Historical Analysis of Submerged Aquatic Vegetation (SAV) in the Potomac River and Analysis of Bay-wide SAV Data to Establish a New Acreage Goal

Final Report

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Introduction

Throughout most regions of the Chesapeake Bay and its tributaries both direct and anecdotal evidence has indicated that large-scale declines of submerged aquatic vegetation (SAV) occurred in the late 1960s and early 1970s (Orth and Moore 1983). These declines have been related to increasing amounts of non-point inputs of nutrients and sediments in the bay system resulting from development of the bay's shorelines and watershed (Twilley et al. 1985). Currently there are approximately 89,659 acres of SAV in Chesapeake Bay (Orth et al. 2003). Although it has been estimated that this is approximately 15% of the bay's historical SAV distribution, most comprehensive analyses have been based on 1971 or later aerial photography and the distributions of SAV prior to this time in many regions are not well known.

SAV is a highly valuable resource and its presence serves as an important indicator of local water quality conditions (Dennison et al. 1993). SAV growth and survival can be decreased by high levels of turbidity and nutrient enrichment. Because SAV beds are non-motile, their presence serves as an integrating measure of variable water quality conditions in local areas (Moore et al. 1996).

Because of the direct relationships between SAV and water quality, trends in the distribution and abundance of SAV over time are also very useful in understanding trends in water quality. Review of photographic evidence from a number of sites dating back to 1937 suggests that SAV, once abundant throughout the Chesapeake Bay system, have declined from historical levels and therefore water quality conditions may have similarly deteriorated (Orth and Moore 1983).

To develop reasonable SAV restoration targets and to formulate the strategies for achieving these targets, it is necessary to first identify the potential for SAV restoration. Some shallow areas that may meet SAV water quality requirements are subject to high currents and wave activity or contain sediments that are very high in organic content and may not have a high potential for SAV growth. Identification of those areas with previous evidence of SAV growth is an important step in quantifying that potential. Therefore initial targets for the geographical limits of SAV restoration have been based on documented evidence of previous SAV growth in the region since 1971 (Batiuk et al. 1992). However, recent studies have shown that historical, pre-1971 levels of SAV in portions of the Bay significantly exceed post 1971 levels. Therefore, initial SAV restoration goals for these regions may underestimate the potential for SAV recovery.

Recent and ongoing studies funded through the Va. Department of Conservation and Recreation and the US EPA CBP have undertaken the analysis and mapping the historical distribution of SAV in the James River (Moore et al. 1999), the York and Rappahannock Rivers (Moore et al.2001), the Patuxent River, the Maryland shoreline of the Potomac River and the upper Chesapeake Bay (Naylor 2002), and the Virginia Eastern Shore and mid-bay island complex (Moore et al. 2003). For example, the James River study found, that, although the established Tier 1 restoration goal for the James River regions was 107 hectares, a total of 1,645 hectares of SAV had been present in the James River during the 1930s and 1940s and that SAV formerly grew to depths of 2 meters or more. Therefore, our estimation of the restored Chesapeake Bay ecosystem for this region greatly underestimated the potential for regrowth of this important living resource. This study follows directly along with these recent works and maps and analyzes historical SAV in the Virginia portion of the Potomac River and elsewhere including the Sassafras and Elk rivers to complete the comprehensive analysis of historical SAV distribution throughout the Chesapeake Bay and its tidal tributaries.

SAV communities are particularly suitable for identification through analysis of aerial photography from a variety of sources (Orth and Moore 1984). Although estuarine waters can be quite turbid, SAV are generally found growing in littoral areas where depths are less than one meter and their photographic signatures can be identified by experienced photo-interpreters. Although the absence of SAV on historical aerial photographs does not necessarily preclude SAV occurrence, SAV signatures would be strong supporting evidence for the previous occurrence of SAV (Orth and Moore 1983b).

SAV water quality habitat requirements originally developed in the early 1990s (Batiuk et al. 1992, Dennison et al. 1993) have quantified a strong linkage between SAV distribution and abundance in the Chesapeake Bay and light availability to the plants. Continued refinement of this SAV light requirement (Batiuk et al. 2000) has resulted in a set of SAV community-based minimum light requirements that, when applied to specific application depths, provide realistic water clarity attainment goals.

The recently signed Chesapeake 2000 Agreement sets a specific goal to, "revise SAV restoration goals and strategies to reflect historical abundance, measured as acreage and density from the 1930s to the present. The revised goals will include specific levels of water clarity that are to be met in 2010. Strategies to achieve these goals will address water clarity, water quality and bottom disturbance." This project completes the work begun several years ago and provides a comprehensive baseline reference of this historical abundance. The information also provides comprehensive historical depth attainment status. When applied with the SAV community-based minimum light requirements for growth and survival (Batiuk et al. 2000) the information provides refined Tidal Waters Designated Uses that will be geographically applied by bay segment.

Study Objectives

- To search aerial photography archives for imagery of the littoral zones in the portions of the tidal Potomac River in Virginia and Sassafras and Elk Rivers in Maryland. These beds will represent an historical, pre-decline benchmark of a healthy SAV community in these regions of the Chesapeake Bay.
- To combine these historical SAV distributions with existing historical surveys to develop a comprehensive baywide reference dataset using a computer-based GIS (ArcInfo).
- To use the historical SAV dataset and water clarity criteria to develop methods and criteria for new SAV restoration acreage goals for the entire Bay and each of its tidal tributaries as well as bay segment-based designated use attainment status.
- To report and summarize the findings of this analysis in a report to be distributed to appropriate state and federal agencies and be available online through the VIMS SAV and CBP Web pages and the Chesapeake Information Management System.

Survey of Historical SAV in the Virginia Portion of the Potomac River

Methods

Key photographic databases including Va. Department of Highways and NOAA, USDA and USGS archives as well as other published reports were searched for photography and other information relative to SAV occurrence prior to the decline in the early 1970s. Photographic databases ranging from the 1930s to the 1971 were initially searched by direct visits to view paper prints and color transparencies. Particular care was taken to select photos from those growing seasons and time periods, including 1950s and 1960s, when many creeks on the Virginia side of the Potomac River experienced significant expansion in SAV distribution. Those photographs that contained useable images of SAV were scanned and brought into the GIS and processed using the methods described below. Web-based USGS and NOAA databases were also searched online using a web browser.

The photo-interpretation of the aerial photographs for the Potomac followed the methods currently used to delineate SAV beds throughout the Chesapeake Bay in the annual aerial SAV surveys (eg. Orth et al. 2003). Generally, high salinity SAV can be identified in the shallow, nearshore regions by their characteristic bottom patterns and reflectance signatures. Low salinity and freshwater SAV beds generally have much darker signatures that can sometimes be confused with other bottom features. Initial screening of photographic prints was accomplished by viewing under 10X magnification viewer. Each print was searched for potential SAV signatures, and the quality of the imagery for SAV delineation estimated as “Good, Fair, or Poor.” Those prints with some evidence of SAV signatures were scanned at a resolution of 600 dpi and viewed using ERDAS Imagine image processing software.

The aerial photography determined to have SAV signatures was processed using a heads-up, on-screen digitizing system. The system improves accuracy by combining the series of images into a single geographically registered image mosaic, permitting final SAV interpretation to be completed seamlessly in a single step. In addition, the image is available digitally and can be printed along with the interpreted lines to show the precise character of the SAV beds.

The standard nine inch square, black and white aerial photographs, which are the usual format for historical SAV photography, were scanned at a resolution of 600 dpi, forming pixels approximately one meter in width. This is the minimum resolution required to accurately delineate SAV beds and results in files that are approximately 30 megabytes in size. The scanned images are then transferred to a Windows platform for registration using ERDAS Orthobase (ERDAS, Atlanta, Ga.). Horizontal control was taken from USGS digital orthophoto quarter quads (DOQQ) and USGS 1:24,000 scale topographic quadrangles. USGS DEMs were used for vertical control. The Orthobase software combines both sources of control with a set of common "tie" points to merge the images into a single geographically corrected product that will be used for interpretation.

SAV bed outlines were traced directly from the combined image displayed on the computer screen into an ArcInfo (ERSI, Redlands, Calif.) GIS polygon file. The image scale was held fixed at a scale of 1:12,000 and line segments characterizing the beds were no shorter than 20 meters to maintain consistency with previous historical SAV surveys. The interpreted boundaries were drawn to include all visible SAV areas regardless of patchiness or density.

Results

In general, the most useful historical photography found in this study for delineation of SAV in previously unmapped areas of the Potomac Sassafras and Elk Rivers came from the U.S. Department of Agriculture. This photography, which was originally acquired for agricultural and land use purposes was primarily black and white format at scales of approximately 1:20,000. The years of photographic coverage used in this delineation are included in Table 1. The results of the analyses of these historical photographs were combined with that of previous mapping efforts (Moore et al. 1999, 2001, 2003 and Naylor 2002) using ArcInfo GIS software to form a single spatial data layer. The results of this bay-wide comprehensive historical SAV mapping effort are presented below as part of a bay-wide SAV composite.

Development of a new bay-wide SAV composite

Methods

Historical SAV distribution GIS data from previous and current mapping projects were combined using ArcInfo GIS software to form a single spatial data layer representing maximum historical SAV coverage for the Chesapeake Bay. In regions where data was available for more than one year, data from the year with maximum coverage was selected. Datasets completed for the James River; York, Piankatank and Rappahannock rivers; Maryland and Virginia portions of the Potomac River; the Patuxent River; the previously unmapped areas of the upper Chesapeake Bay tributaries including the Sassafras and Elk; and the mid-bay islands and Eastern Shore were joined to form a comprehensive, composite, historical bay-wide SAV coverage. This GIS data layer represents the SAV that was visible on the available historical aerial photography for the Chesapeake Bay. Areas that were not visible on any of the available photography were not included. In some cases this was due to limited and poor quality of the available photography. This historical record therefore can be considered a conservative estimate of areas vegetated with SAV historically.

While similar processing and interpretation guidelines were followed in the creation of the historical dataset for each region, some concerns did need to be addressed. Any data quality and interpretation issues resulting from the combination of the datasets that were prepared separately were resolved through referral to the original photography for the Virginia portion and through consultation with Maryland DNR for the Maryland portion.

Results

A GIS composite layer of the single best year (SBY), historical coverage has been previously provided to EPA Chesapeake Bay program for inclusion in development of the, "Ambient Water Quality for Dissolved Oxygen, Water Clarity and Chlorophyll a for the Chesapeake Bay and Its Tidal Tributaries" (EPA 2003a) and "Technical Support Document for Identification of Chesapeake Bay Designated Uses and Attainability" (EPA 2003b). Table 1 presents, for each Chesapeake Bay Program segment, the year(s) of historical photography used in developing the bay wide, SBY composite. Asterisks (*) indicate that no SAV was observed on any photography from the 1930s to 1970s. The acreages of SBY historical SAV are presented by individual bay segment in Tables 2a, 2b, and 2c.

Development of New Restoration Acreage Goals

Background

The initial restoration goal for Chesapeake Bay (Tier I goal) was created in 1984 using the acreage of SAV visible in 1971 - 1990 aerial photos (Batiuk et al. 1992). Subsequent interim goals were based on estimates of potential SAV habitat at less than1 meter (Tier II) and less than 2 meter (Tier III) water depths. Since these goals were established, it has become apparent that for some areas, the goals do not reflect the amount of SAV that would be indicative of a restored resource. For instance, in 1996 SAV in the upper Patuxent River covered 100 hectares (Orth et al. 1997). This was more than 16 times the 6 hectare Tier I goal for this section of the river, yet only 11% of the Tier III restoration goal of 890 hectares. This clearly reflects a disconnect between the goal and the amount of SAV that once grew in the upper Patuxent. This is true for many other areas as well. Tier I goals throughout the Bay range from 0 to 47% of Tier III goals for a given location, revealing that restoration to initial levels of success depends as much upon the condition of each location between 1971 and 1990 (i.e. how degraded had it become before 1971) as it does upon how much vegetation each location could potentially contain.

Goals based strictly upon depths (Tiers II and III) are more consistent from region to region, but these goals assume that all areas at down a specific depth could potentially support SAV given appropriate light levels. It is recognized that natural exclusion zones exist; areas where wave energy, sediment type, or other factors preclude SAV growth. But these areas are not easy to define and are only applied for a small and poorly defined fraction of the Chesapeake Bay (see EPA 2003b). While the exclusion zone concepts are understood, the specific levels of each exclusion factor are not. Even if the effects of these multiple limiting factors do become better understood in the future, data do not currently exist to allow bay scientists to accurately predict their combined influences at all sites. None of this answers the larger question, "How much SAV actually could grow in a given area?" Even in the 1950s, at a time when SAV was more abundant, it was estimated that only about 20 to 30% of the shoals in the lower Patuxent were vegetated (Manning 1957). The Tier II and III goals assume that 100% of these shoals would be vegetated each growing season.

A more quantitative estimate how much SAV could grow in an unvegetated area would be to measure how much actually existed at some time prior to the recent population declines. This is now feasible through the use of GIS technology combined with photo-interpretation of historical aerial photos. While it is true that SAV coverage varies annually, and that each year's coverage may not represent an average year, comparison of several areas over multiple years of historical photography demonstrated very similar SAV distributions. Additionally, review of more recent photography taken annually since the 1980s demonstrates that year-to-year variability in most sites in small (Orth et al. 2003) Therefore a historical composite coverage of SAV was deemed to be an appropriate estimation of SAV abundance prior to the significant, bay-wide SAV declines in the 1970s (Orth and Moore 1983).

The development of new restoration acreage goals required a three-step process:

1 - Creation of a bay-wide "Single Best Year" GIS coverage;

2 - Establishment of application depths;

3 - Establishment of SAV goal areas.

Creation of a bay-wide "Single Best Year" GIS coverage

It was decided that for consistency, the SAV restoration goals would be established using the SBY criteria (EPA 2003a). Advantages of this approach to setting new SAV goals included the following:

1. The SAV single best year acreage is the best available data on SAV abundance over the long-term record. Because, even in good water quality conditions, the position of SAV beds often vary within a segment over time and summing acreage over a number of years into a composite acreage would overestimate the likely future abundance of SAV in any single year.

2. Using the single best year as the basis for new SAV goals establishes consistency with the method used to determine segment-specific application depths for use stated in water quality standards.

3. A new bay-wide total acreage goal would likely be approximately twice the 2001 bay-wide SAV acreage, which will be challenging to meet by 2010, but not unrealistic.

Historical aerial photos for Maryland and Virginia (Table 1) were scanned, geo-referenced, and photo-interpreted, as describe above, to determine the extent of SAV beds from these years. Because a comprehensive set of suitable historical photos were not available in some areas due to water clarity, wind, and sun angle constraints, it was also necessary to include more recent distributions for goal setting. In some segments with limited historical aerial photography, SAV coverage in more recent photography was found to be greater. In these few instances the more recent area coverage was used to develop the SBY.

The total amount of SAV evident in each of several years' photography available for each segment was compared, and the year with the greatest amount of SAV was used as the acreage for each region's SBY coverage (Tables 2a, b, c).

Establishment of application depths

In addition to the creation of a new SAV goal, the SBY data were used to define, within each Chesapeake Bay segment, the depth to which the shallow water SAV designated use should be considered. That depth is the maximum depth at which water clarity criteria would apply in the context of state water quality standards, and is therefore referred to as the "application depth" for each segment. A summary of the various Chesapeake Bay water clarity criteria for application to shallow-water bay grass designated use habitats and the development of the applications depth for each segment are provided in EPA (2003a and 2003b)

Decision rules have been set up to ensure full consistency between the establishment of the shallow water designated use depths (the depth at which the Bay water clarity criteria will be applied) and the setting of the new SAV restoration goal. This set of decision rules has been carefully reviewed by and was recommended by the

Living Resources Subcommittee's SAV Task Group. Tables 3a, 3b and 3c provide the SAV areas within the different depth zones that were used to develop the application depths. Areas listed as "On Land" are portions of historically mapped SAV beds that fell landward of the GIS shoreline polygon.

Establishment of SAV goal areas

Within each Bay Program segment, the 2010 restoration goal for SAV designated use attainment purposes has been set to equal the SBY acreage from the shoreline out to the segments application depth ("SBY clipped to criteria depth and shoreline;" Tables 2a-c; EPA 2003a, 2003b). However, the rules for establishing application depths (EPA 2003a, 2003b) truncated the SBY observed historical SAV acreage coverages at the application depths as well as the GIS bay shoreline in some segments. Tables 2a, 2b, and 2c compare the SAV acreages between the "SBY" Historical SAV coverage and the reduced SBY coverages due to "clipping" this coverage by the application criteria depth and Chesapeake Bay shoreline polygon. Bay wide, the SAV Restoration Goal based on historical photo-interpretation was found to be 206,720 acres, when clipped by application depth it is reduced to 189,919 acres, and when additionally clipped to shoreline polygon it is 184,933 acres.

Conclusions

Analysis of historical photography dating from the 1930s to the 1970s was found to be a quantifiable approach to determine determining SAV abundances in the Chesapeake Bay prior to massive diebacks in the 1970s. These SAV coverages were found to be much more site specific and quantifiable than goals based on specific depths (ie. Tier II or Tier III). The SBY approach was found to be a conservative estimate of historical SAV abundance even though it is a composite of a number of years of coverage. When coverages during several historical years were available for comparison, the SAV beds outlines were similar. However, the historical SAV coverages available during the SAV growing seasons were generally limited and the lack of SAV signatures on the historical photographs which were available for analyses may not indicate the absence of SAV, but simply that SAV could not be seen. The setting of SAV Restoration Goals and Water

Clarity Application Depths based on these historical distributions are sound approaches to the quantification of these goals and criteria. Overall, the SAV restoration goal of 184,933 (EPA 2003a) is a conservative goal that includes some “clipping” of the composite, historical SAV abundance of 206,720. This should be considered when comparing current, annual SAV mapping coverages which are not “clipped” by shoreline or depth contour.

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Table 1. Historical Photography Coverage Years

CBP Segment	CBP Segment Name	Year
AAWPH	Assawoman Bay	*
ANATF	Anacostia River	*
APPTF	Appomattox River	1937, 1948
BACOH	Back River	*
BIGMH	Big Annemessex River	1952
BOHOH	Bohemia River	1964
BSHOH	Bush River	1952
C&DOH	Chesapeake & Delaware Canal	*
CB1TF	Northern Chesapeake Bay	1957, 1964
CB2OH	Upper Chesapeake Bay	1964, 1952
CB3MH	Upper Central Chesapeake Bay	1964, 1957
CB4MH	Middle Central Chesapeake Bay	1937, 1952
CB5MH	Lower Central Chesapeake Bay	1937, 1953, 1959
CB6PH	Western Lower Chesapeake Bay	1953, 1968
CB7PH	Eastern Lower Chesapeake Bay	1938, 1949, 1955, 1959, 1960
CB8PH	Mouth of the Chesapeake Bay	*
CHKOH	Chickahominy River	*
CHNPH	Chincoteague Bay	*
CHOMH1	Mouth of the Choptank River	1952
CHOMH2	Lower Choptank River	1952, 1937
CHOOH	Middle Choptank River	1952, 1937
CHOTF	Upper Choptank River	*
CHSMH	Lower Chester River	1957, 1952
CHSOH	Middle Chester River	1957
CHSTF	Upper Chester River	*
CRRMH	Corrotoman River	1953, 1959
EASMH	Eastern Bay	1952, 1937
EBEMH	Eastern Branch of the Elizabeth River	*
ELIPH	Lower Elizabeth River	*
ELKOH	Elk River	1964, 1957
FSBMH	Fishing Bay	1952
GUNOH	Gunpowder River	1964
HNGMH	Honga River	1952
IOWPH	Isle of Wight Bay	*
JMSMH	Lower James River	1953, 1954, 1963, 1976
JMSOH	Middle James River	*
JMSPH	Mouth of the James River	*
JMSTF	Upper James River	1937, 1947, 1948
LAFMH	Lafayette River	*
LCHMH	Little Choptank River	1952
LYNPH	Lynnhaven & Broad Bays	*
MAGMH	Magothy River	1938, 1952
MANMH	Manokin River	1952

CBP Segment	CBP Segment Name	Year
MATTF	Mattawoman Creek	1937
MIDOH	Middle River	1964
MOBPH	Mobjack Bay	1953, 1959
MPNOH	Lower Mattaponi River	*
MPNTF	Upper Mattaponi River	*
NANMH	Lower Nanticoke River	1938
NANOH	Middle Nanticoke River	1938
NANTF	Upper Nanticoke River	*
NORTF	Northeast River	1957
PATMH	Patapsco River	1957
PAXMH	Lower Patuxent River	1952, 1938
PAXOH	Middle Patuxent River	1952
PAXTF	Upper Patuxent River	*
PIAMH	Piankatank River	1953, 1968
PISTF	Piscataway Creek	*
PMKOH	Lower Pamunkey River	*
PMKTF	Upper Pamunkey River	*
POCMH	Lower Pocomoke River	1949, 1955, 1959, 1960, 1952, 1937
POCOH	Middle Pocomoke River	*
POCTF	Upper Pocomoke River	1952
POTMH	Lower Potomac River	1937, 1952, 1953, 1960, 1961
POTOH	Middle Potomac River	1937
POTTF	Upper Potomac River	1937
RHDMH	Rhode River	1952
RPPMH	Lower Rappahannock River	1953, 1959, 1968
RPPOH	Middle Rappahannock River	*
RPPTF	Upper Rappahannock River	*
SASOH	Sassafras River	1952
SBEMH	South Branch of the Elizabeth River	*
SEVMH	Severn River	1938
SOUMH	South River	1952
SPXPH	Sinepuxent Bay	*
SVCPH	Southern Va. Coastal Bays	*
TANMH	Tangier Sound	1938, 1949, 1952, 1955, 1959, 1960
WBEMH	Western Branch of the Elizabeth River	*
WBRTF	Western Branch of the Patuxent River	*
WICMH	Wicomico River	1952
WSTMH	West River	1952
YRKMH	Middle York River	1953
YRKPH	Lower York River	1953, 1959

* Indicates no visible SAV in historical photos

Table 2a. Historical SAV Composite (acres) Upper Bay Zone

Segment	Application Depth (m)	Single Best Year (SBY)	SBY area clipped by application depth	SBY clipped to application depth	SBY area clipped by shoreline	SBY clipped to application depth and shoreline
CB1TF	2	13,228	217	13,011	103	12,908
NORTF	0.5	164	75	89	1	88
ELKOH	2	1,710	22	1,688	40	1,648
BOHOH	0.5	187	75	112	15	97
C&DOH	0.5	2	1	0	0	0
CB2OH	0.5	1,010	684	327	25	302
SASOH	1	960	144	816	52	764
BSHOH	0.5	236	70	166	9	158
GUNOH	2	2,432	27	2,405	128	2,277
MIDOH	2	911	32	879	41	838
BACOH	0.5	0	0	0	0	0
CB3MH	0.5	1,370	353	1,018	75	943
PATMH	1	585	196	389	91	298
MAGMH	1	716	137	579	34	545
CHSMH	1	3,762	834	2,928	204	2,724
CHSOH	0.5	117	39	77	14	63
CHSTF	0.5	0	0	0	0	0
Upper Bay Total		**27,388**	**2,904**	**24,484**	**832**	**23,652**

Table 2b. Historical SAV Composite (acres) Middle Bay Zone

Segment	Application Depth (m)	Single Best Year (SBY)	SBY area clipped by application depth	SBY clipped to application depth	SBY area clipped by shoreline	SBY clipped to application depth and shoreline
CB4MH	2	2,824	292	2,533	22	2,511
EASMH	2	6,397	187	6,210	101	6,108
CHOMH1	2	8,721	538	8,183	140	8,044
CHOMH2	1	2,020	400	1,621	122	1,499
CHOOH	0.5	89	16	73	9	63
CHOTF	0.5	0	0	0	0	0
LCHMH	2	4,134	58	4,076	126	3,950
SEVMH	1	455	104	351	22	329
SOUMH	1	552	73	479	20	459
RHDMH	0.5	98	38	60	12	48
WSTMH	0.5	338	99	238	24	214
CB5MH	2	16,209	1,160	15,048	87	14,961
HNGMH	2	7,948	187	7,761	75	7,686
FSBMH	0.5	730	533	198	4	193
NANMH	0.5	6	4	3	0	3
NANOH	0.5	13	1	12	9	3
NANTF	-	0	0	0	0	0
WICMH	0.5	8	4	3	0	3
TANMH	2	39,982	1,624	38,358	394	37,965
MANMH	2	4,434	37	4,397	39	4,359
BIGMH	2	2,212	166	2,047	32	2,014
POCMH	1	4,978	759	4,220	128	4,092
POCOH	0.5	0	0	0	0	0
POCTF	-	0	0	0	0	0
PAXMH	1	1,685	305	1,380	55	1,325
PAXOH	0.5	115	12	104	36	68
PAXTF	0.5	158	5	153	147	5
WBRTF	0.5	0	0	0	0	0
POTMH	1	13,255	2,593	10,662	490	10,172
POTOH	2	4,304	44	4,260	539	3,720
POTTF	2	4,618	97	4,521	154	4,367
MATTF	1	331	34	296	20	276
PISTF	2	789	0	789	5	783
ANATF	0.5	12	5	7	1	6
Middle Bay Total		**127,415**	**9,374**	**118,041**	**2,815**	**115,226**

(-) No application depth determined

Table 2c. Historical SAV Composite (acres) Upper Bay Zone

Segment	Application Depth (m)	Single Best Year (SBY)	SBY area clipped by application depth	SBY clipped to application depth	SBY area clipped by shoreline	SBY clipped to application depth and shoreline
CB6PH	1	1,267	252	1,015	35	980
CB7PH	2	15,107	133	14,974	355	14,619
RPPMH	1	7,814	2,314	5,500	120	5,380
CRRMH	1	647	129	518	2	516
RPPOH	0.5	0	0	0	0	0
RPPTF	0.5	40	1	39	20	20
PIAMH	2	3,479	170	3,309	54	3,256
MOBPH	2	15,901	506	15,394	299	15,095
YRKPH	1	2,793	469	2,324	25	2,299
YRKMH	0.5	239	52	187	11	176
MPNOH	0.5	0	0	0	0	0
MPNTF	0.5	85	9	76	1	75
PMKOH	0.5	0	0	0	0	0
PMKTF	0.5	187	29	159	3	155
JMSPH	1	693	78	615	11	604
JMSMH	0.5	712	107	605	74	531
ELIPH	-	0	0	0	0	0
WBEMH	-	0	0	0	0	0
SBEMH	-	0	0	0	0	0
EBEMH	-	0	0	0	0	0
LAFMH	-	0	0	0	0	0
CHKOH	0.5	535	74	461	113	348
JMSOH	0.5	15	1	14	8	7
JMSTF	0.5	1,905	124	1,781	182	1,599
APPTF	0.5	379	34	346	26	319
CB8PH	0.5	11	5	6	0	6
LYNPH	0.5	107	36	71	2	69
Lower Bay Total		**51,916**	**4,523**	**47,393**	**1,339**	**46,055**
Chesapeake Bay Total		**206,720**	**16,801**	**189,919**	**4,985**	**184,933**

(-) No application depth determined

Table 3a. SBY SAV Acreage by Depth Zone for Upper Bay Zone.

		SAV Area (acres)					
Segment	**SBY**	**"On Land"**	**0 - 0.5 m**	**0.5 - 1 m**	**1 - 2 m**	**> 2 m**	**Total**
CB1TF	Historical	103	4,551	5,962	2,394	217	13,228
NORTF	Historical	1	88	36	39	-	164
ELKOH	2000	40	504	389	755	22	1,710
BOHOH	2000	15	97	28	47	0	187
C&DOH	1978	0	0	0	0	1	2
CB2OH	Historical	25	302	387	282	14	1,010
SASOH	2000	52	400	364	135	9	960
BSHOH	Historical	9	158	67	2	-	236
GUNOH	2000	128	672	543	1,062	27	2,432
MIDOH	Historical	41	350	205	283	32	911
BACOH	*	-	-	-	-	-	-
CB3MH	1978	75	943	292	57	3	1,370
PATMH	Historical	91	91	207	173	23	585
MAGMH	Historical	34	300	245	120	17	716
CHSMH	Historical	204	1,374	1,350	754	80	3,762
CHSOH	Historical	14	63	37	3	0	117
CHSTF	*	-	-	-	-	-	-
Upper Zone Total		832	9,891	10,113	6,108	444	27,388

*No SAV Mapped

Table 3b. SBY SAV Acreage by Depth Zone for Middle Bay Zone.

Segment	SBY	SAV Area (acres)					
		"On land"	0 - 0.5 m	0.5 - 1 m	1 - 2 m	> 2 m	Total
CB4MH	Historical	22	372	758	1,381	292	2,824
EASMH	Historical	101	1,698	2,411	2,000	187	6,397
CHOMH1	Historical	140	2,455	2,880	2,708	538	8,721
CHOMH2	Historical	122	801	698	357	43	2,020
CHOOH	Historical	9	63	10	4	1	89
CHOTF	*	-	-	-	-	-	-
LCHMH	Historical	126	1,645	1,343	961	58	4,134
SEVMH	1999	22	193	136	77	26	455
SOUMH	Historical	20	258	202	67	5	552
RHDMH	Historical	12	48	24	13	1	98
WSTMH	Historical	24	214	96	3	-	338
CB5MH	Historical	87	3,496	3,853	7,612	1,160	16,209
HNGMH	Historical	75	3,821	2,569	1,296	187	7,948
FSBMH	Historical	4	193	221	305	6	730
NANMH	Historical	0	3	4	-	-	6
NANOH	Historical	9	3	0	0	0	13
NANTF	*	-	-	-	-	-	-
WICMH	Historical	-	3	4	0	-	8
TANMH	Historical	394	11,641	12,684	13,639	1,624	39,982
MANMH	Historical	39	1,084	1,951	1,324	37	4,434
BIGMH	Historical	32	700	723	592	166	2,212
POCMH	Historical	128	1,426	2,666	737	22	4,978
POCOH	*	-	-	-	-	-	-
POCTF	*	-	-	-	-	-	-
PAXMH	Historical	55	726	599	287	18	1,685
PAXOH	2000	36	68	9	3	0	115
PAXTF	1996	147	5	1	2	2	158
WBRTF	*	-	-	-	-	-	-
POTMH	Historical	490	6,488	3,684	2,078	515	13,255
POTOH	1998	539	1,606	1,252	862	44	4,304
POTTF	1991	154	1,397	1,585	1,386	97	4,618
MATTF	2000	20	196	80	28	7	331
PISTF	1987	5	169	326	288	-	789
ANATF	1991	1	6	2	3	0	12
Middle Zone Total		2,815	40,779	40,771	38,013	5,037	127,415

*No SAV Mapped

Table 3c. SBY SAV Acreage by Depth Zone for Lower Bay Zone and Total Chesapeake Bay.

Segment	SBY	SAV Area (acres)					
		"On Land"	0 - 0.5 m	0.5 - 1 m	1 - 2 m	> 2 m	Total
CB6PH	Historical	35	527	453	248	4	1,267
CB7PH	Historical	355	8,361	4,702	1,556	133	15,107
RPPMH	Historical	120	2,998	2,382	1,765	549	7,814
CRRMH	Historical	2	349	166	84	44	647
RPPOH	*	-	-	-	-	-	-
RPPTF	2000	20	20	1	0	0	40
PIAMH	Historical	54	1,274	1,243	739	170	3,479
MOBPH	Historical	299	6,467	5,253	3,375	506	15,901
YRKPH	Historical	25	1,317	982	389	80	2,793
YRKMH	Historical	11	176	51	1	0	239
MPNOH	*	-	-	-	-	-	-
MPNTF	1998	1	75	5	3	1	85
PMKOH	*	-	-	-	-	-	-
PMKTF	1998	3	155	18	9	2	187
JMSPH	Historical	11	315	289	78	0	693
JMSMH	Historical	74	531	98	4	5	712
ELIPH	*	-	-	-	-	-	-
WBEMH	*	-	-	-	-	-	-
SBEMH	*	-	-	-	-	-	-
EBEMH	*	-	-	-	-	-	-
LAFMH	*	-	-	-	-	-	-
CHKOH	2000	113	348	36	20	19	535
JMSOH	1998	8	7	0	0	0	15
JMSTF	Historical	182	1,599	90	28	7	1,905
APPTF	Historical	26	319	18	5	10	379
CB8PH	1996	-	6	4	1	0	11
LYNPH	1986	2	69	26	9	1	107
Lower Zone Total		1,339	24,914	15,817	8,313	1,533	51,916
Chesapeake Bay Total		4,985	75,585	66,702	52,433	7,014	206,720

*No SAV Mapped