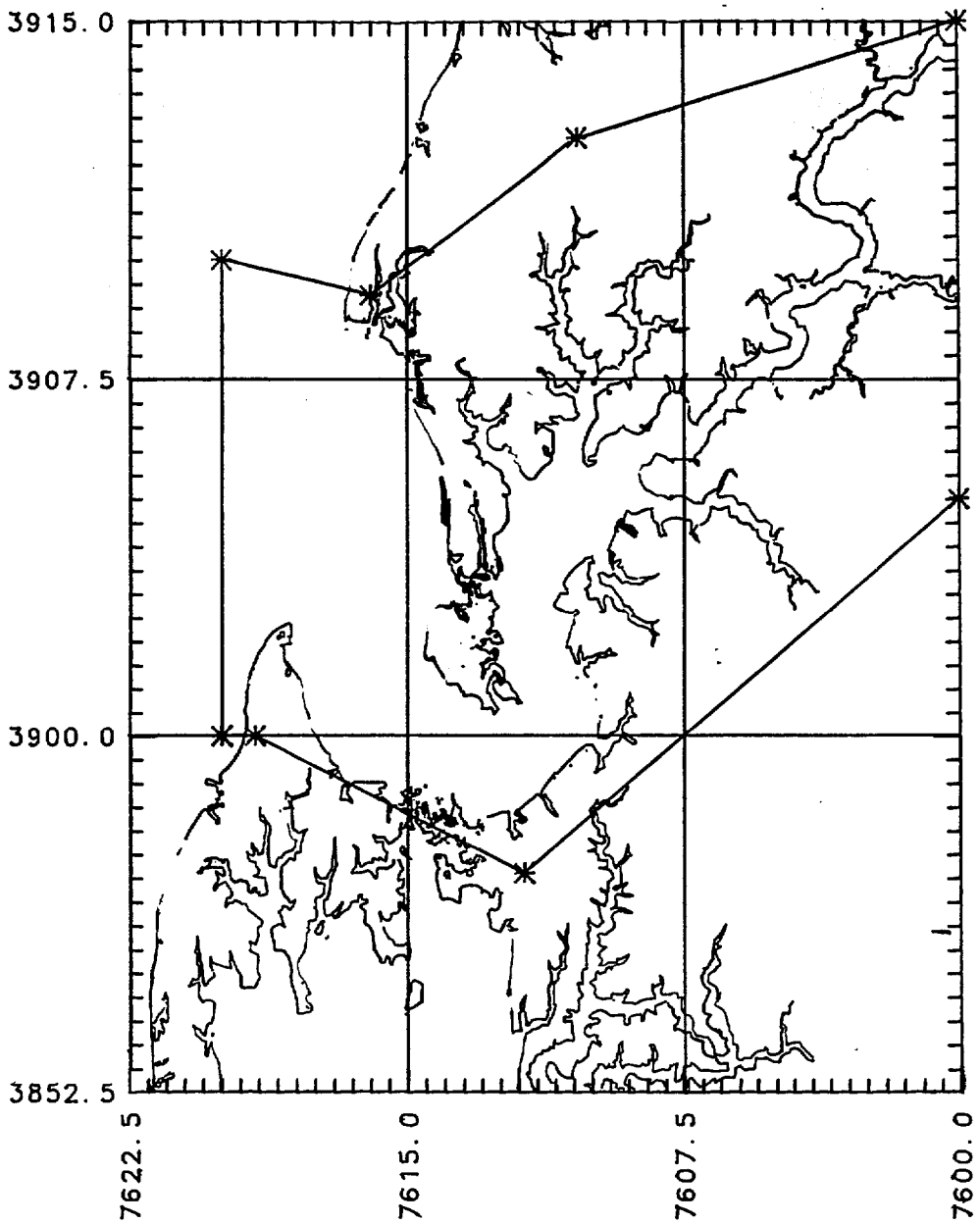

Figure 11. Distribution of SAV in Chester River (Section 4).

5. CENTRAL WESTERN SHORE

There was no SAV observed from the aerial photography in the Central Western Shore section in 1989 (Tables 4-6, Fig. 12) which was similar to 1987. Although not evident in the aerial photography, the Citizen survey reported SAV, primarily P. pectinatus, Z. palustris, and R. maritima, from a few sites in this section (maps 23, 30, 35).

6. EASTERN BAY

There were 834 hectares (2060 acres) of SAV identified from the Eastern Bay section in 1989 (Tables 4-6; Fig. 13; Appendix C, Maps 32, 33, 36, and 37) compared to 900 hectares reported in 1987. SAV occurred as very sparse (13.7% of the total) to sparse (72.1% of the total) beds throughout this section. In 1989, SAV was identified as being particularly abundant along both shorelines in Crab Alley Bay, Prospect Bay, Parson Island, Piney Neck and the lower portion of the Miles River. Little SAV was present from Punch Point on the Western shore of Eastern Bay to Pawpaw Cove on Tilghman Island, as well as in the Miles and Wye River. R. maritima, P. pectinatus, and Z. palustris were reported by the Citizen survey (maps 32, 33, and 37). However, field information from this source as well as the Charterboat Captains survey was very limited compared to previous years.

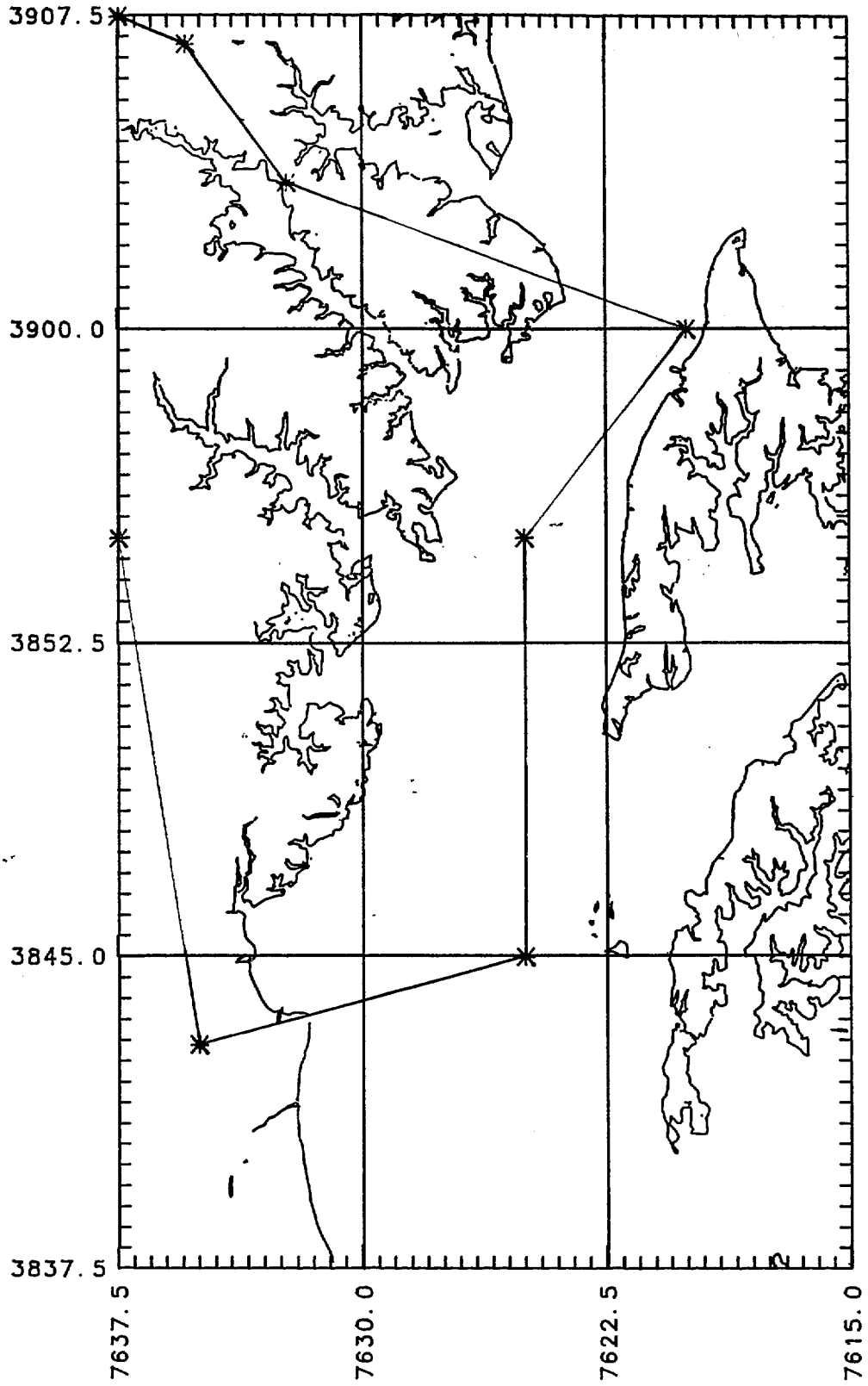

Figure 12. Distribution of SAV in Central Western Shore (Section 5).

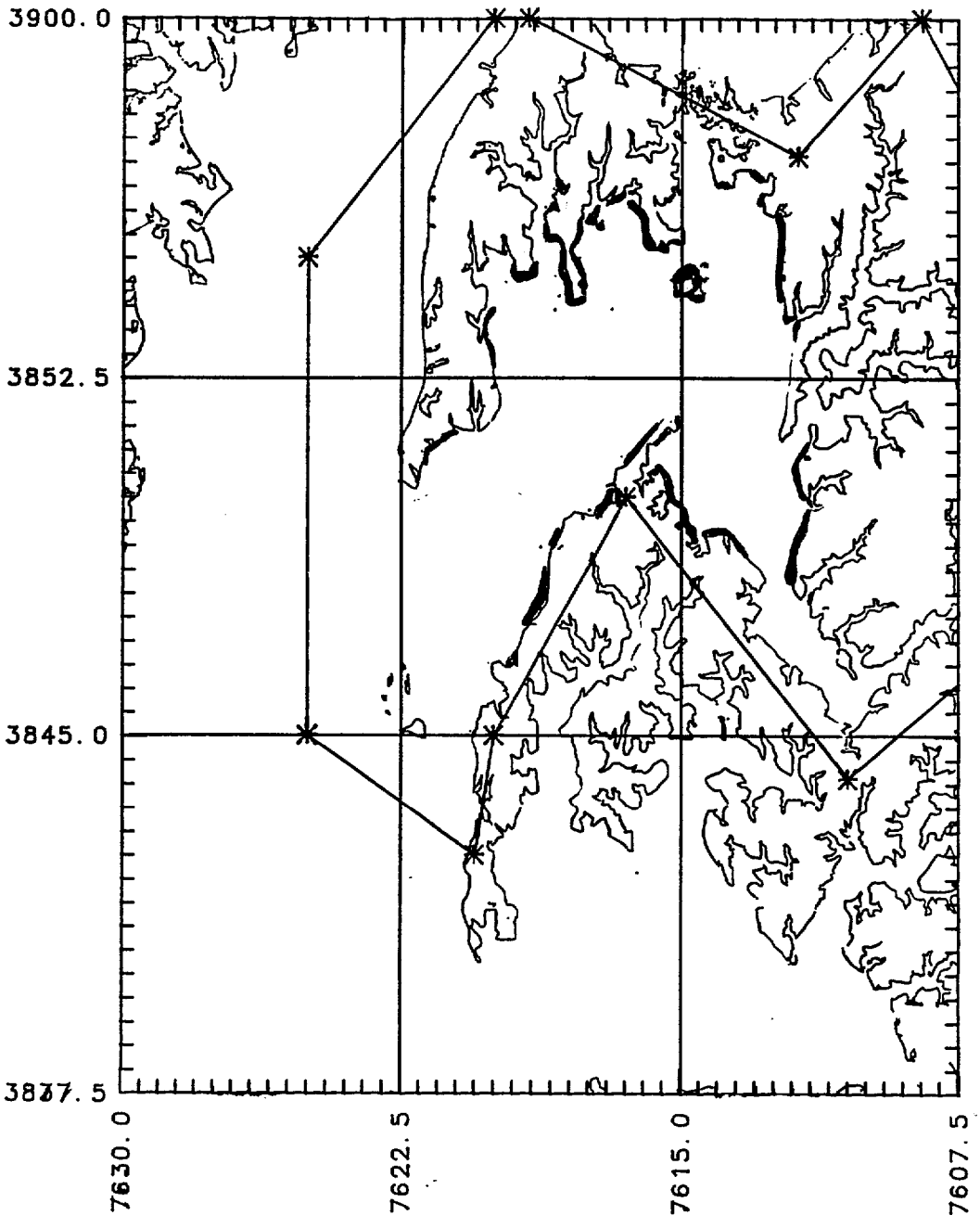

Figure 13. Distribution of SAV in Eastern Bay (Section 6).

7. CHOPTANK RIVER

There were 862 hectares (2129 acres) of SAV observed in the Choptank River section in 1989 (Tables 4-6, Fig. 14; Appendix C, Maps 43, 44, 51, 52, and 62) compared to 356 hectares in 1987. Most of the SAV occurred in sparse (23.9% of the total) to moderate (63.8% of the total) beds in only a few areas. Most of the SAV was found in Harris Creek and Brannock Bay. Other areas were principally along the eastern side of Tilghman Island, the mouth of Chapel Creek, Cook Point Cove, Covey Creek, and Cators Cove. There was little or no SAV in Broad Creek, Tred Avon River and much of the Little Choptank River. Vegetation above Chapel Creek in the Choptank River is sparse but not completely absent.

Ground surveys by Citizen and Charterboat Captains surveys as well as scientists from the University of Maryland's Horn Point Environmental Laboratories, located three species of SAV in this section (maps 36, 43, 44, 51, 52, 62), with R. maritima being the most prevalent. P. pectinatus and Z. palustris were observed in scattered locations.

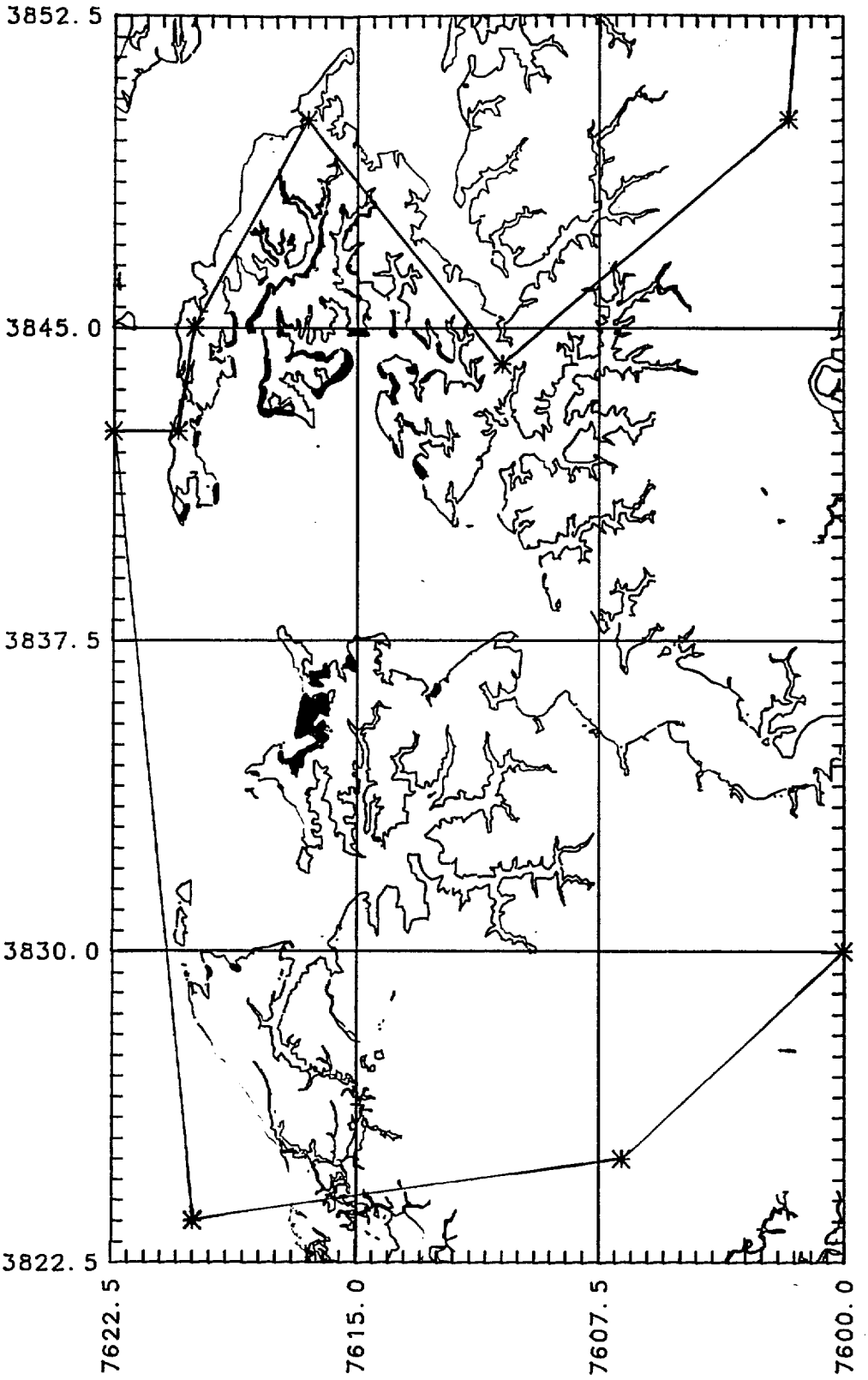

Figure 14. Distribution of SAV in Choptank River (Section 7).

8. PATUXENT RIVER

There were 3 hectares (7 acres) of SAV reported in the Patuxent River section in 1989 (Tables 4-6, Fig. 15) compared to 41 hectares reported in 1987. SAV in the Patuxent River has always been at very low levels of abundance and has not exceeded 50 hectares in any year since the baywide effort began in 1978. There were sporadic sightings of four SAV species in the Patuxent River by the Citizens and Charterboat Captains surveys (maps 49, 60, 61, 70, 71, 159). Those species reported from the lower sections of the river were: Z. palustris, P. pectinatus, M. spicatum, and R. maritima. Species found from the upper sections of the river were V. americana, C. demersum, P. pectinatus, N. guadalupensis, E. canadensis, P. crispus, P. pusillus, and Najas spp.

9. MIDDLE WESTERN SHORE

There were no SAV beds identified in the Middle Western Shore section in 1989 (Tables 4-6, Fig. 16) which was similar to 1987. There were no observations from ground surveys in 1989. Most of the area in this broad section of the bay is of high energy, exposed beaches that are unsuitable for SAV growth. We would therefore not expect large expanses of SAV, rather only small pockets of SAV in creeks or ponds that empty into the bay. Previous surveys have reported no more than 23 hectares of SAV.

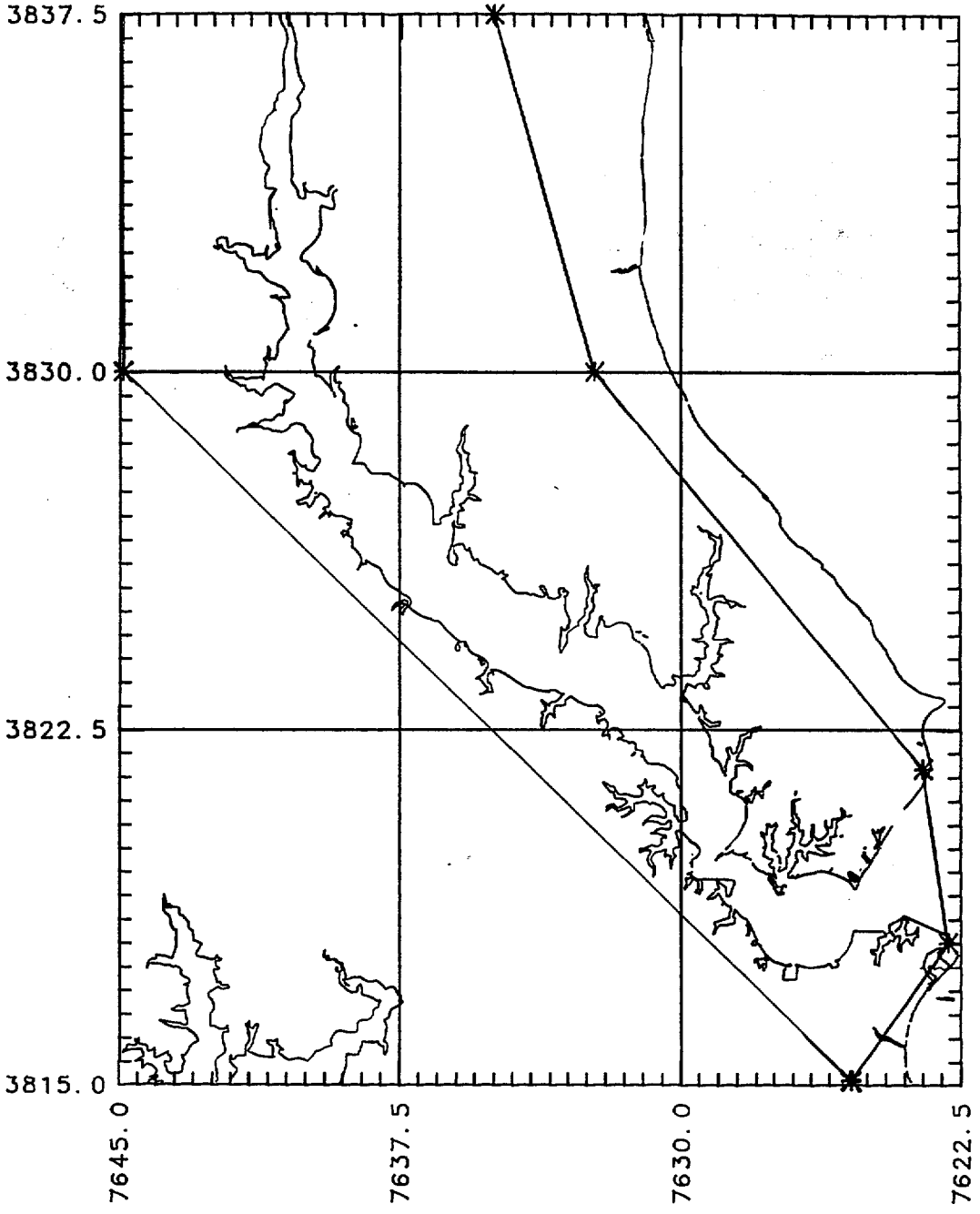

Figure 15. Distribution of SAV in Patuxent River (Section 8).

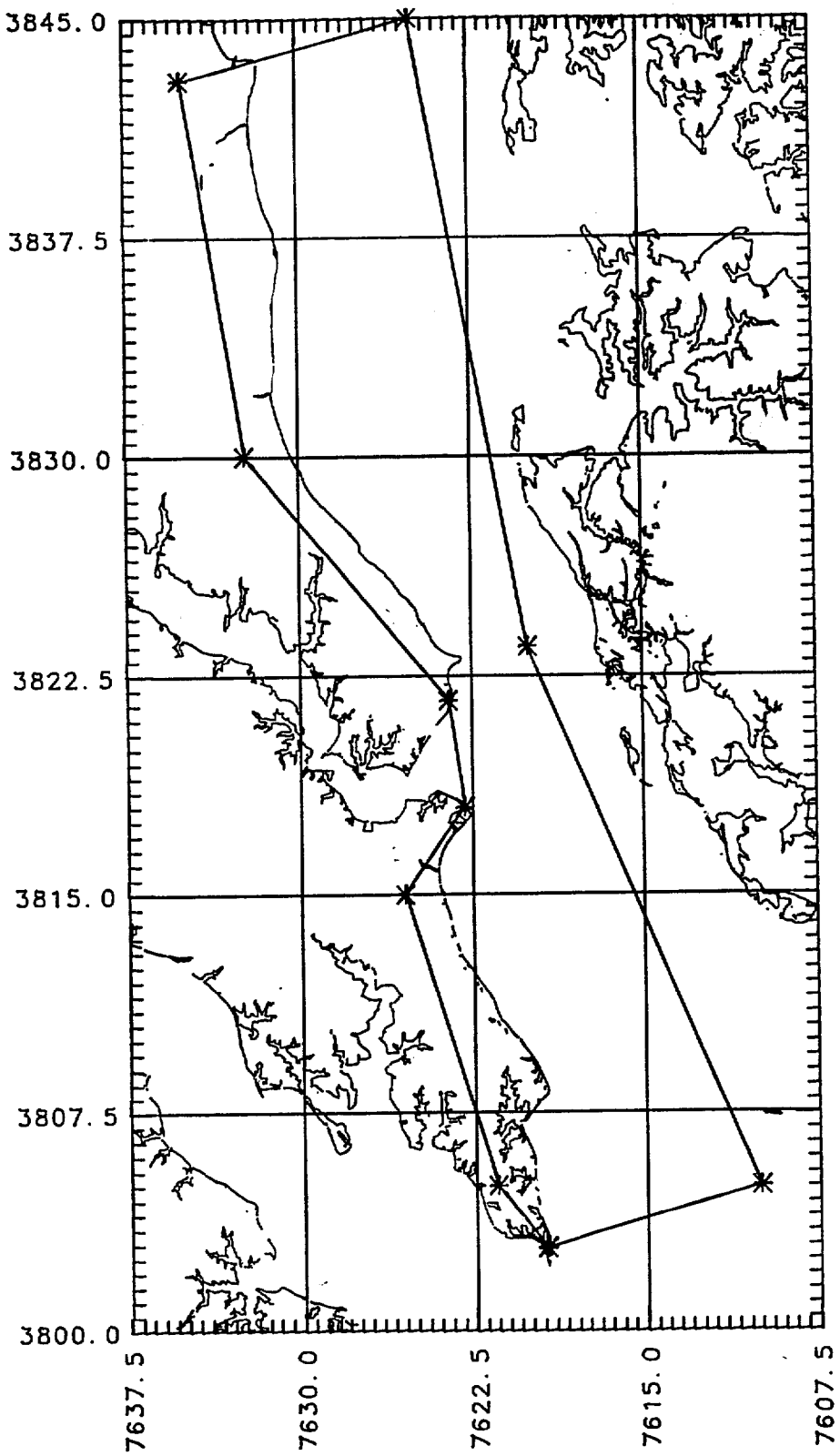

Figure 16. Distribution of SAV in Middle Western Shore (Section 9).

10. LOWER POTOMAC RIVER

There were 616 hectares (1522 acres) of SAV identified in the Lower Potomac River section from the 1989 aerial photography (Tables 4-6; Fig. 17; Appendix C, Maps 56, 57, 65, 66, 67, and 161) compared to 458 hectares reported in 1987. All of the SAV, except for a small bed near the mouth of the St. Mary's river, occurred in the region near the Rt. 301 bridge, in Nanjemoy and Port Tobacco Creeks and in the shoreline adjacent to these two creeks. A majority of SAV beds were densely vegetated (71% in density class 4). SAV beds were identified as fringing along the eastern side of Mathias Point Neck to the Rt. 301 bridge. Several small beds were observed in Machodoc, Rosier, and Cuckhold Creeks, just below the Rt. 301 bridge.

Citizen survey observations were made only in the St. Mary's River (map 80) where R. maritima was the only species present, Herring Creek (Piney Point, map 79) where R. maritima and Z. marina were reported, and in Breton Bay (Leonardtown Quad, map 69) where E. canadensis and P. perfoliatus were observed. U. S. Fish and Wildlife and U.S.G.S. surveys were made in the Port Tobacco River and Nanjemoy Creek (maps 56 and 57). They reported V. americana, M. spicatum, P. perfoliatus, C. demersum, P. pectinatus, Najas spp., P. pusillus, P. crispus, and R. maritima. The U.S.G.S. also reported P. perfoliatus near the 301 bridge on the Virginia side of the Potomac River.

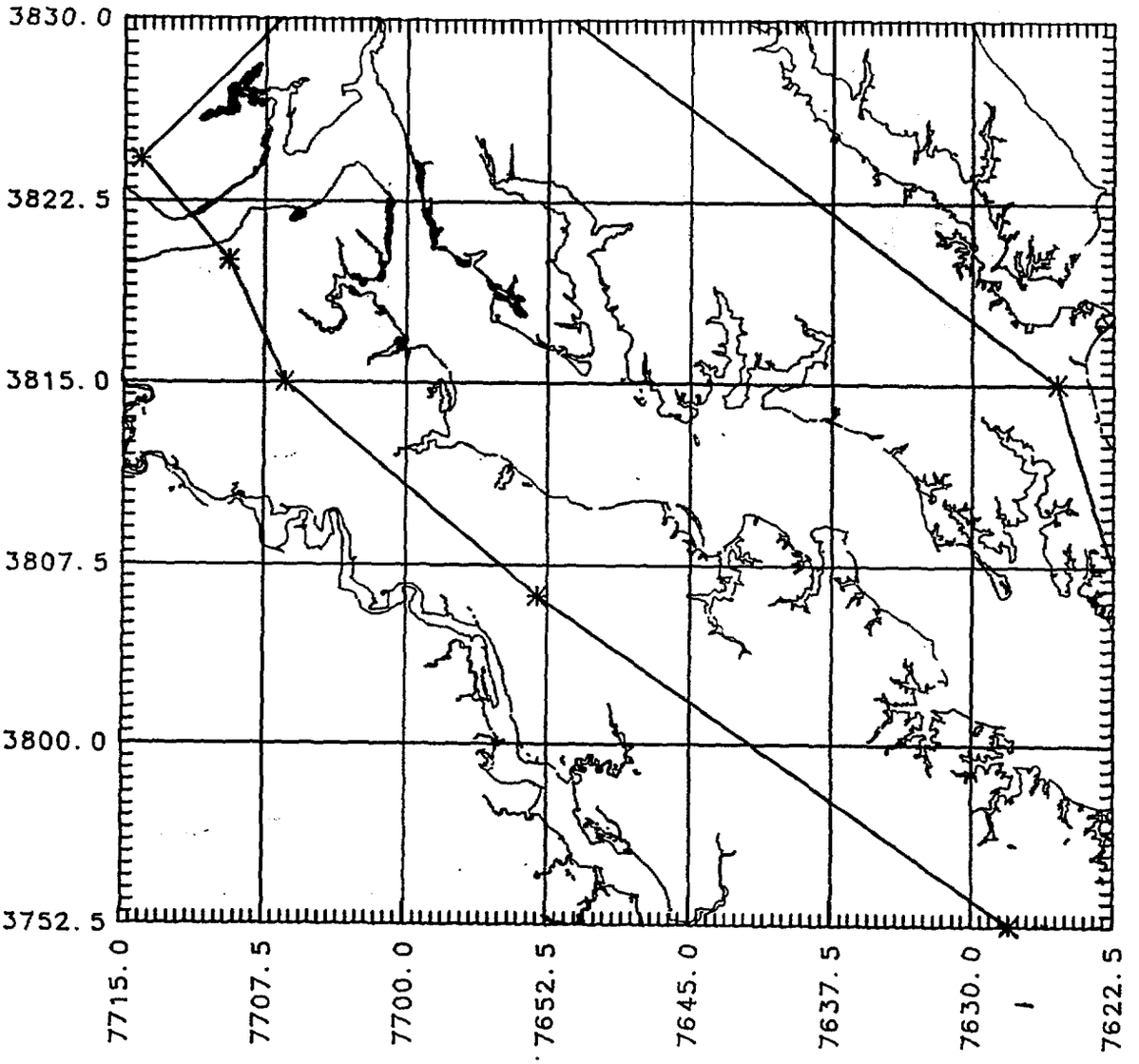

Figure 17. Distribution of SAV in Lower Potomac River (Section 10)).

11. UPPER POTOMAC RIVER

There were 1,998 hectares (4935 acres) of SAV mapped in the Upper Potomac River section (Tables 4-6; Fig. 18; Appendix C, Maps 34, 39, 40, 47, 48, 55, 65, and 161), compared to 1,655 hectares reported in 1987, with 68.6% being densely vegetated (density class 4). Although the total abundance of SAV in this section had increased, many of the dense beds from the Woodrow Wilson Bridge, except the one in the middle of the river, to just below Piscataway Creek, declined. SAV in the Alexandria and Mount Vernon Quadrangles declined 21% and 68% from 1987, respectively. SAV increased from Quantico to Aquia Creek, along both shores, with large increases in the Indian Head (17.6 to 184.0 hectares), Widewater (39.2 to 466.6 hectares), King George (3.6 to 37.4 hectares), and Fort Belvoir (19.3 to 63.5 hectares) quadrangles. SAV is still absent from Occoquan and Belmont Bays and Aquia Creek.

Numerous SAV species were reported by the Citizen survey (maps 39, 40, and 48) which included H. verticillta, M. spicatum, C. demersum, H. dubia, Najas minor, V. americana, P. pectinatus and P. pusillus.

Results from the USGS survey of this region (maps 34, 39, 40, 48, and 55), which was less quantitative than in previous years, were very similar to that reported from the Citizen survey, but also included N. guadilupensis.

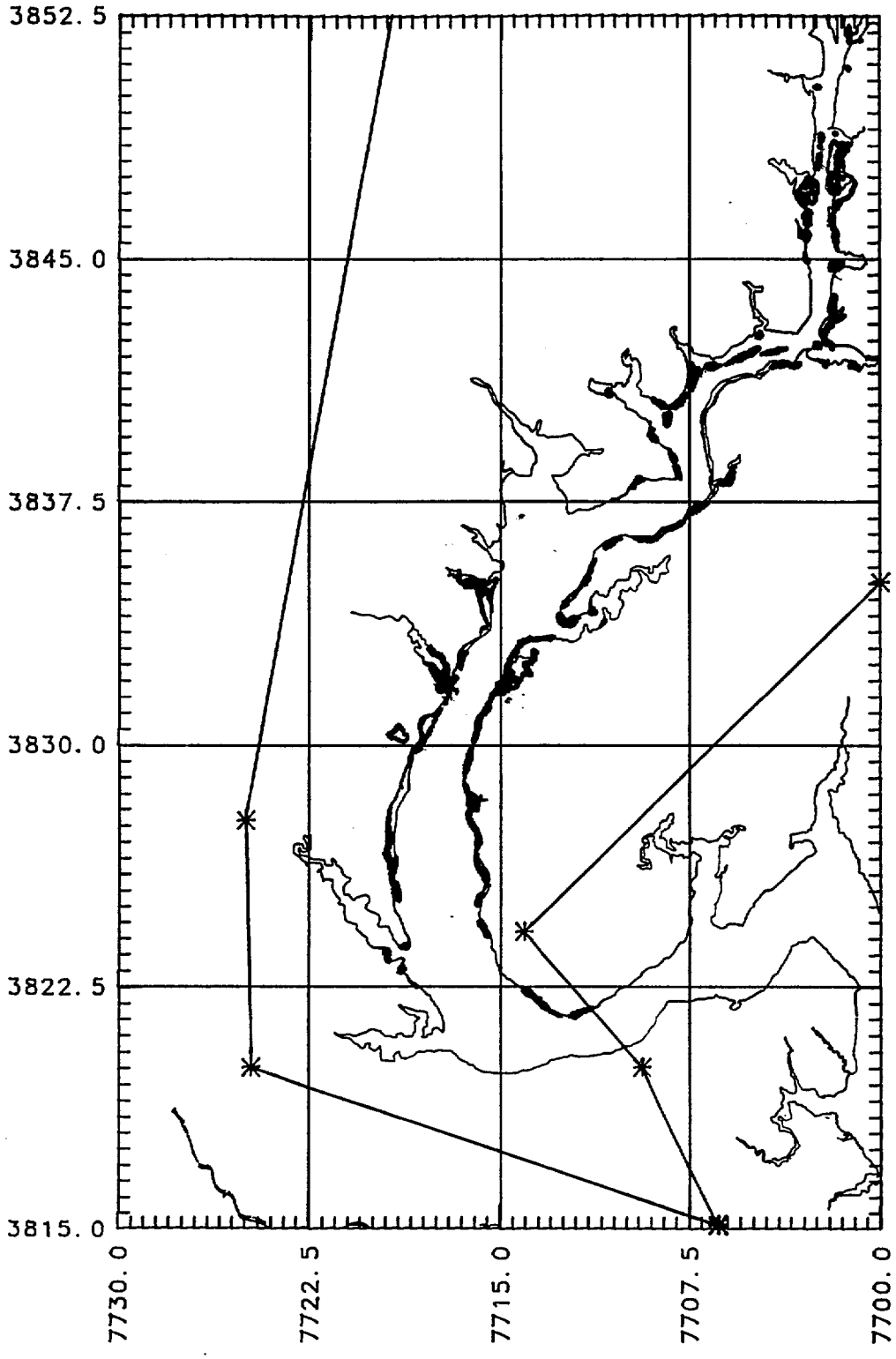

Figure 18. Distribution of SAV in Upper Potomac River (Section 11).

12. MIDDLE EASTERN SHORE

There were 2,035 hectares (5026 acres) of SAV identified in the Middle Eastern Shore section (Tables 4-6; Fig. 19; Appendix C, Maps 63, 72, 73, 74, 82, 83, 84, 85, 92, 93, 100, and 101) compared to 1,527 hectares reported in 1987. SAV beds, of which 64.5% were dense (class 4), 17.4 % moderate (class 3), and 16.5% sparse (class 2), were very abundant in: 1. the lower Honga River adjacent to Middle Hooper Island, Wroten Island, Parks Neck, and Asquith Island; 2. between Barren Island and Meekins Neck-Upper Hooper Island; and 3. the lower Manokin and the Big and Little Annemessex Rivers. Little SAV was observed in Fishing Bay, the Nanticoke and Wicomico Rivers.

R. maritima was the predominant species found by the Citizen and Charterboat Captains surveys (maps 72, 73, 74, 75, 82, 83, 84, 85, 91, 92, 100, and 101). Z. marina was reported from several locations on the Great Fox Island (map 100) and Crisfield (map 101) quadrangles.

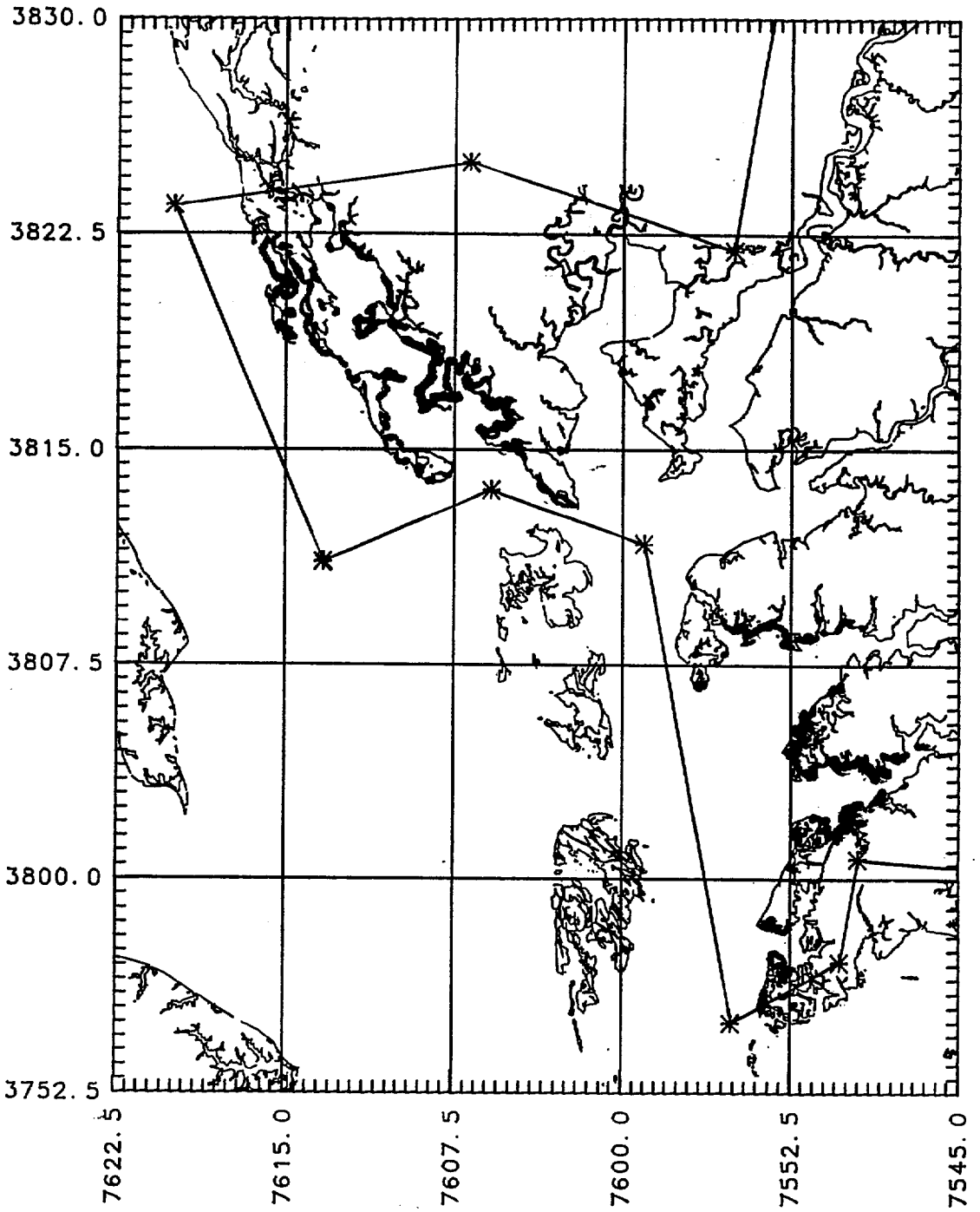

Figure 19. Distribution of SAV in Middle Eastern Shore (Section 12).

13. MID-BAY ISLAND COMPLEX

There were 5,196 hectares (12,834 acres) of SAV mapped in the Mid-Bay Island Complex in 1989 (Tables 4-6; Fig. 20; Appendix C, Maps 83, 91, 92, 99, 100, and 107), compared to 4,265 hectares reported in 1987. This section contains 21.2% of the SAV in the entire Chesapeake Bay. The broad, expansive shoal area between Tangier Island and Smith Island continued to be densely vegetated by both R. maritima and Z. marina, and was by far the largest bed in the Chesapeake Bay. Eighty percent of the SAV was in density class 4.

R. maritima was the species most often reported by the Charterboat Captains survey around these islands, with one report of Z. marina. Previous VIMS surveys had documented much more extensive occurrences of Z. marina.

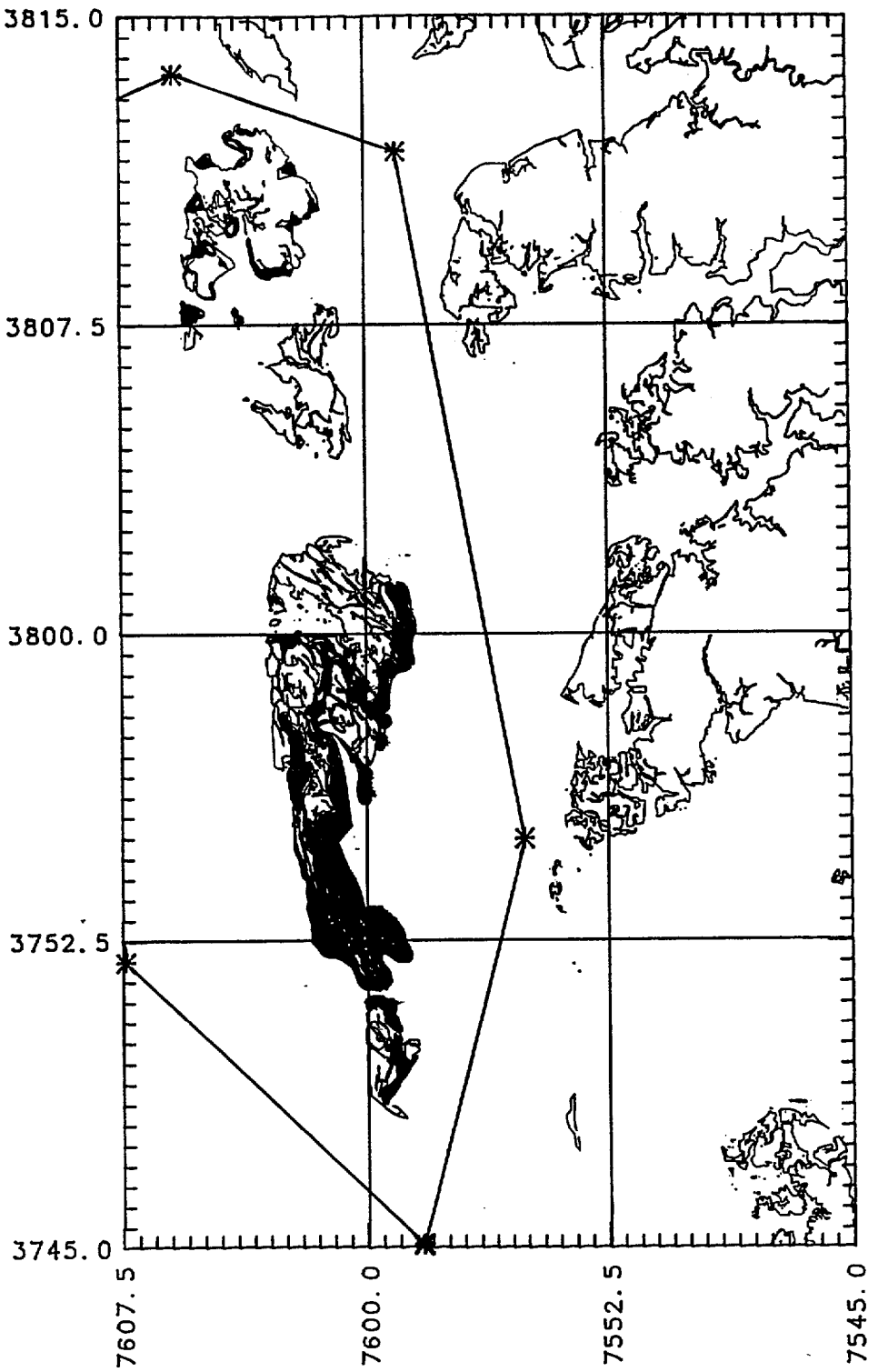

Figure 20. Distribution of SAV in Mid-Bay Island Complex (Section 13).

14. LOWER EASTERN SHORE

There were 4,718 hectares (11,653 acres) of SAV observed in the Lower Eastern Shore section in 1989 (Tables 4-6; Fig. 21; Appendix C, Maps 100, 101, 107, 108, 109, 113, 114, 119, 124, 133, 134, 142, and 143), compared to 4,036 hectares reported in 1987. Large, dense beds (50% of the total SAV is in density class 4) of Z. marina and R. maritima (includes observations from both the Citizen and Charterboat Captains surveys, maps 100, 101, and 133) continue to persist at the mouth of Cherrystone Inlet near Cape Charles, at the mouths of Hungars Creek, Mattawoman Creek, Occahannock Creek, Craddock Creek, Pungoteague Creek, Onancock Creek, and Chesconessex Creek, at the Big Marsh area near Chesconessex Creek, at Webb Island off the mouth of Deep Creek, and on the large shoal area on the eastern side of the Fox Islands. Those areas between the above mentioned creeks were sparsely vegetated. This was due largely to the dynamic and exposed nature of these sites. There was very little SAV in the Pocomoke Sound area, and there was no SAV south of Old Plantation Creek just below Cape Charles.

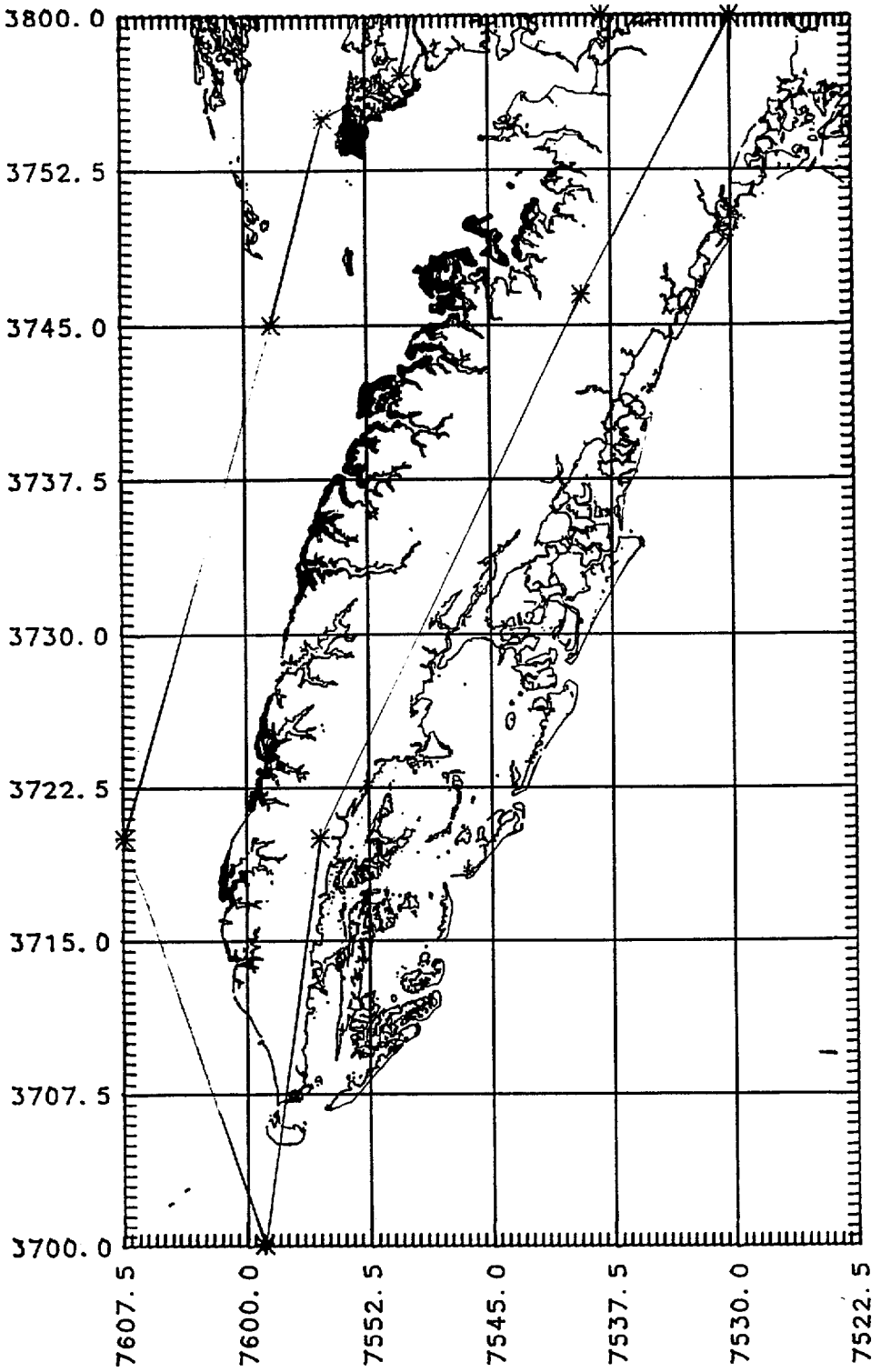

Figure 21. Distribution of SAV in Lower Eastern Shore (Section 14).

15. REEDVILLE

There were 738 hectares (1823 acres) of SAV identified in the Reedville section in 1989 (Tables 4-6; Fig. 22; Appendix C, Maps 106 and 112), compared to 324 hectares reported in 1987. SAV beds consisted of sparse (19% in density class 2), moderate (47% in density class 3), and dense (21% in density class 4) beds of R. maritima and Z. marina (based on prior years scientific and citizens information since there was none for 1989). Most were found in Little Bay, Dymer Creek, Indian Creek, Ball Creek, Dameron Marsh, Fleeton Point and Taskmasker Creek.

16. RAPPAHANNOCK RIVER COMPLEX

There were 669 hectares (1652 acres) of SAV observed in the Rappahannock River Complex in 1989 (Tables 4-6; Fig. 23; Appendix C, Maps 110, 111, 116, 117, 118, and 123), compared to 208 hectares reported in 1987, consisting mostly of sparse to moderate beds (77% in density classes 2 and 3). SAV has continued to rapidly increase in this system since 1986, when only 18 hectares were mapped. R. maritima continues to be the dominant species in both the Rappahannock and Piankatank Rivers. In particular, dense beds of R. maritima were again present in the Corrotoman River (this includes obervations from the Citizen and VIMS surveys). R. maritima was now present in small scattered patches along the north shore of the Rappahannock River above Towles Point. Z. marina, once a dominant species in this section similar to the other sections in the lower bay, but rare since 1971, was now present in small patches in both rivers, a result of

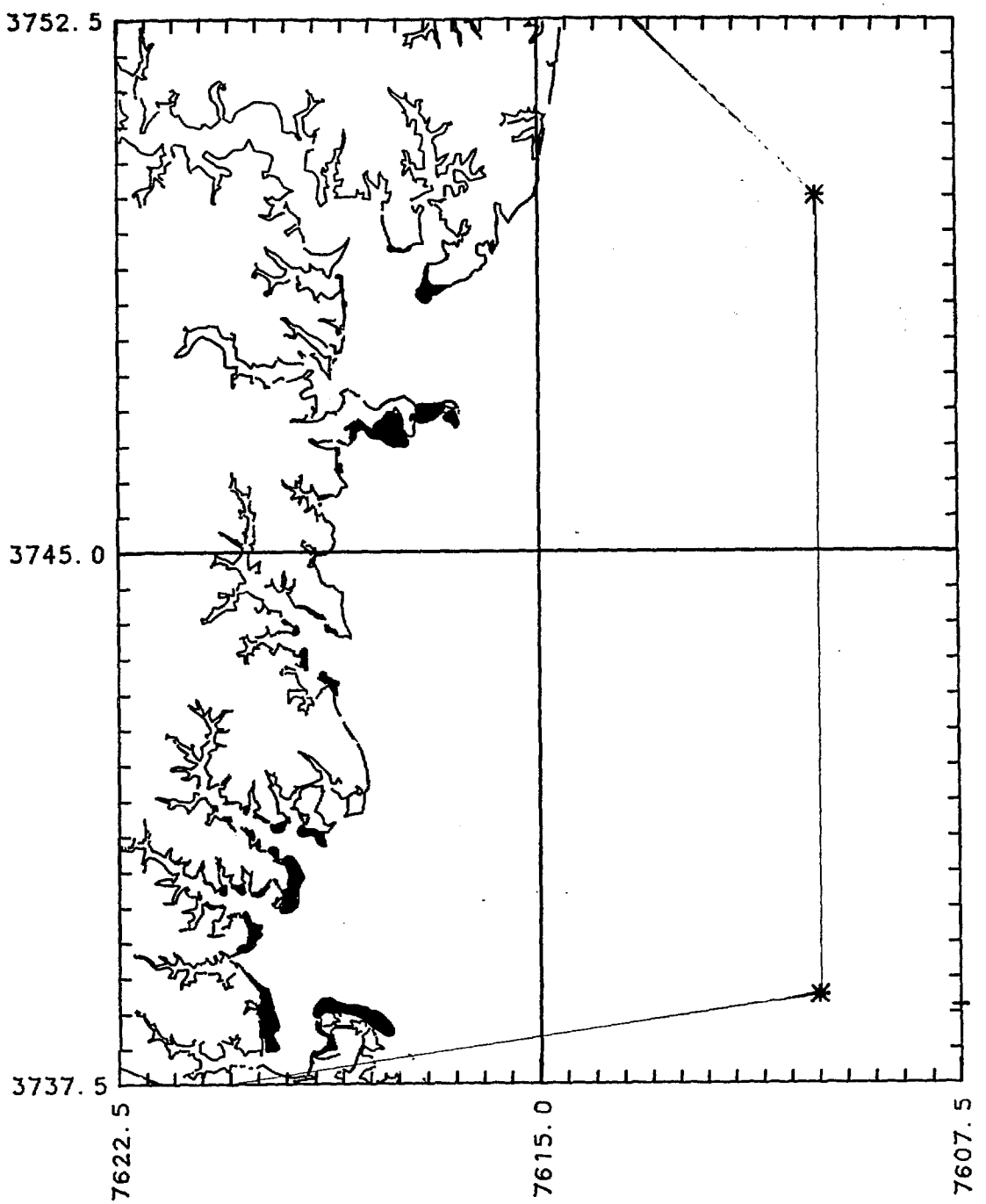

Figure 22. Distribution of SAV in Reedville (Section 15).

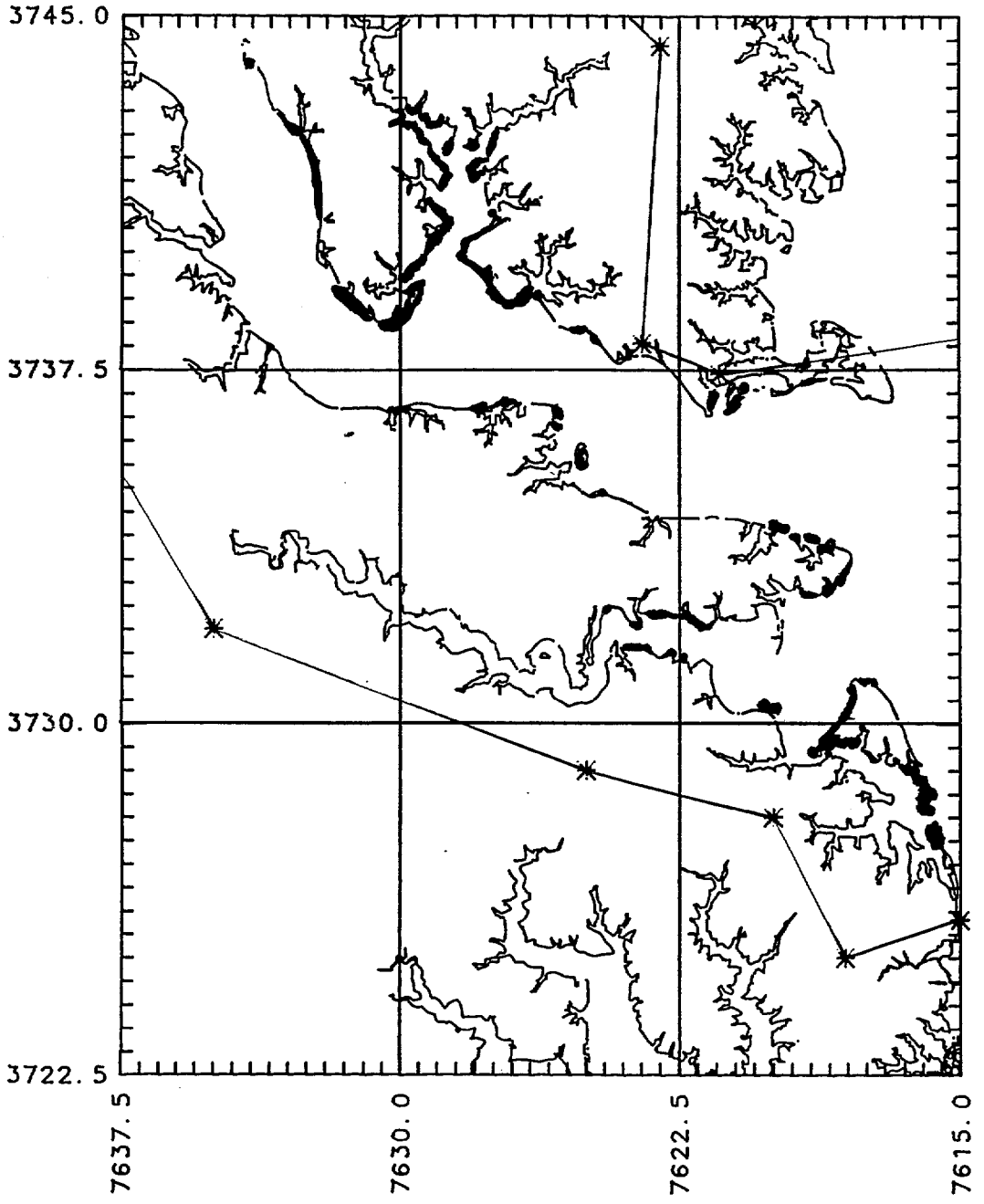

Figure 23. Distribution of SAV in Rappahannock River Complex (Section 16).

successful transplant efforts using both seeds and whole plants in a number of different areas since 1984 (VIMS, unpublished data). In the Rappahannock River, transplanted Z. marina is present adjacent to Parrott Island, off Sanders Cove just above the bridge, at the mouth of Carters Creek, Ball Point, off Wharton Grove, and adjacent to Towles Point. In the Piankatank River and Milford Haven area, transplanted Z. marina is present off Burton Point, along the northeast side of Gwynn Island, and at the mouth of Healy and Hills Creek. Naturally occurring Z. marina is present on the west side of Gwynn Island off The Hole in the Wall and off the northeast tip of the island, and in the Willis Wharf area.

17. NEW POINT COMFORT REGION

There were 344 hectares (850 acres) of SAV identified in the New Point Comfort Region in 1989 (Tables 4-6; Fig. 24; Appendix C, Map 132), compared to 238 hectares reported in 1987. SAV consisted of dense beds (68% is in density class 4) of Z. marina and R. maritima (observations include those from the Citizen and VIMS surveys) between New Point Comfort and just north of Horn Harbor.

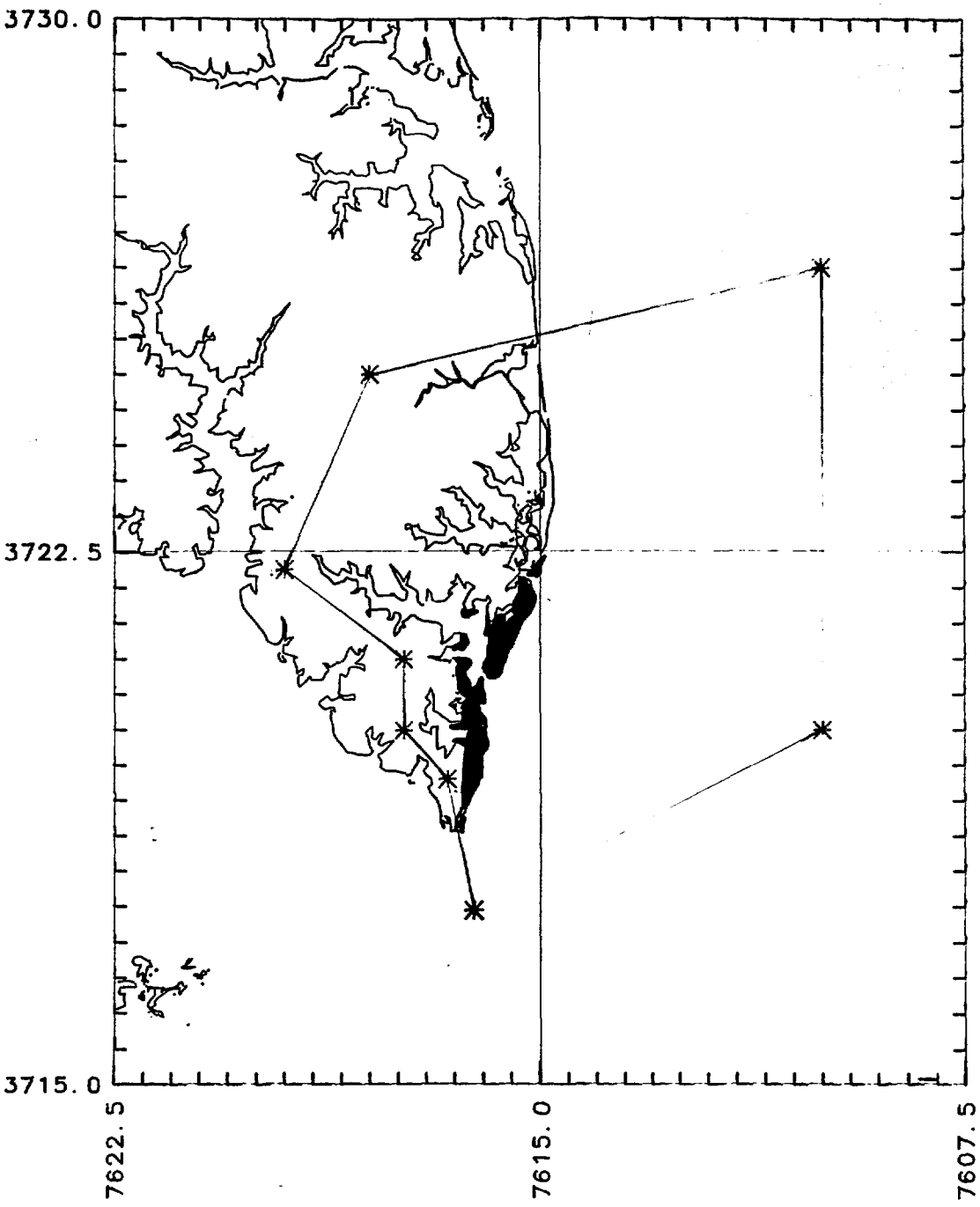

Figure 24. Distribution of SAV in New Point Comfort Region (Section 17).

18. MOBJACK BAY COMPLEX

The Mobjack Bay Complex contained 1,589 hectares (3925 acres) of SAV in 1989 (Tables 4-6; Fig. 25; Appendix C, Maps 122, 123, 131, and 132), compared to 1,227 hectares reported in 1987. SAV beds, consisting of Z. marina and R. maritima (observations include those from the Citizen and VIMS surveys), were most abundant along the entire shoreline of the Mobjack Bay as well as in three of four tributary rivers: Severn, Ware and North. Several small beds of R. maritima were observed within the East River. The Mobjack Bay area continued to harbor some of the more extensive SAV beds on the western shore of the lower Chesapeake Bay. Sixty-four percent of the SAV in this section is in density class 4.

19. YORK RIVER

There were 679 hectares (1677 acres) of SAV observed in the York River section in 1989 (Tables 4-6; Fig. 26; Appendix C, Maps 130, 131, 132, 139, and 140), compared to 608 hectares reported in 1987. Dense SAV beds (80% of the total in this section is in density class 4), consisting of both Z. marina and R. maritima (observations include those from the Citizen and VIMS surveys), were located principally along the north shore from Gloucester Point to the mouth of the river. The only beds present along the south shore were located on the north side of Goodwin Islands. SAV beds were absent upstream of Gloucester Point on the north shore except for a small area of Z. marina (less than 0.5 hectares) adjacent to Big Mumfort Island. This area was planted from seeds broadcast in the fall, 1988 (VIMS,

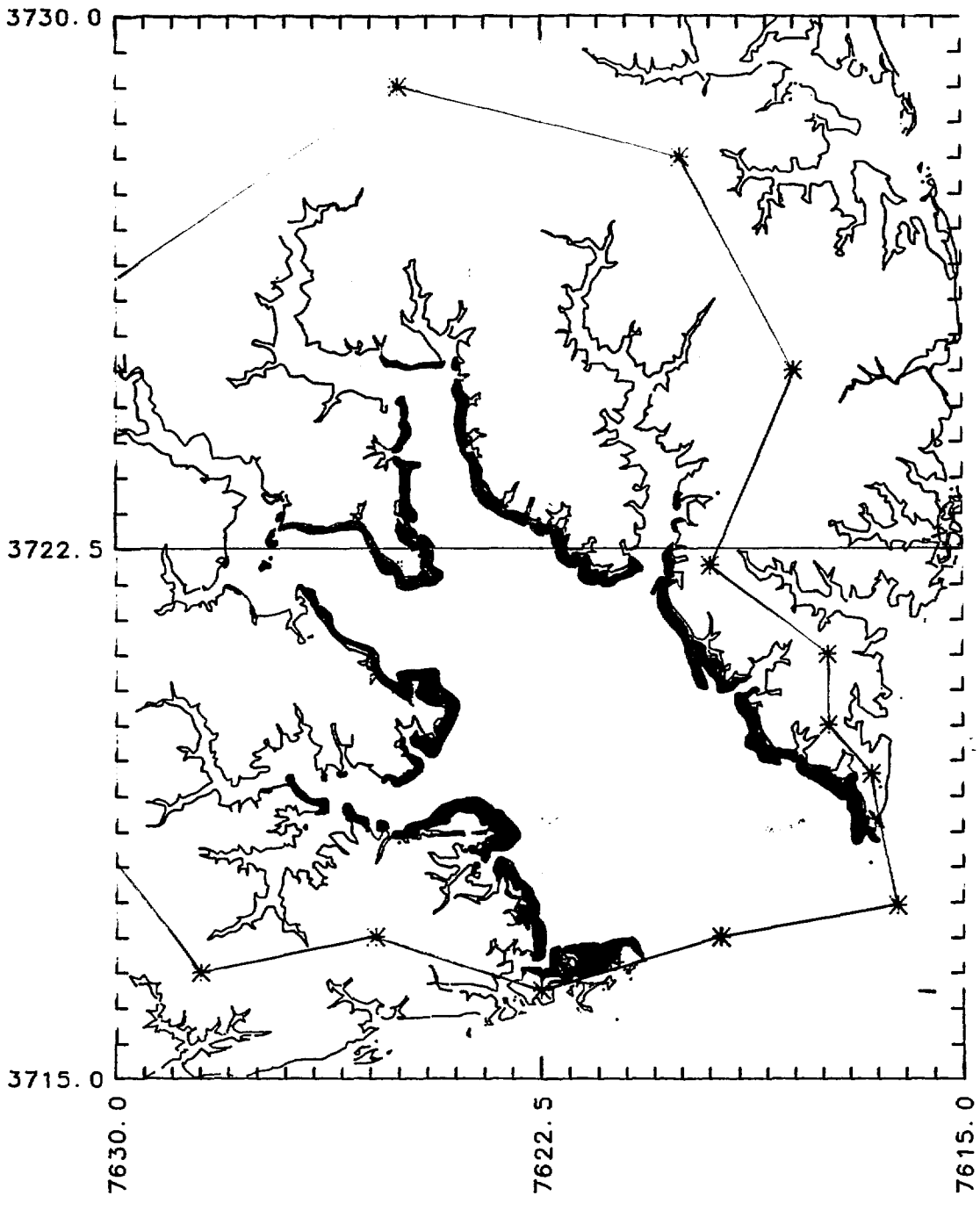

Figure 25. Distribution of SAV in Mobjack Bay Complex (Section 18).

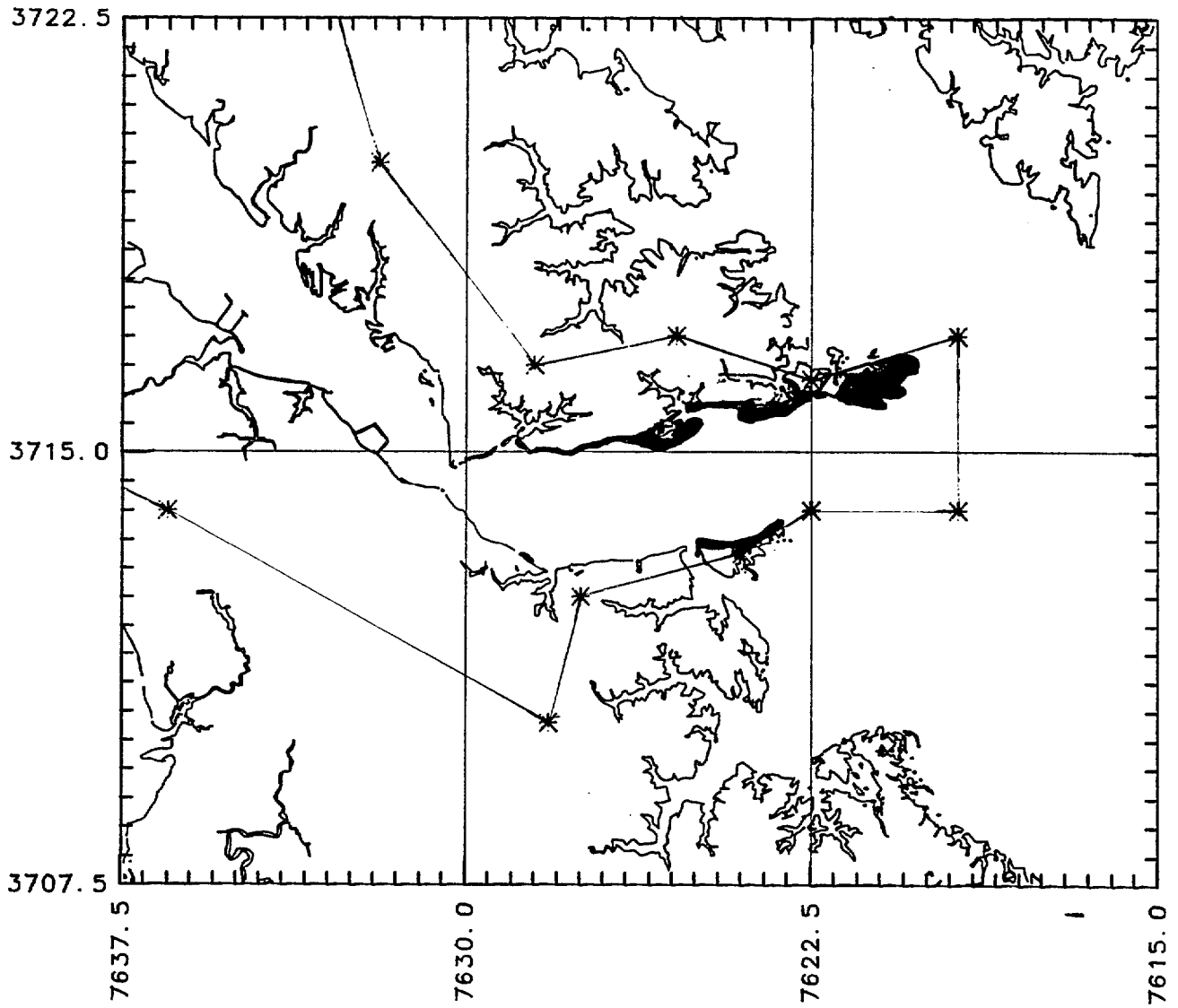

Figure 26. Distribution of SAV in York River (Section 19).

unpublished data). Small patches of Z. marina (approximately 1 -2m^2) are present just below the Naval Weapons Station on the south shore. These were transplanted in the fall of 1985, 1986, 1987, and 1988 (VIMS, unpublished data) and have persisted through 1989. R. maritima is also present in this transplant area, but unlike Z. marina, has reestablished naturally. The SAV beds planted at Gloucester Point in 1982 and 1983, as well as the smaller areas planted immediately adjacent to these larger areas from 1984 through 1988, continue to thrive in 1989, similar to many naturally expanding beds along the north shore.

20. LOWER WESTERN SHORE

There were 1,670 hectares (4125 acres) of SAV mapped in the lower Western Shore section in 1989 (Tables 4-6; Fig. 27; Appendix C, Maps 140, 141, 147, and 152), compared to 1,322 hectares reported in 1987. SAV beds, consisting of Z. marina and R. maritima (including observations from the Citizen and VIMS surveys), remained as dense beds (60% of the total is in density class 4) in Broad Bay, Back River, the mouth of Poquoson River off Pasture and Hunts Neck, Drum Island Flats, adjacent to Crab Neck just south of Goodwin Island, and on the south side of Goodwin Island. No SAV was present in the southwest and northwest branches of Back River, or in the Poquoson River, Chisman Creek and Back Creek.

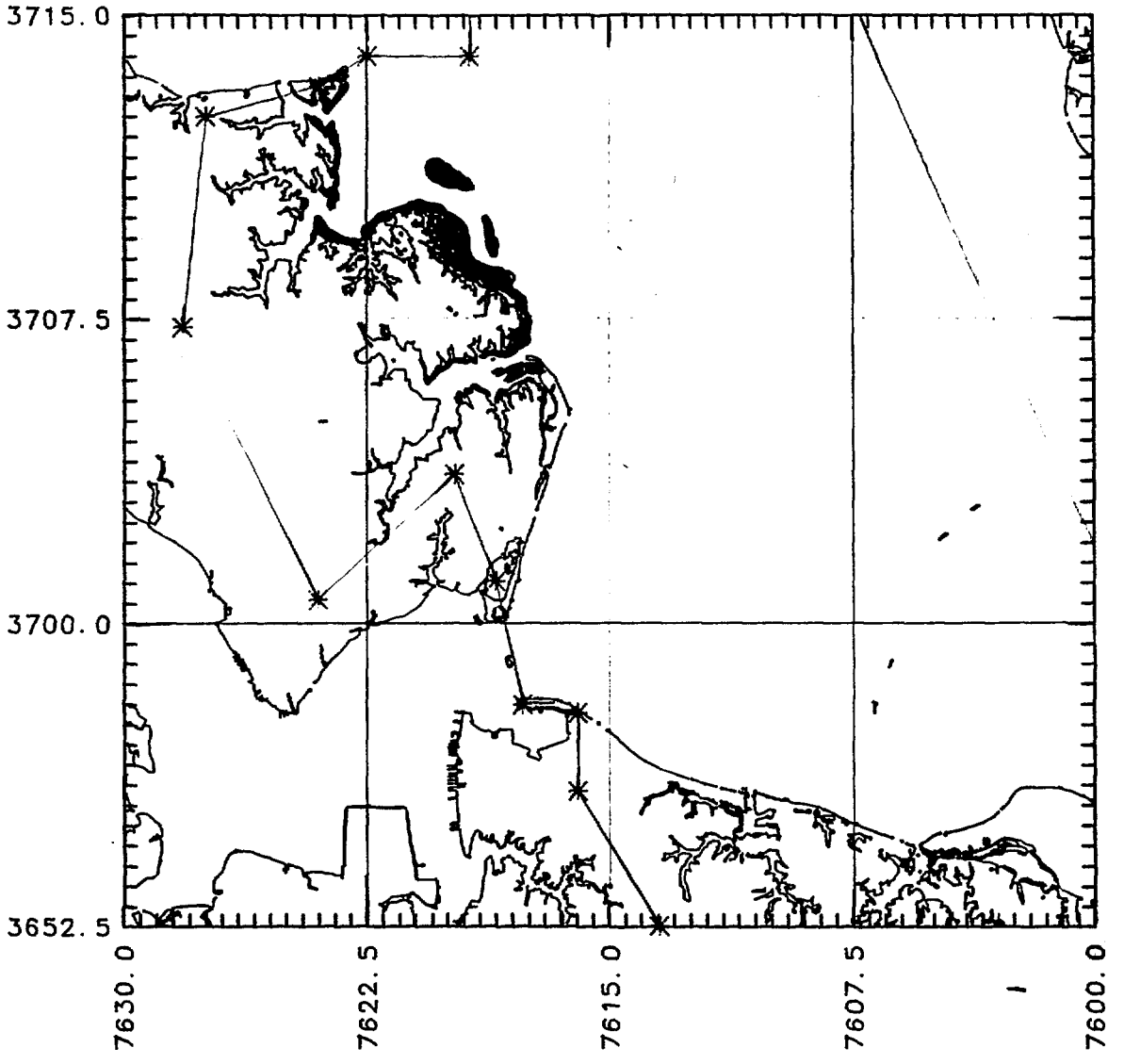

Figure 27. Distribution of SAV in Lower Western Shore (Section 20).

21. JAMES RIVER

The mainstem James River and tributaries emptying into the James remained, for the most part, unvegetated in 1989 (Tables 4-6; Fig. 28; Appendix C, Map 147). The only apparent SAV bed in the mainstem of the lower James River was located at the mouth of Hampton Creek adjacent to the Veterns Hospital. This small, 3.8 hectare (9 acre) dense bed consisted predominantly of Z. marina.

A small section of the Chickahominy that was identified as having SAV in 1989 was photographed. It included Cordon and Nettles Creek, and Nayses Bay. The photography showed SAV beds as occurring in similar locations to previous aerial surveys, indicating that these beds appear to be relatively stable. However, SAV beds were not mapped because the observed beds occurred in small creeks and could only have been represented by a thin line on a 1:24000 scale topographic quadrangle. Tracing and digitizing a single line rather than a polygon shaped bed would have resulted in large errors, thereby compromising our quality control standards. Citizen survey information from the Brandon quadrangle indicated fringing SAV beds consisting of N. quadalupensis, C. demersum and Chara sp. along Parsons Creek in Sunken Marsh by the Chickahominy main stem. SAV species are probably distributed throughout the Chickahominy River system, occupying the fringes of many tidal creeks.

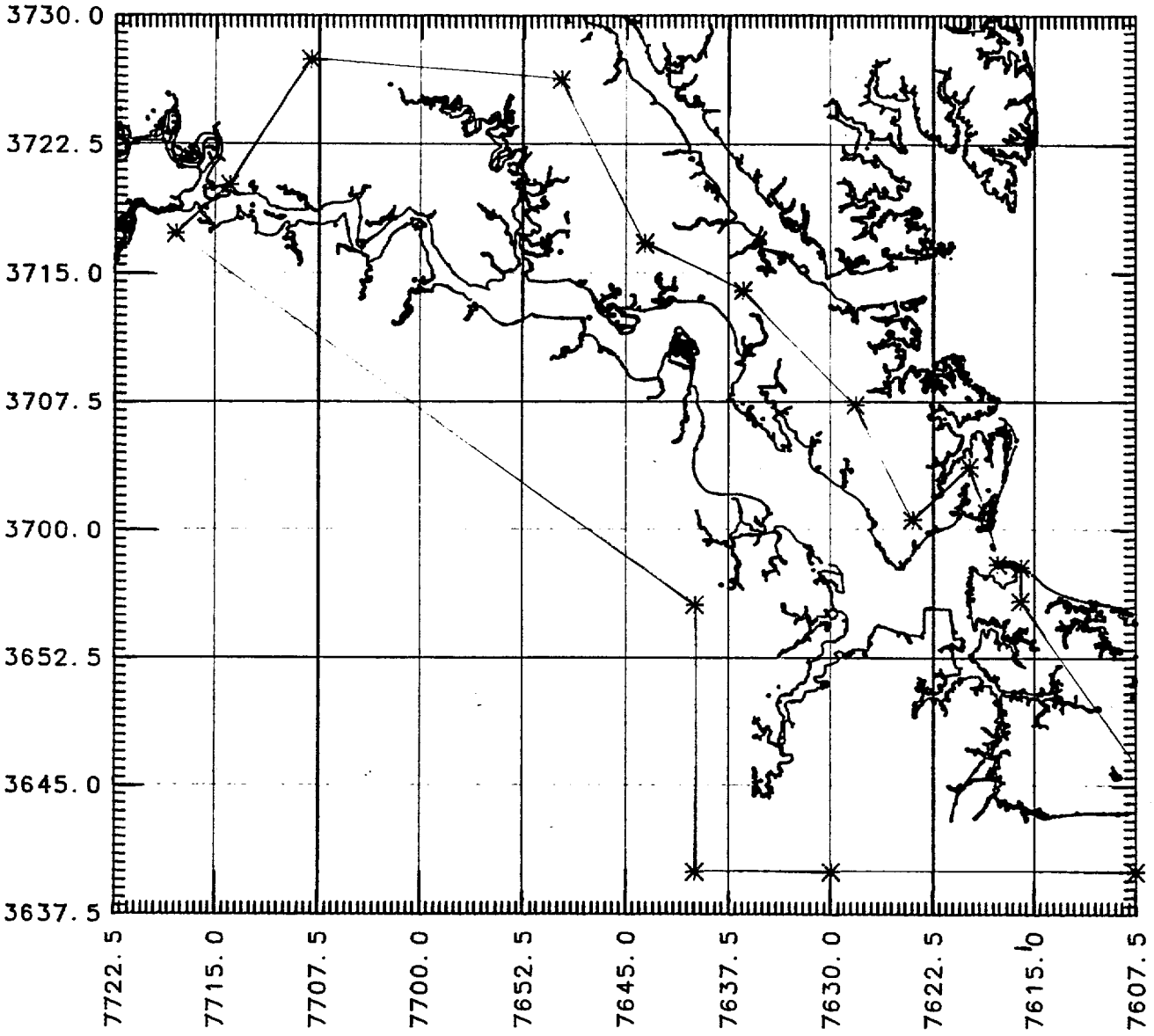

Figure 28. Distribution of SAV in James River (Section 21).

CHINCOTEAGUE BAY

There were 2,311 hectares 5708 acres) of SAV identified in Chincoteague Bay in 1989 (Tables 4-6; Fig. 29; Appendix C, Maps 167, 168, 170, 172, 173, and 175) compared to 2310 hectares reported 1n 1987. Beds were mostly of moderate (74% of the total) to dense (21% of the total) coverage with the Citizen and Charterboat Captains surveys finding both Z. marina and R. maritima throughout the bay (maps 167, 168, 170, 172, and 173). All of the SAV continues to be present on the eastern side of the bay adjacent to Assateague Island in water depths of less than 1 meter (MLW). The vegetation was concentrated in four relatively distinct areas identical to that reported in the 1986 and 1987 surveys. They were located west of the northern end of Chincoteague Island, and west of West Bay, Green Run Bay, and the Tingles Island area. Seven percent of the total bottom of this region (32,536 hectares) supports SAV.

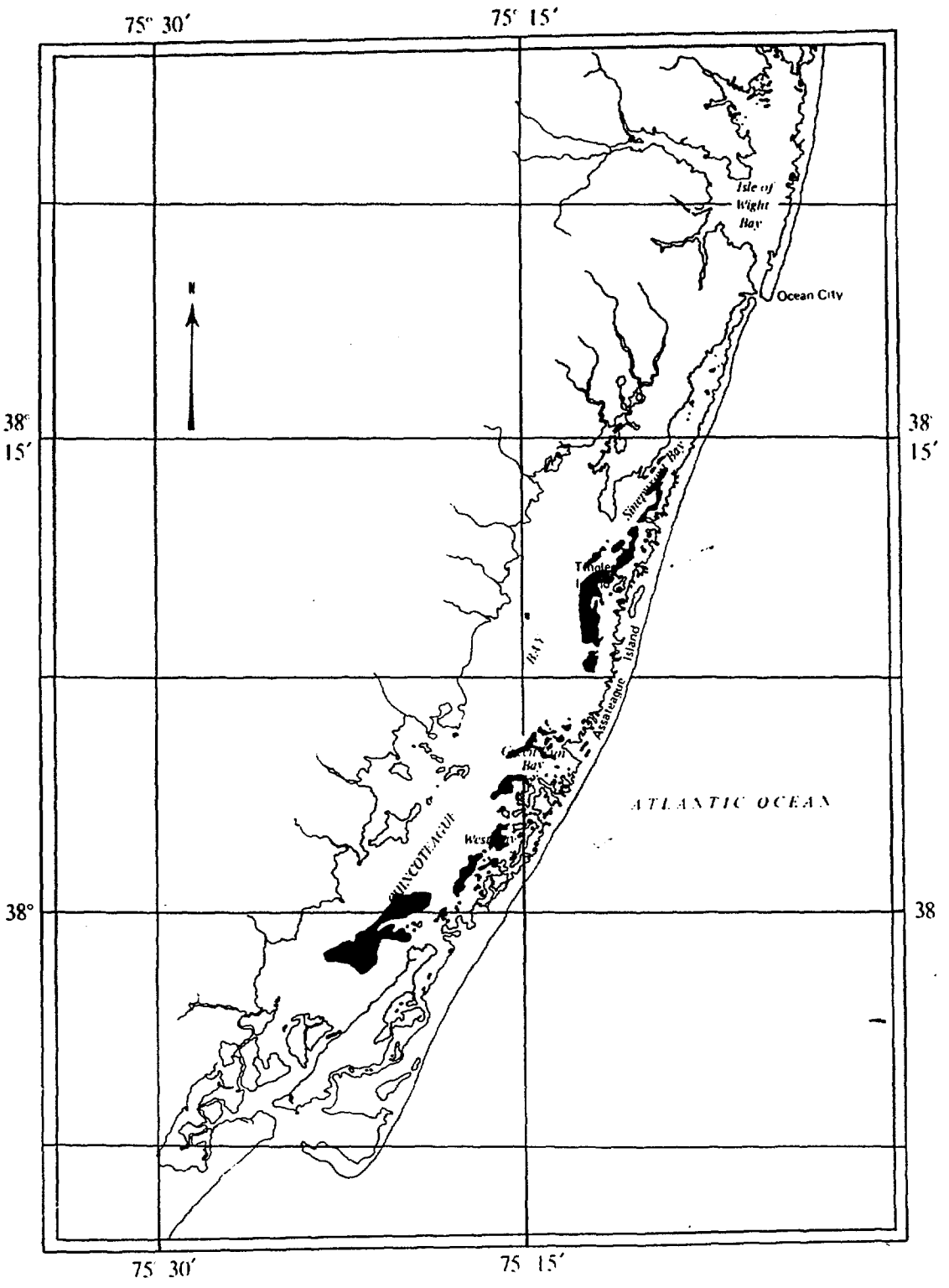

Figure 29. Distribution of SAV in Chincoteague Bay.

SECTION 5

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