Analysis of Historical Distribution of SAV in the Eastern Shore Coastal Basins and Mid-Bay Island Complexes as Evidence of Historical Water Quality Conditions and a Restored Bay Ecosystem

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Executive Summary

Historical black and white format photographs at scales of approximately 1:20,000, dating from 1952 to 1956 were used to delineate the maximum coverage of SAV in the study region. Coverage of photography from decades before and after this period were found to generally to be of poorer quality and show less SAV presence. Photo-interpretation of the aerial photographs was accomplished using a head-up, on-screen digitizing system at fixed image scale of 1:12,000 and followed as closely as possible the methods currently used to delineate SAV beds throughout the Chesapeake Bay as well as the delineation of historical SAV coverage for other region.

A total of 13,046 hectares of sub-tidal bottom in the Eastern Shore bay region between the tip of Fisherman's Island to the Virginia-Maryland border, including the mid-bay island complex, were found to display SAV signatures. Of this historical total, approximately 10,451 ha, or 80%, were determined to be growing at depths shallower than 1 m MLW (Mean Low Water), 2,511 ha or 19% between 1 m and 2 m MLW, and 84 ha or <1% at depths below 2 m MLW. Approximately 6,116 ha of historical SAV were found growing in Bay Segment CB7PH along the eastern shoreline of the bay and extending into the lower one third of the various shoreline tidal creeks found there. Approximately 5,284 ha of historical SAV were growing in the Virginia portion of the mid-bay island complex (TANMH) and 1,646 ha in the Virginia portion of the Pocomoke River region (POCMH). An average of 49.1% of the historical SAV was mapped in 2001.

Losses of SAV (between the 1950s and 2001) have occurred in all areas with the coastal basins and tidal tributaries along the eastern shoreline of Accomac and Northampton Counties (CB7PH) showing the least declines (39.3%) compared to 57.7% and 64.0% in segments TANMH and POCMH respectively. Within CB7PH losses have been least in the historical SAV areas located in the lower portions of the individual creek systems and along the bay shoreline and greatest within the creeks themselves.

Introduction

This report is the third in a series that quantify the historical distribution of submersed aquatic vegetation (SAV) in the Virginia portion of the Chesapeake Bay and its tributaries through photo-interpretation of historical aerial photograph (see Moore et al. 1999 and 2001). 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 1983a). These declines have been attributed 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 35,000 ha of SAV in Chesapeake Bay (Orth et al. 2001). Although it has been estimated that this is approximately 10% 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 only now being quantified.

SAV is a highly valuable resource whose presence serves as an important indicator of local water quality conditions (Dennison et al. 1993, Batiuk et al. 2000). High levels of turbidity and nutrient enrichment can decrease SAV growth and survival, and 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). Water quality requirements for SAV growth are particularly crucial as barometers of the health of the Chesapeake Bay environment because, unlike restoration requirements developed for various species of fish and shellfish, they are not impacted by direct human harvesting activities.

Because of the direct relationships between SAV and water quality, especially nutrient levels and water clarity, 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 historic levels (Moore et al. 1999, 2001) and therefore water quality conditions may have similarly deteriorated (Orth and Moore 1983a).

Goals for water clarity criteria for shallow water zones in Virginia that are currently being developed by the Chesapeake Bay Program are based in large part on the historical depth limits of SAV that are quantified by this work and previous work (Moore et al. 1999, 2001). Since SAV growth and survival has been directly related to seasonal levels of water clarity (Batiuk et al. 2000) historical growth to various depths such as 0.5 m, 1.0 m and 2.0 m suggest greater levels of water clarity the greater the depth of growth. By superimposing isobaths with historical SAV distributions the proportion of historical SAV growing at or below specific depths can be determined, and subsequently used to set water clarity targets.

Areas with high currents and wave activity or sites where sediments are very high in organic content may not be suitable for SAV growth. Therefore 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, 2000).

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 two meters 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 are strong supporting evidence for the previous occurrence of SAV (Orth and Moore 1983b).

The objectives of this study were: 1) To search photo archives for imagery of the littoral zones in the tidal portions of the Eastern Shore coastal basins and mid-bay island complexes (Appendix 1) for evidence of SAV. These beds represent an historical, pre-decline benchmark of a healthy SAV community in these regions of the Chesapeake Bay and its tributaries. 2) To create a digital composite database of these photo-interpreted bed outlines and to quantify these historic SAV distributions using a computer-based GIS (Arc/Info) and to provide this information to the Chesapeake Information Management System (CIMS).

Methods

Key photographic databases, including Virginia Department of Transportation (VDOT), National Oceanic and Atmospheric Administration (NOAA), United States Department of Agriculture (USDA), United States Geological Survey (USGS), and the Virginia Institute of Marine Science (VIMS) archives as well as other published reports, were searched for photography and other information relative to SAV occurrence in the Eastern Shore coastal basins and mid-bay island complexes prior to the decline in the early 1970s. Photographic databases ranging from the 1930s to the 1960s were searched by direct visits to view paper prints and color transparencies. Photographs that contained images of SAV were scanned, photo-interpreted and digitized as described below. Web-based USGS and NOAA databases were also searched online using a web browser. Photo-interpretation of the selected aerial photographs followed as closely as possible the methods currently used to delineate SAV beds throughout the Chesapeake Bay in the annual aerial SAV surveys (eg. Orth et al. 2001) and earlier historical SAV reports (Moore et al. 1999, 2001). Generally, high salinity SAV beds, which may have occurred in regions of the Eastern Shore where salinities are typically above 10 psu, can be identified in the shallow, near shore regions by their characteristic bottom patterns and reflectance signatures. These patterns are similar to beds currently found in other regions of the lower bay.

Initial screening of photographic prints was accomplished by viewing under a 10X magnification viewer. Each print was searched for SAV signatures, and the quality of the imagery for SAV delineation was estimated as “Good,” “Fair,” or “Poor.” Those prints that showed some evidence of SAV signatures were scanned at a resolution of 600 dpi and viewed using ERDAS Imagine™ image processing software.

The aerial photography that was 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 permitting the final SAV interpretation to be completed seamlessly in a single step. In addition, the images are available digitally and can be printed along with the interpreted lines to show the precise character of the SAV beds.

The standard 9 in X 9 in, 1:24,000 scale black and white aerial photographs, which were scanned at a resolution of 600 dpi, formed pixels approximately one meter in width. This is the minimum resolution required to accurately delineate SAV beds and resulted in files that were approximately 30 megabytes in size. The scanned images were then transferred to a Windows 2000 workstation 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 for the region were merged and used for vertical control. The Orthobase™ software combined both sources of control with a set of common “tag” points that were identified on pairs of photos to generate a photogrammetric solution and orthorectify the images, producing a single geographically corrected product that was used for interpretation. The total RMS error for the solution varied among images from 2.6 meters to 4.1 meters with a mean of 3.5 meters.

SAV bed outlines were traced directly from the combined image displayed on the computer screen using ERDAS Imagine™ into an ArcInfo™ (ESRI, Redlands, Ca.) GIS polygon file. The image scale was held fixed at 1:12,000 and line segments for polygons characterizing the beds were set to be 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 and Discussion

Acquisition of Historical Photography

A variety of pre-1971 historical aerial photographic images of the Eastern Shore study region were located and reviewed, however the quality of the imagery for determination of SAV abundance ranged from good to poor. In general, a number of criteria must be met for acquisition of aerial photographs that are optimum for delineation of estuarine SAV (eg. Orth and Moore 1983a; Orth et al, 2001). These address tidal stage, plant growth stage, sun elevation, water and atmospheric transparency, wind, sensor operation, flight line plotting and film type. Most imagery used for historical SAV analyses was obtained for other purposes, usually land use or farming analyses, and therefore, while criteria for atmospheric conditions are usually met (eg. sun elevation, atmospheric transparency, etc.), those important for SAV delineation (eg. tidal stage, water transparency, plant growth stage) may not be met. In addition, while standard black and white, and color photographs are useful for SAV delineation (Orth and Moore 1984) other film types such as infrared or color infrared photography, which effectively delineations upland vegetation, are less useful in delineating submerged vegetation because of the rapid absorption of the infrared wavelengths of sunlight in water.

In general, the most useful historical photography found in this study for delineation of SAV in the Eastern Shore came from USDA. This photography acquired for land use and agricultural purposes was primarily black and white format at scales of approximately 1:20,000. The earliest photography is from USDA over-flights conducted during 1936 and 1937. However much of this 1930s photography was found to show less SAV coverage than similar photography from the 1950s. This pattern of coverage is similar to that found for many other regions of the Virginia portion of the bay (Moore et al. 1999,2001). Qualitatively, in many areas the difference appeared to be related to overall poorer atmospheric and water clarity conditions making SAV less apparent. In many other areas it appeared that the SAV were generally less abundance during the periods of the over-flights during the 1930s compared to the 1950s. Slight seasonal differences may have also been a factor, however, both sets of photography were taken during the approximate middle of the principal SAV growing season (April-October). Given these differences, the 1950s series of USGS photographs ranging from 1952 to 1956 were chosen to delineate maximum coverage of SAV in the study region.

Historical SAV Distribution

This study investigated the historical distribution of SAV in three bay segments: CB7PH, POCMH and TANMH. Of these three only CB7PH is located entirely in Virginia. POCMH and TANMH have portions in Maryland. In this report only the Virginia portions of these two segments are discussed and summarized. These results are being combined with the results of a companion Maryland historical SAV study to provide a bay-wide complete analysis of these and other bay segments that cross state boundaries.

A total of 13,046 hectares of sub-tidal bottom in the Eastern Shore of Virginia bay study area between the southern tip of Fisherman's Island and the Virginia-Maryland border, including the mid-bay island complex, were found to display historical SAV signatures. Of this total approximately 10,451 ha, or 80%, were determined to be growing at depths shallower than 1 m MLW (Mean Low Water), 2,511 ha or 19% between 1 m and 2 m MLW, and 84 ha or <1% at depths below 2 m MLW (Table 1). Approximately 6,116 ha of the historical SAV in Bay segment CB7PH (Table 2) were located along the eastern shoreline of the bay and extending into the lower one-third of the various shoreline tidal creeks. Approximately 5,584 ha of historical SAV were growing in the Virginia portion of the mid-bay island complex (TANMH) and 1,646 ha in the Virginia portion of the Pocomoke River region (POCMH).

The mid-bay island complex segment (TANMH) was found to have a greater proportion of historical SAV growing deeper than 1 m (30.6 %) compared to the Pocomoke River segment (17.8%; POCMH) or the Eastern Shore Coastal Bay segment (11.2%; CB7PH). This difference may have been related to water clarity since both POCMH and CB7PH segments include areas within tidal creeks and embayments that may have been subject to higher levels of runoff. Additionally, many areas with depths between 1 and 2 meters in POCMH and CB7PH that might have supported SAV from a water quality standpoint are located in areas that are subject to high levels of physical stress that historically have been unprotected by bars or islands from the long fetch to the west. SAV would have been excluded from these regions by physical factors.

An average of 50.1% of the historical SAV in this Eastern Shore study area was also observed in 2001 (Table 2). Losses of SAV have occurred in all areas with the coastal basins and tidal tributaries along the eastern shoreline of Accomac and Northampton Counties (CB7PH) showing the least declines (39.3%) compared to 57.7% and 64.0% in segments TANMH and

Table 1. Historical SAV Distribution for Each CBP Bay Segment in Study Area (Total and by Depth Zone Below MLW)

BAY SEGMENTS	**DEPTH ZONES****						**TOTAL HISTORICAL (HECTARES)****
	0 TO 1 METERS		1 TO 2 METERS		> 2 METERS		
	HECTARES	*% TOTAL*	*HECTARES*	*% TOTAL*	*HECTARES*	*% TOTAL*	
CB7PH	5,435	88.8	633	10.3	54	0.9	6,116
POCMH	1,353	82.2	284	17.3	9	0.5	1,646
TANMH	3,666	69.4	1,597	30.2	22	0.4	5,284
Total	10,451	80.1	2,511	19.2	84	0.6	13,047

** = Include only Virginia areas.

Table 2. Historical (Pre-1971), Tier 1, Tier 2, Tier 3, 1971-2001 Composite and Current (2001) Distribution of SAV by CBP Segment in Study Area

BAY SEGMENT	**HISTORICAL SAV (PRE 1971)****	**TIER 1 GOAL***	**TIER 2 TARGET***	**TIER 3 TARGET***	**1971-2001 COMPOSITE TARGET****	**2001 MAPPED SAV****	**2001 % HISTORICAL****
CB7PH	6,116	4889	11,538	13,183	6,265	3,712	60.7
POCMH	1,646	841	5,672	7,272	1,016	595	36.0
TANMH	5,566	8,053	15,732	23,482	4,012	2,234	40.1
Total	13,329	13,783	20,936	43,937	11,293	6,541	49.1

* = Include both Maryland and Virginia areas

** = Include only Virginia areas.

POCMH respectively. Within CB7PH losses have been least in the historical SAV areas located in the lower portions of the individual creek systems and along the bay shoreline and greatest within the creeks themselves. The Tier 1 goal and Tier 2 and 3 targets (Batiuk et al. 2000) have not been established for the Virginia-only portions of these segments. The goal and targets for the entire segments are presented in Table 2 for comparative purposes.

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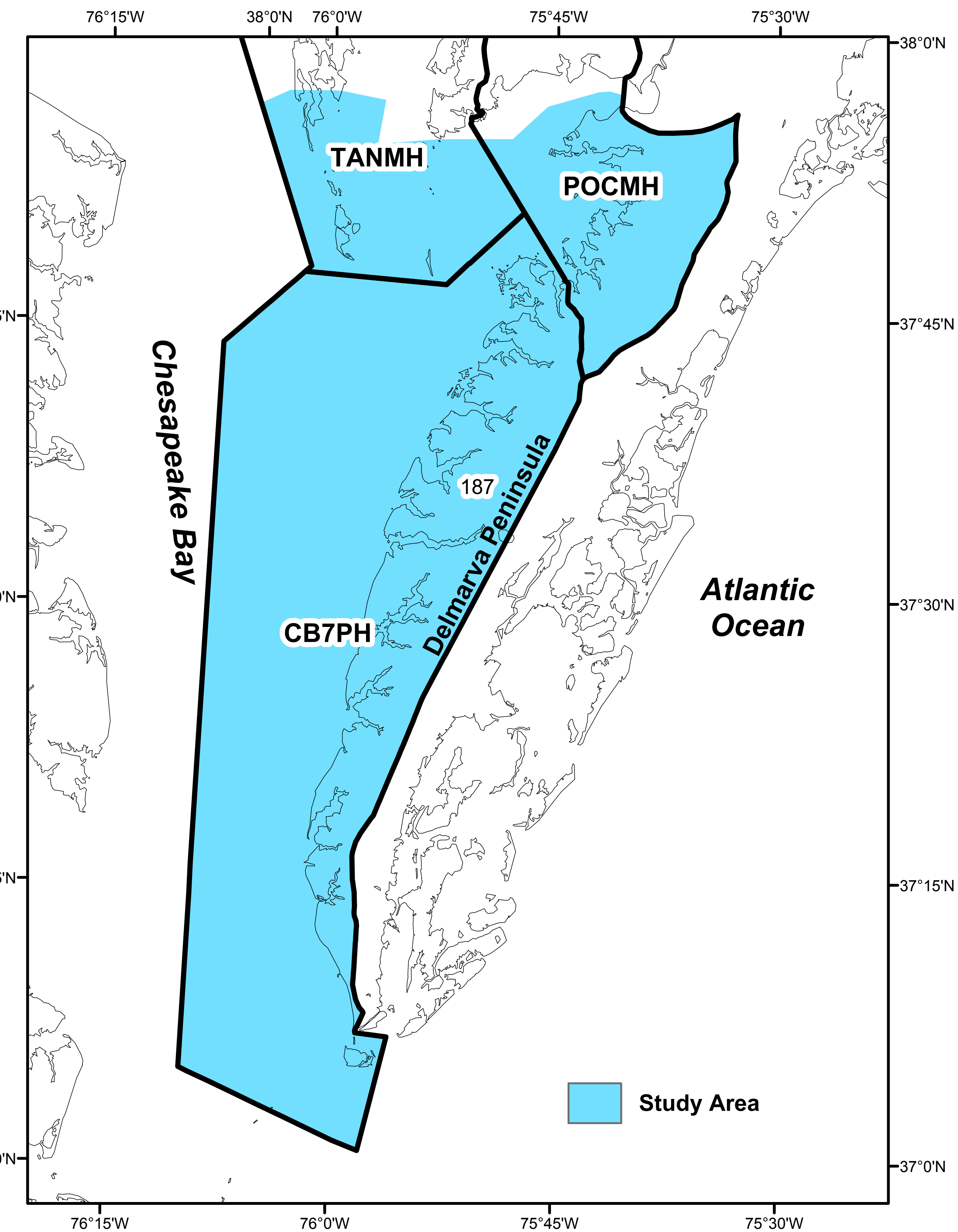
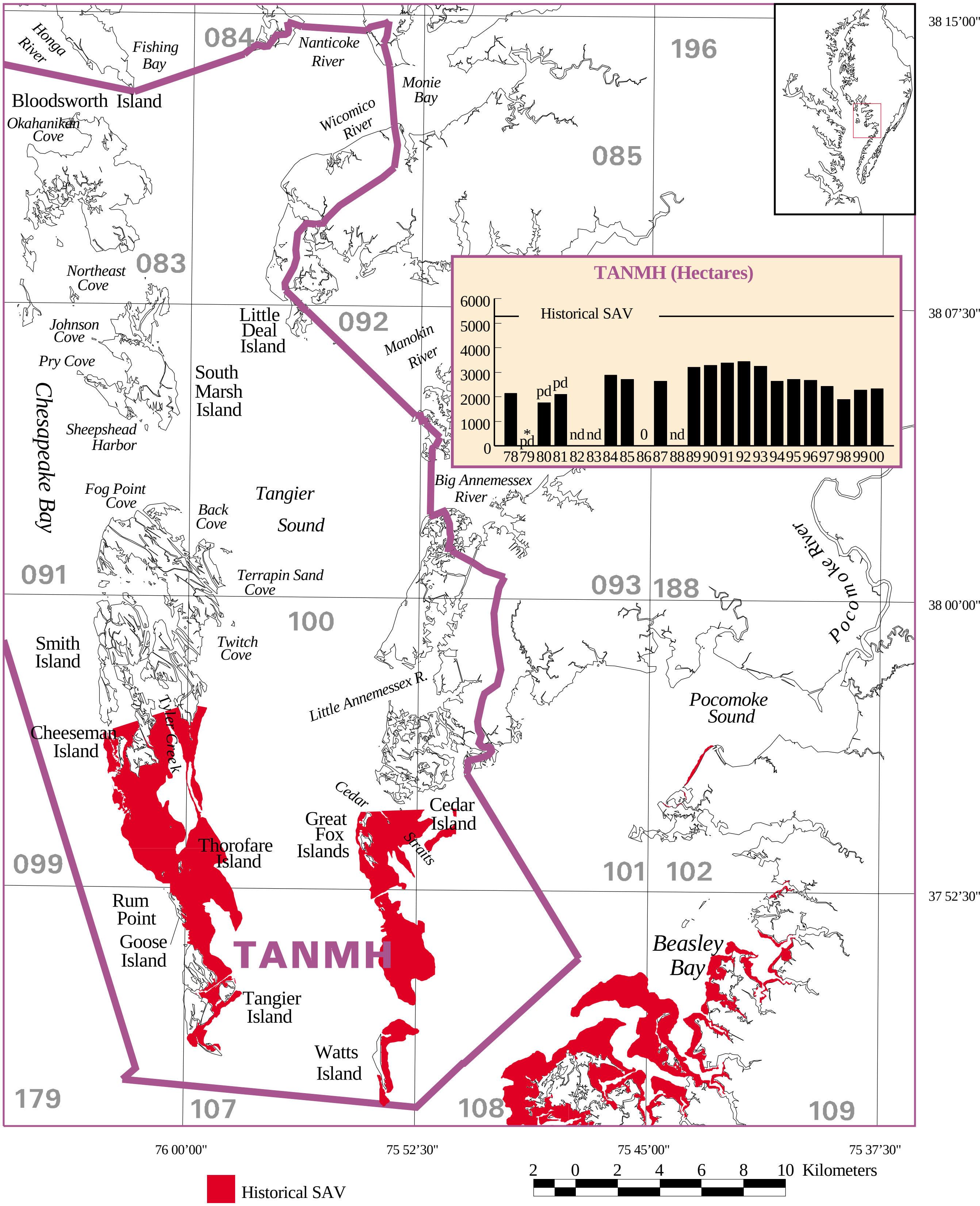
Appendix 1

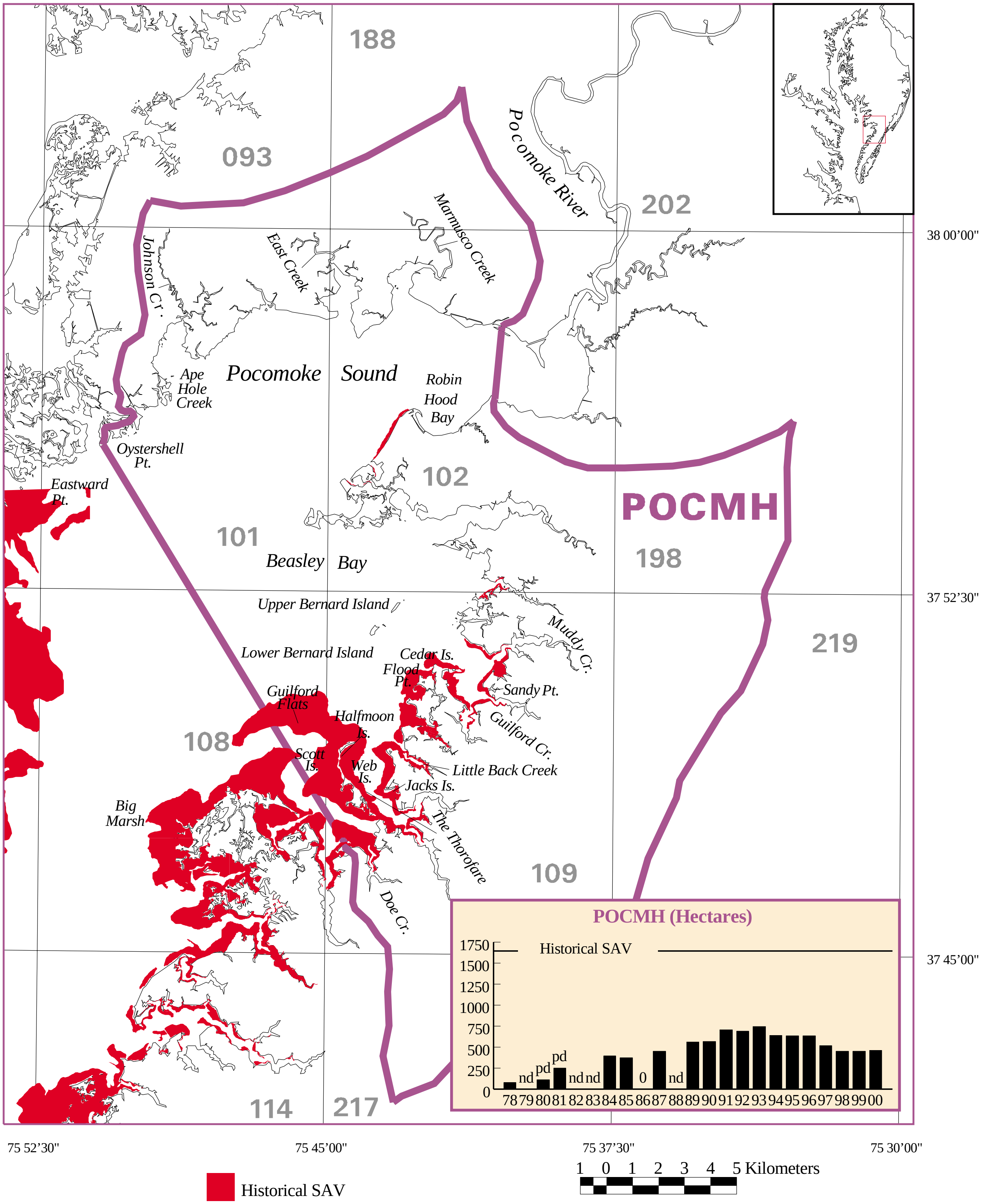
CBP Bay Segments Showing Distribution and Abundance of Historical SAV



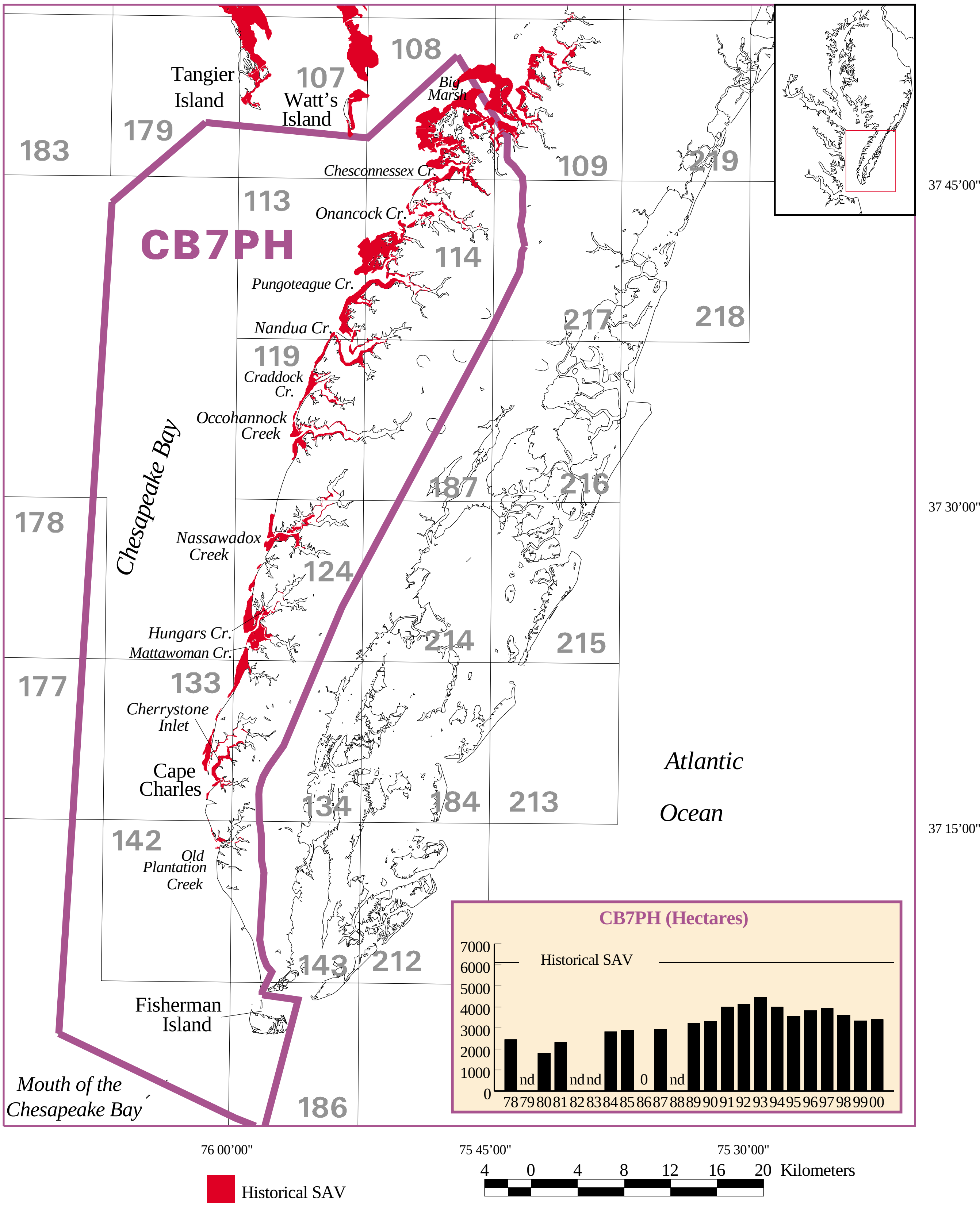
76°15'W
38°0'N
76°0'W
75°45'W
75°30'W
38°0'N
37°45'N
37°30'N
37°15'N
37°0'N
TANMH
POCMH
CB7PH
187
Chesapeake Bay
Delmarva Peninsula
Atlantic Ocean
Study Area



Honga River
Fishing Bay
084
Nanticoke River
196
Monie Bay
Bloodsworth Island
Okahanikan Cove
Wicomico River
085
Northeast Cove
083
TANMH (Hectares)
6000
5000
4000
3000
2000
1000
0
Historical SAV
pd
pd
*
pd
nd nd
0
nd
78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 00
Little Deal Island
092
Manokin River
Johnson Cove
Pry Cove
South Marsh Island
Chesapeake Bay
Sheepshead Harbor
Big Annemessex River
Fog Point Cove
Tangier Sound
Back Cove
Pocomoke River
091
Terrapin Sand Cove
093
188
100
Smith Island
Twitch Cove
Little Annemessex R.
Pocomoke Sound
Cheeseman Island
Tyler Creek
Cedar Straits
Cedar Island
Great Fox Islands
Thorofare Island
099
101
102
Rum Point
Goose Island
TANMH
Beasley Bay
Tangier Island
Watts Island
179
107
108
109
38 15'00"
38 07'30"
38 00'00"
37 52'30"
76 00'00"
75 52'30"
75 45'00"
75 37'30"
2 0 2 4 6 8 10 Kilometers
Historical SAV



188
093
202
Pocomoke River
Marmusco Creek
East Creek
Johnson Cr.
Ape Hole Creek
Pocomoke Sound
Robin Hood Bay
Oystershell Pt.
Eastward Pt.
102
POCMH
101
Beasley Bay
198
Upper Bernard Island
Muddy Cr.
Lower Bernard Island
Cedar Is.
Flood Pt.
219
Sandy Pt.
Guilford Flats
Halfmoon Is.
Guilford Cr.
108
Scott Is.
Web Is.
Little Back Creek
Jacks Is.
Big Marsh
The Thorofare
109
Doe Cr.
114
217
38 00'00"
37 52'30"
37 45'00"
75 52'30"
75 45'00"
75 37'30"
75 30'00"
POCMH (Hectares)
Historical SAV
1750
1500
1250
1000
750
500
250
0
nd
pd
pd
nd nd
0
nd
78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 00
1 0 1 2 3 4 5 Kilometers
Historical SAV

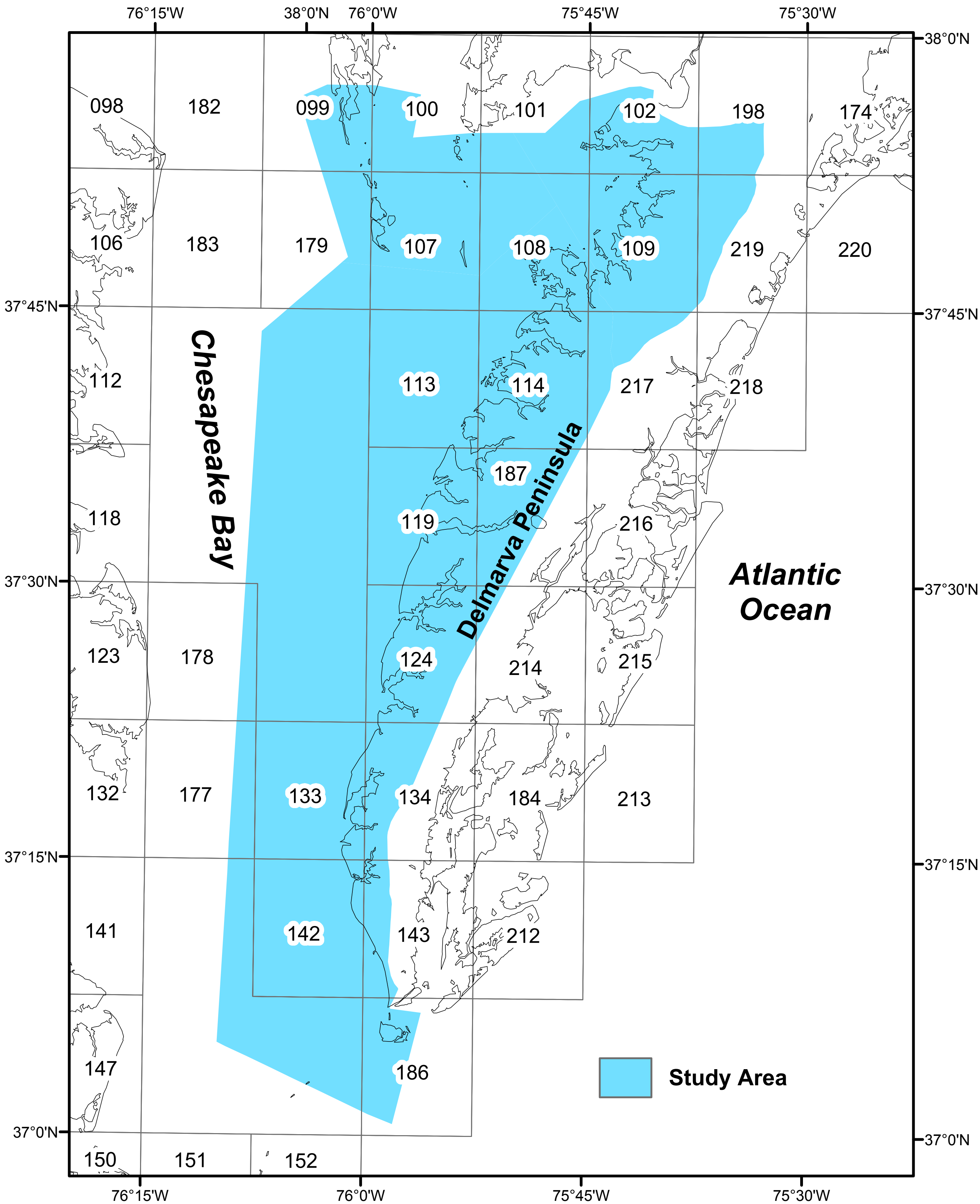


CB7PH
Tangier Island
Watt's Island
Big Marsh
Chesconnessex Cr.
Onancock Cr.
Pungoteague Cr.
Nandua Cr.
Craddock Cr.
Occohannock Creek
Chesapeake Bay
Nassawadox Creek
Hungars Cr.
Mattawoman Cr.
Cherrystone Inlet
Cape Charles
Old Plantation Creek
Fisherman Island
Mouth of the Chesapeake Bay
Atlantic Ocean
183
179
107
108
109
219
113
114
217
218
119
187
216
178
124
214
215
177
133
134
184
213
142
143
212
186
37 45'00"
37 30'00"
37 15'00"
76 00'00"
75 45'00"
75 30'00"
CB7PH (Hectares)
Historical SAV
7000
6000
5000
4000
3000
2000
1000
0
nd
nd nd
0
nd
78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 00
Historical SAV
4 0 4 8 12 16 20 Kilometers

Appendix 2

7.5 minute USGS Quadrangles Showing Distribution and Abundance

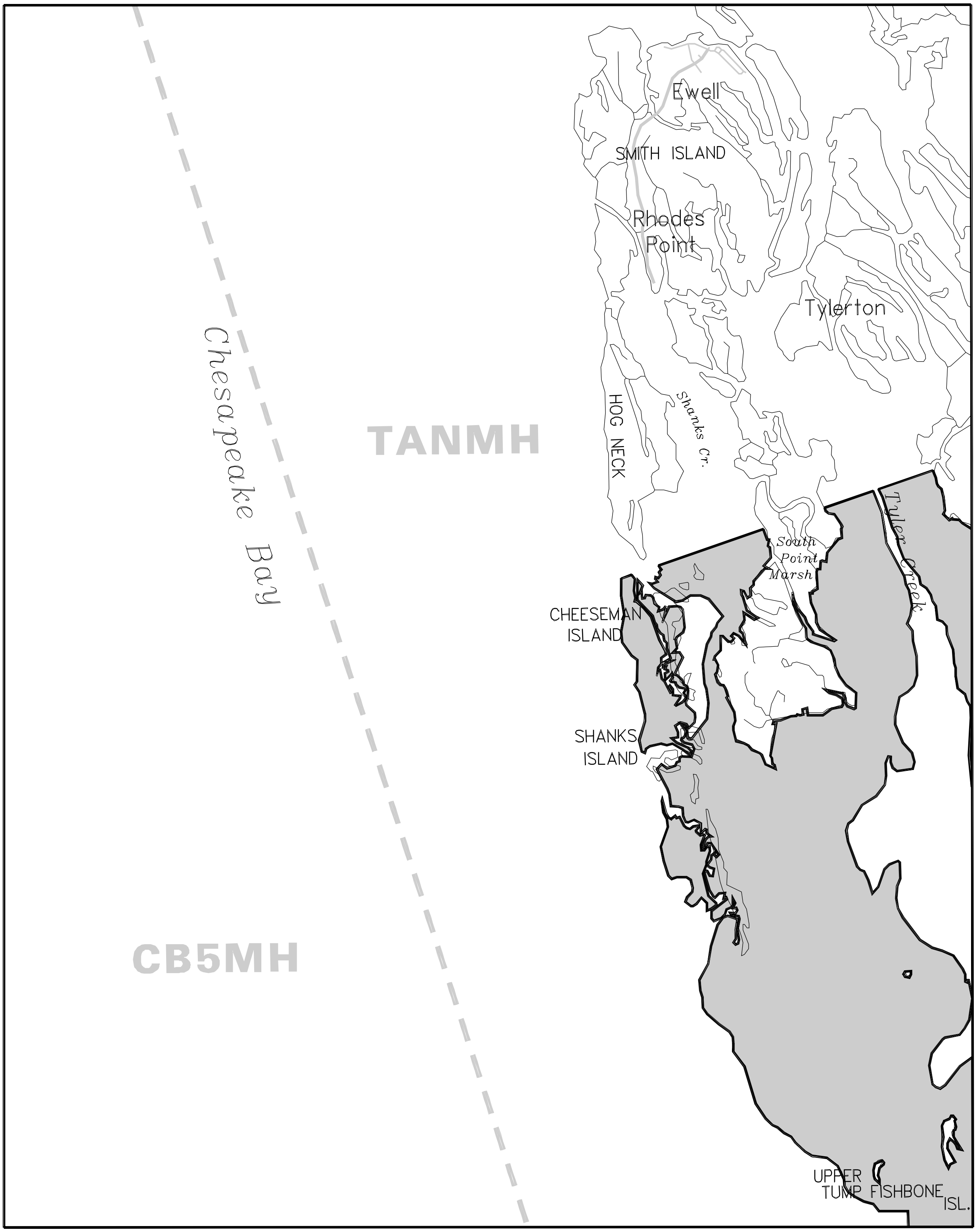
Of Historical SAV



76°15'W
38°0'N
76°0'W
75°45'W
75°30'W
38°0'N
37°45'N
37°30'N
37°15'N
37°0'N
098
182
099
100
101
102
198
174
106
183
179
107
108
109
219
220
112
113
114
217
218
118
119
187
216
123
178
124
214
215
132
177
133
134
184
213
141
142
143
212
147
186
150
151
152
Chesapeake Bay
Delmarva Peninsula
Atlantic Ocean
Study Area

Historical Submerged Aquatic Vegetation

Ewell, Md.- Va. (099)



Hectares of SAV: 1,787.98

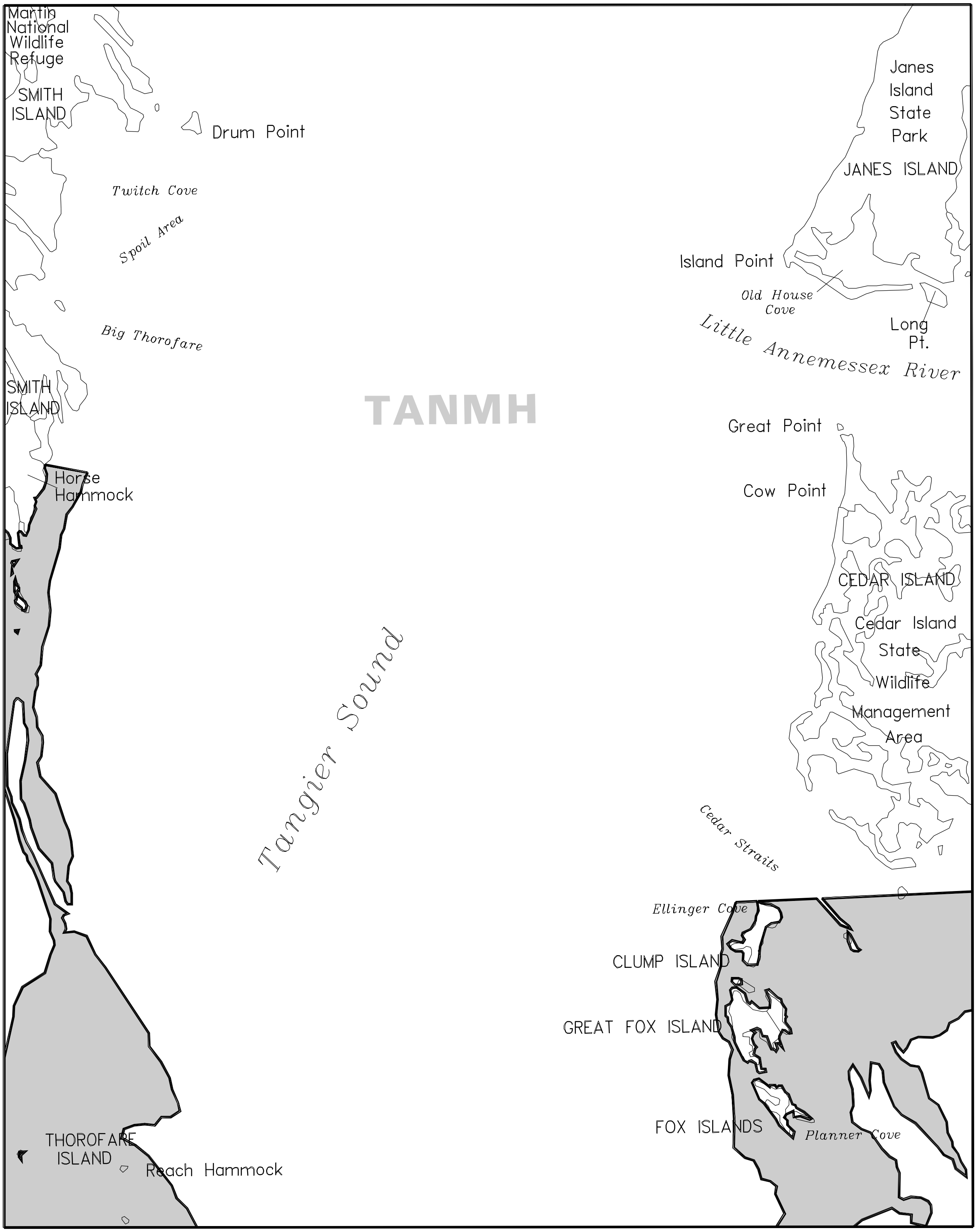
1000 0 1000 2000 meters

Historical SAV Coverage

Sources: VIMS,USGS

Historical Submerged Aquatic Vegetation

Great Fox Island, Va.- Md. (100)



Hectares of SAV: 1,449.12

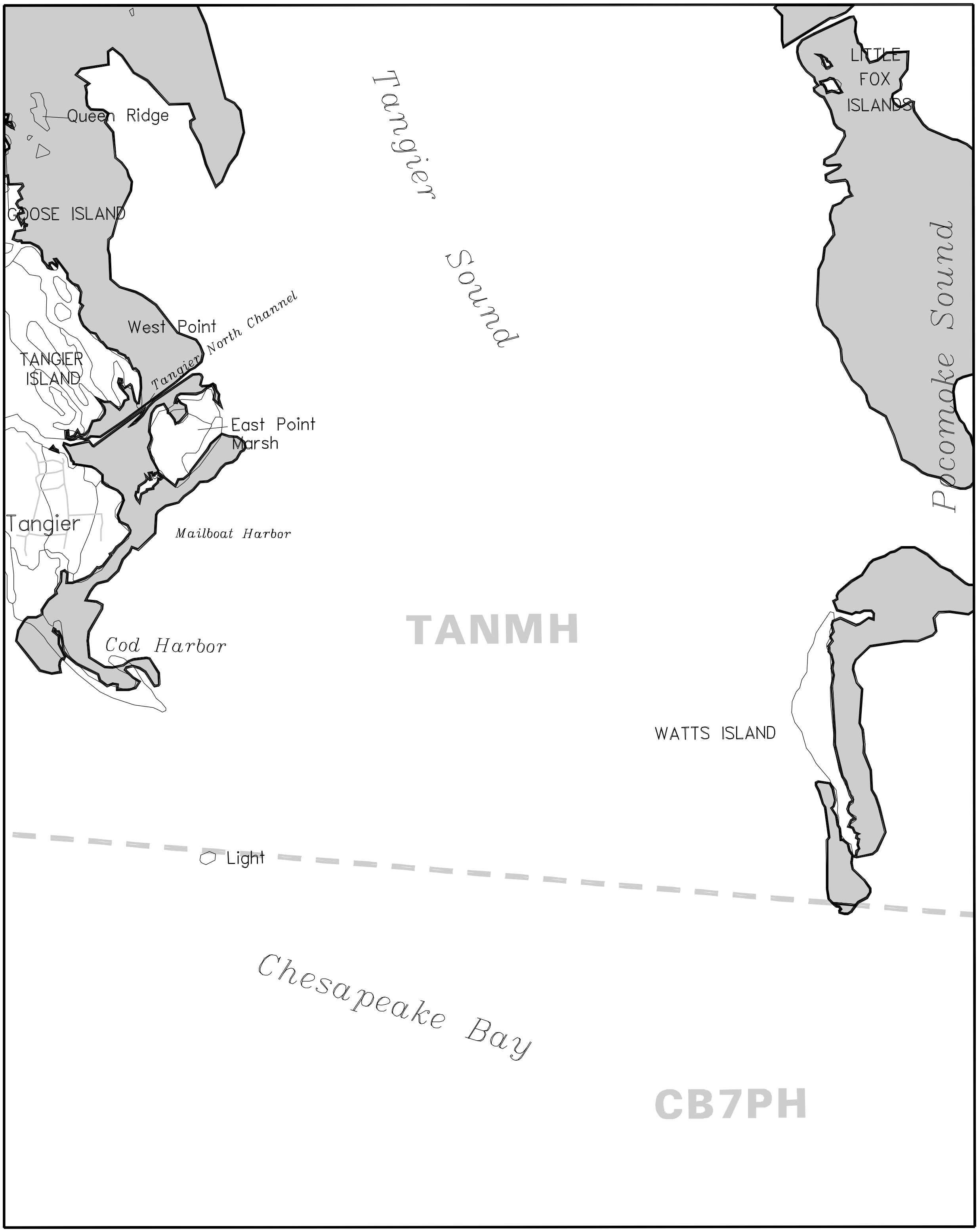
1000 0 1000 2000 meters

Historical SAV Coverage

Sources: VIMS,USGS

Historical Submerged Aquatic Vegetation

Tangier Island, Va. (107)



Hectares of SAV: 1,704.37

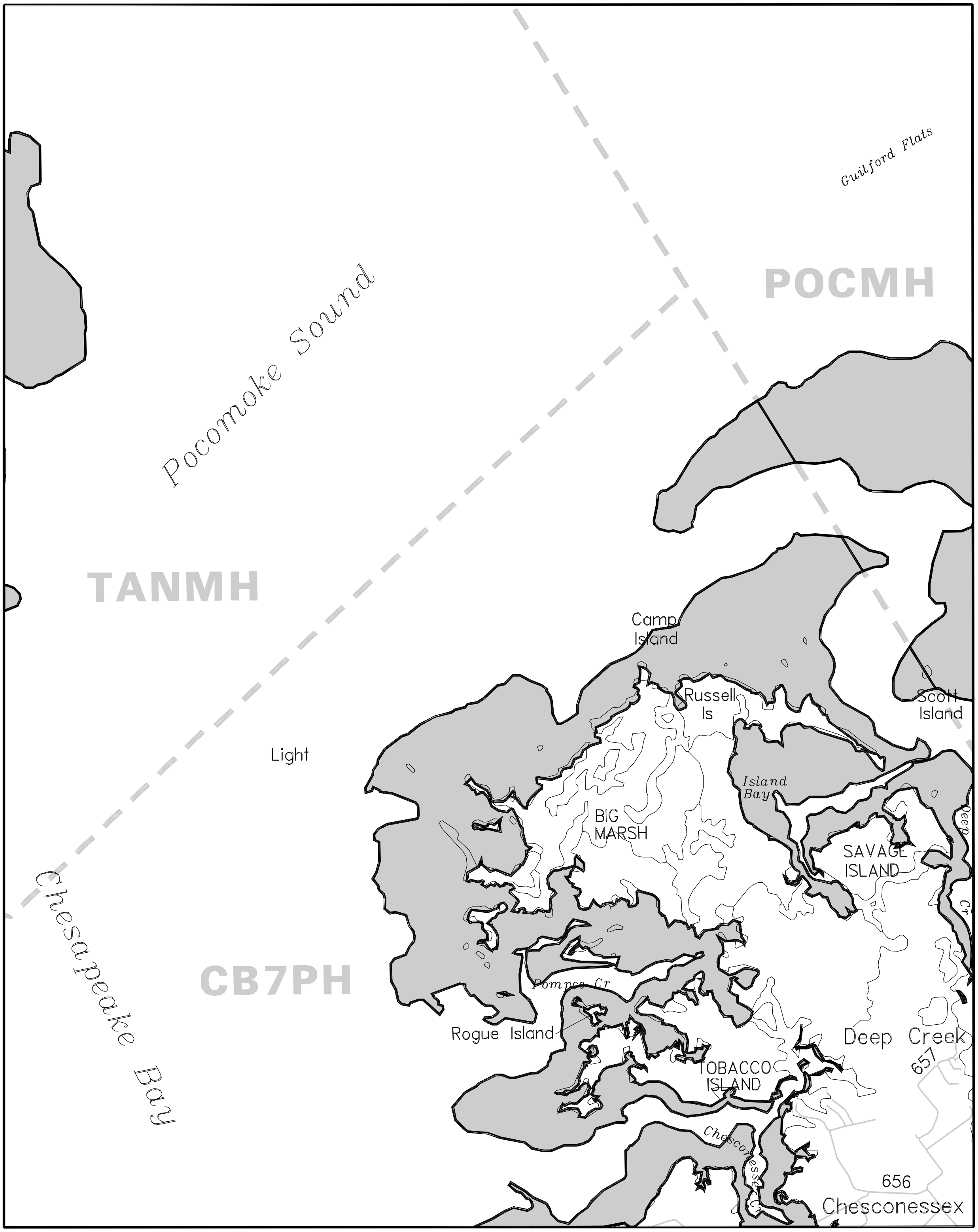
1000 0 1000 2000 meters

Historical SAV Coverage

Sources: VIMS,USGS

Historical Submerged Aquatic Vegetation

Chesconessex, Va. (108)



Hectares of SAV: 2,428.36

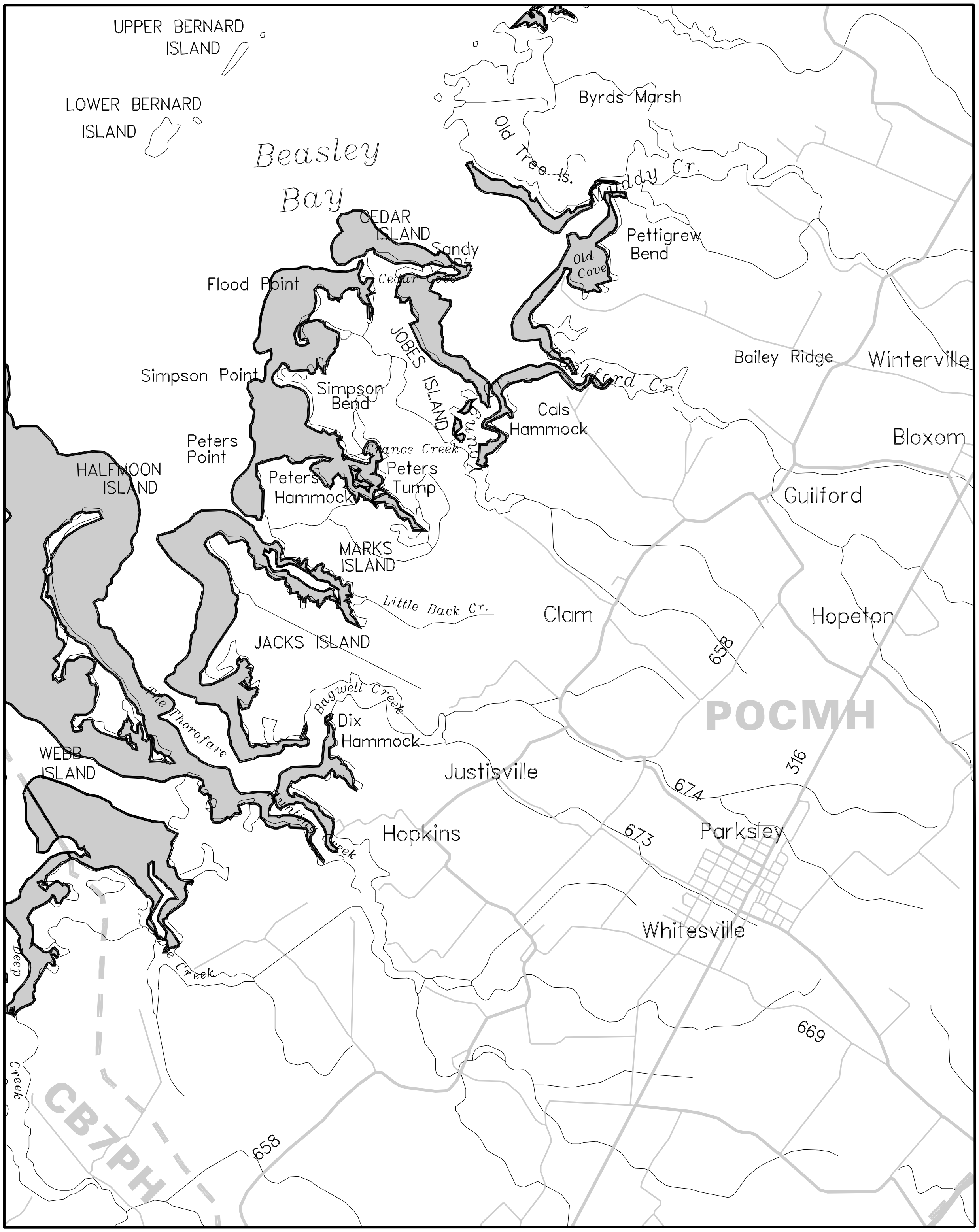
1000 0 1000 2000 meters

Historical SAV Coverage

Sources: VIMS,USGS

Historical Submerged Aquatic Vegetation

Parksley, Va. (109)



Hectares of SAV: 1,264.80

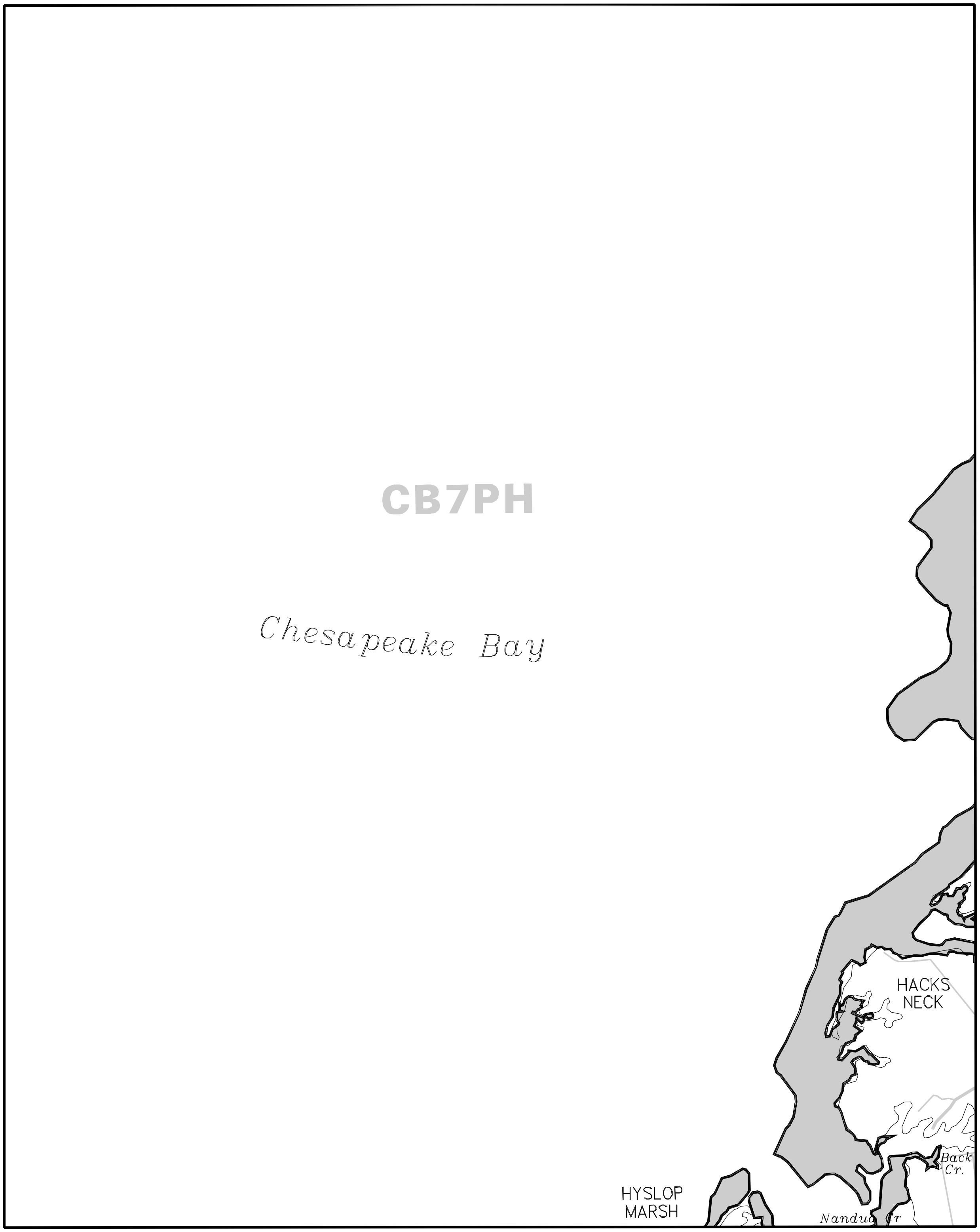
Historical SAV Coverage

1000 0 1000 2000 meters

Sources: VIMS,USGS

Historical Submerged Aquatic Vegetation

Nandua Creek, Va. (113)



Hectares of SAV: 526.80

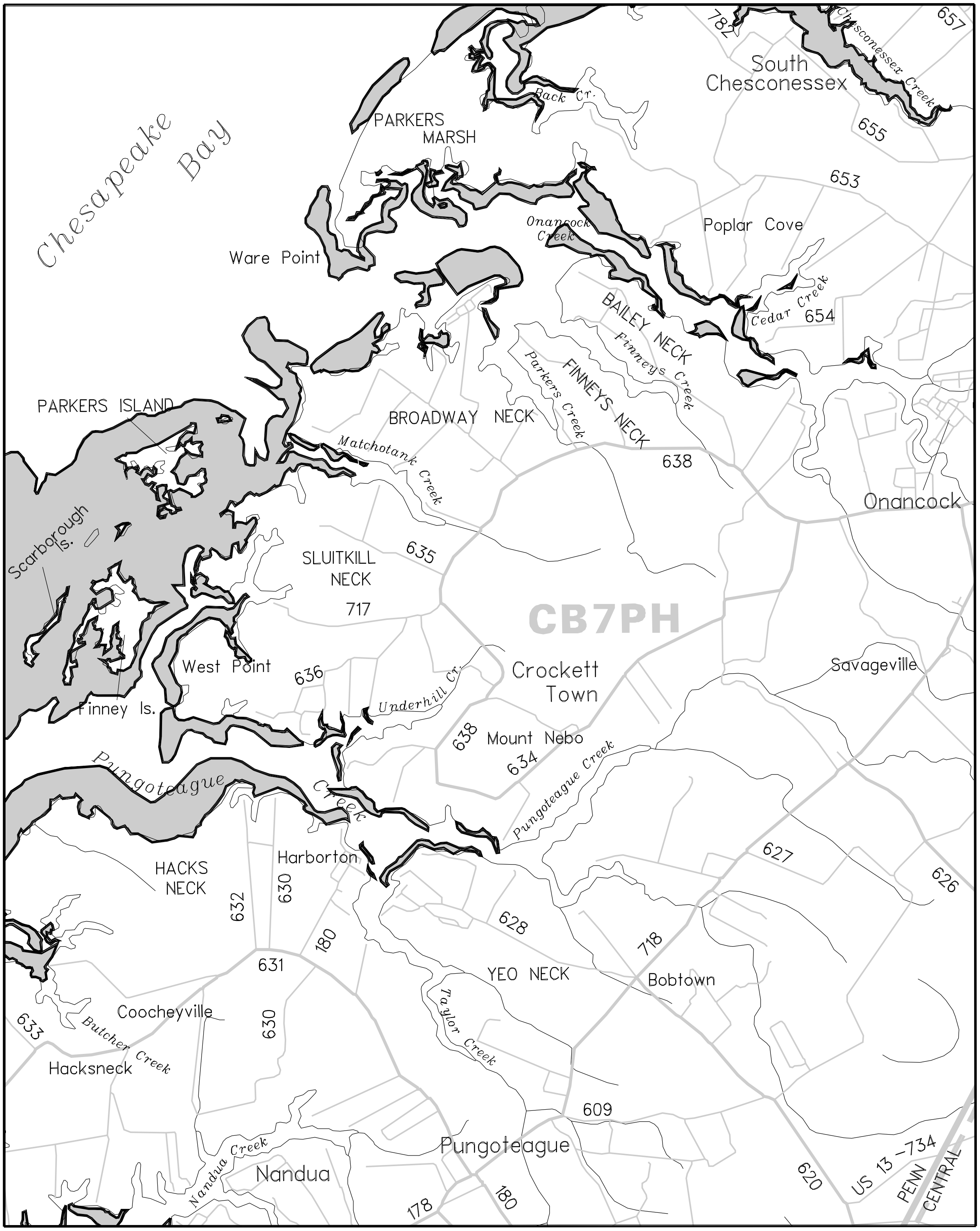
1000 0 1000 2000 meters

Historical SAV Coverage

Sources: VIMS,USGS

Historical Submerged Aquatic Vegetation

Pungoteague, Va. (114)



Hectares of SAV: 1,283.37

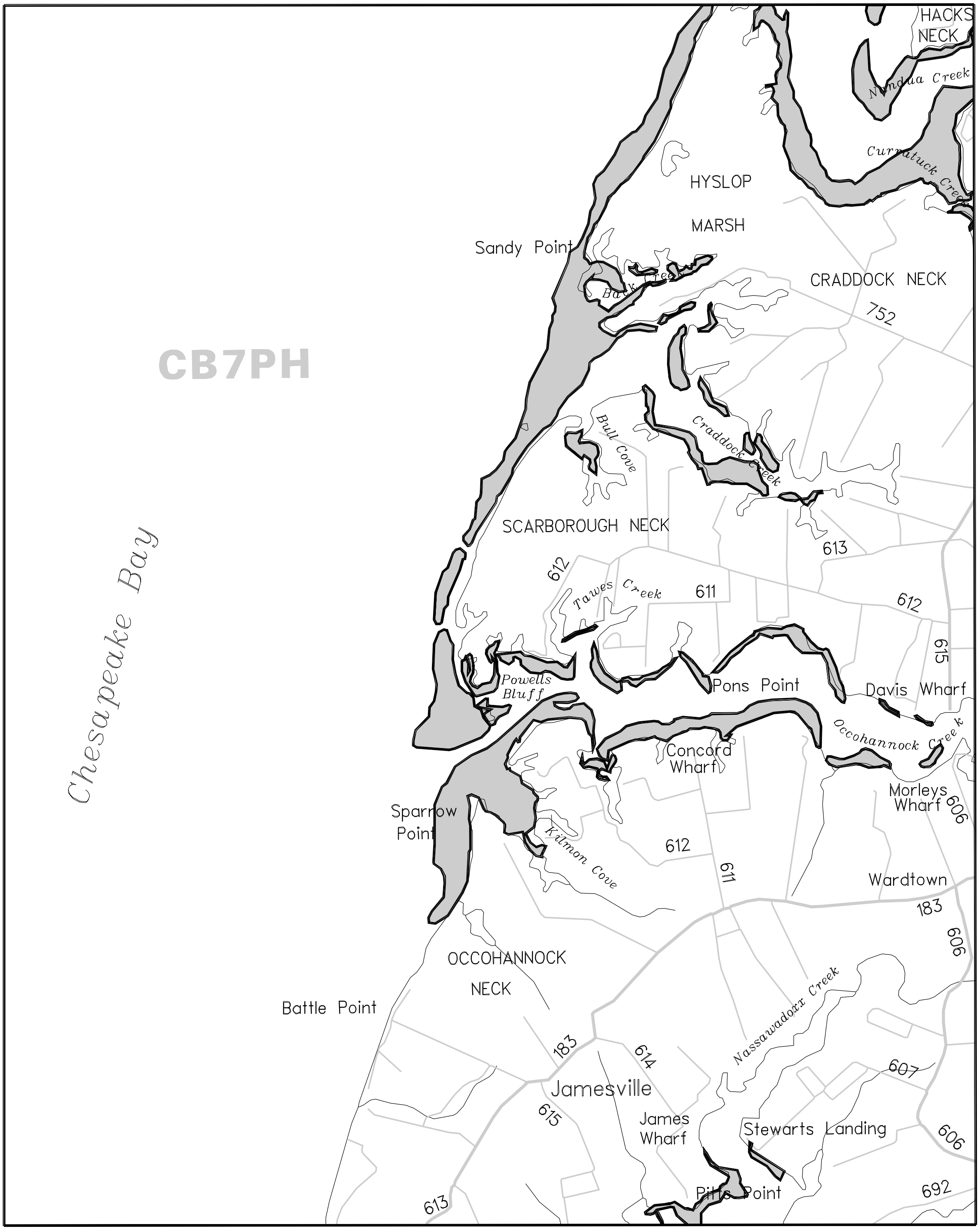
1000 0 1000 2000 meters

Historical SAV Coverage

Sources: VIMS,USGS

Historical Submerged Aquatic Vegetation

Jamesville, Va. (119)



Hectares of SAV: 785.45

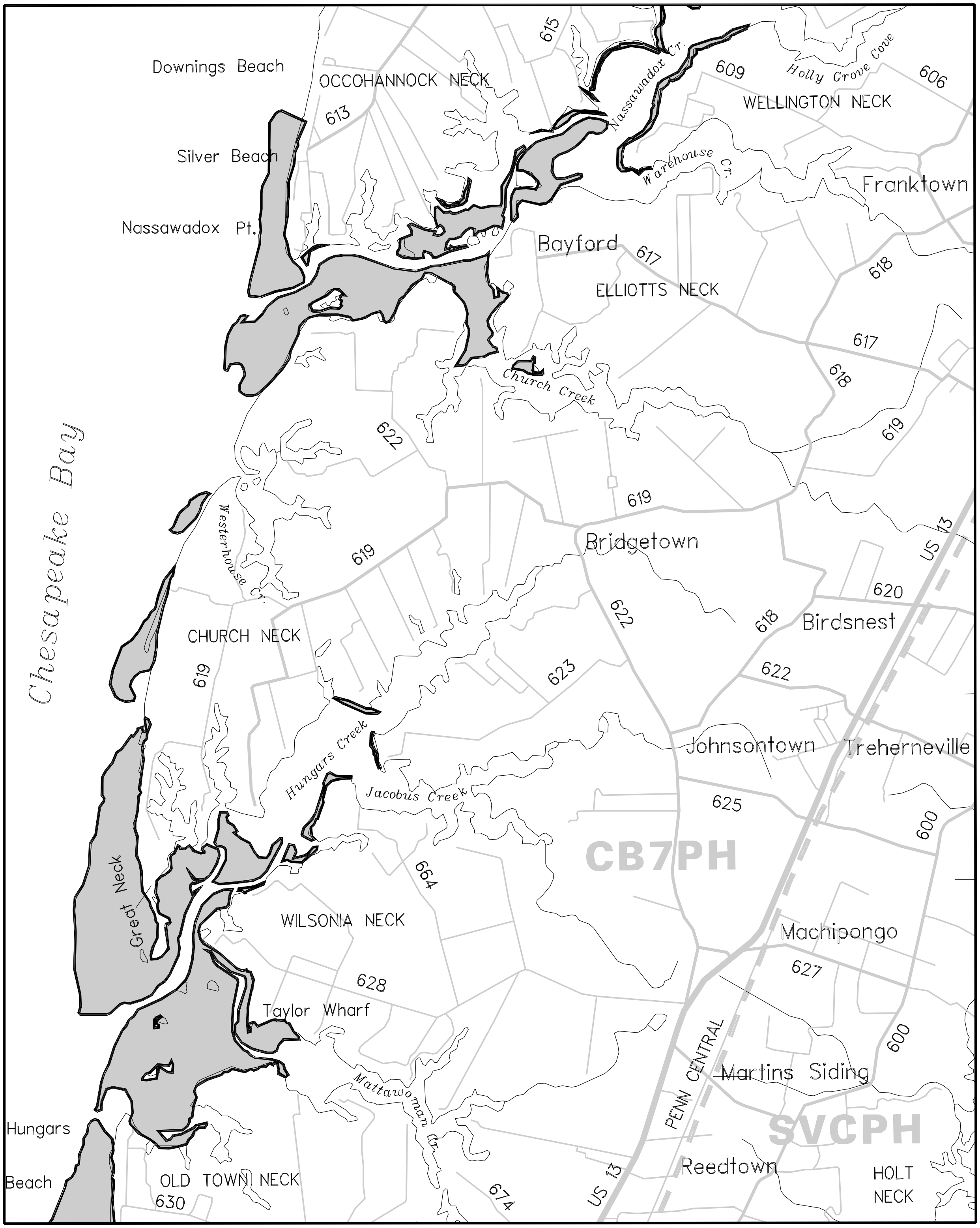
1000 0 1000 2000 meters

Historical SAV Coverage

Sources: VIMS,USGS

Historical Submerged Aquatic Vegetation

Franktown, Va. (124)

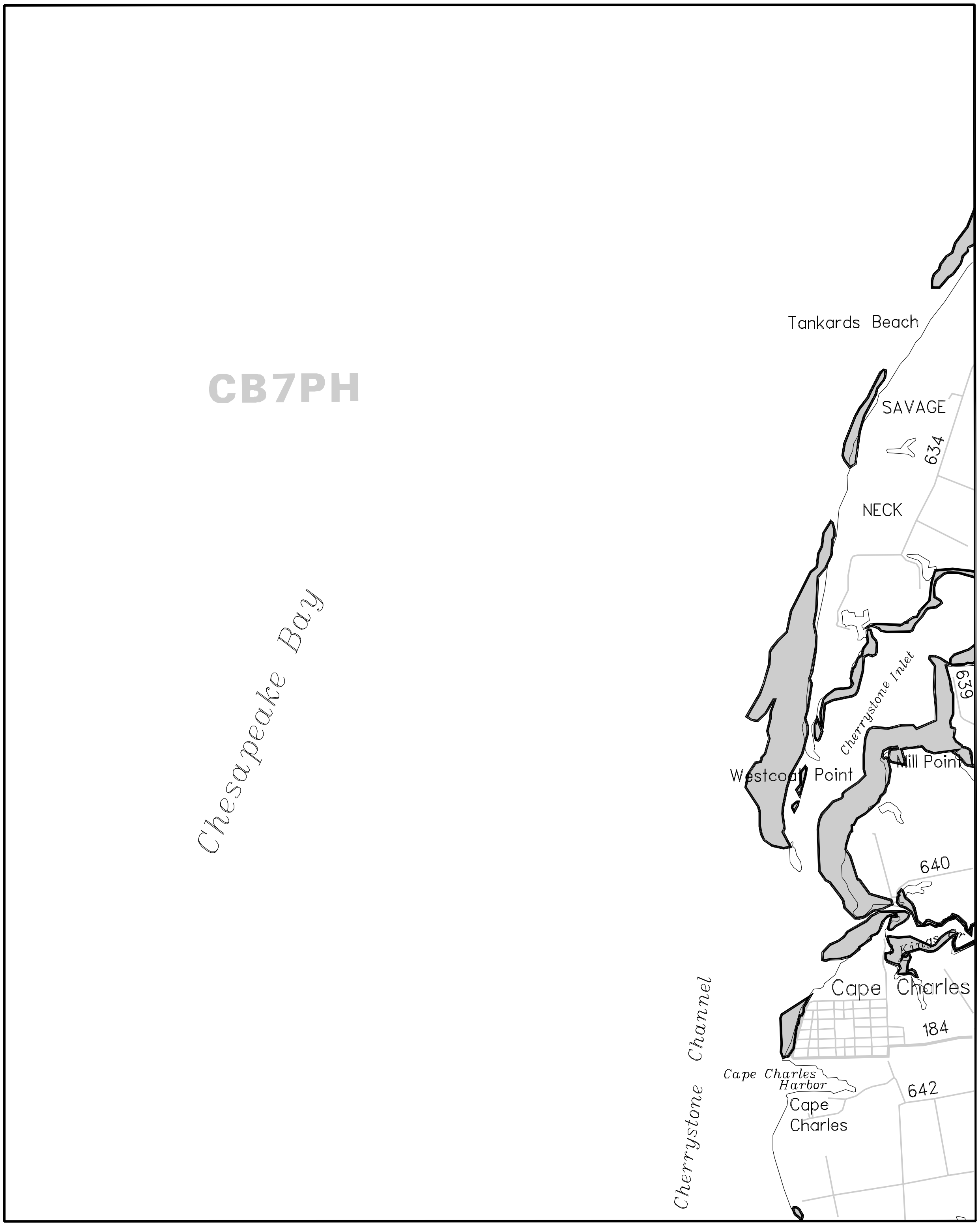


Hectares of SAV: 970.13

Sources: VIMS,USGS

Historical Submerged Aquatic Vegetation

Cape Charles, Va. (133)



Hectares of SAV: 349.76

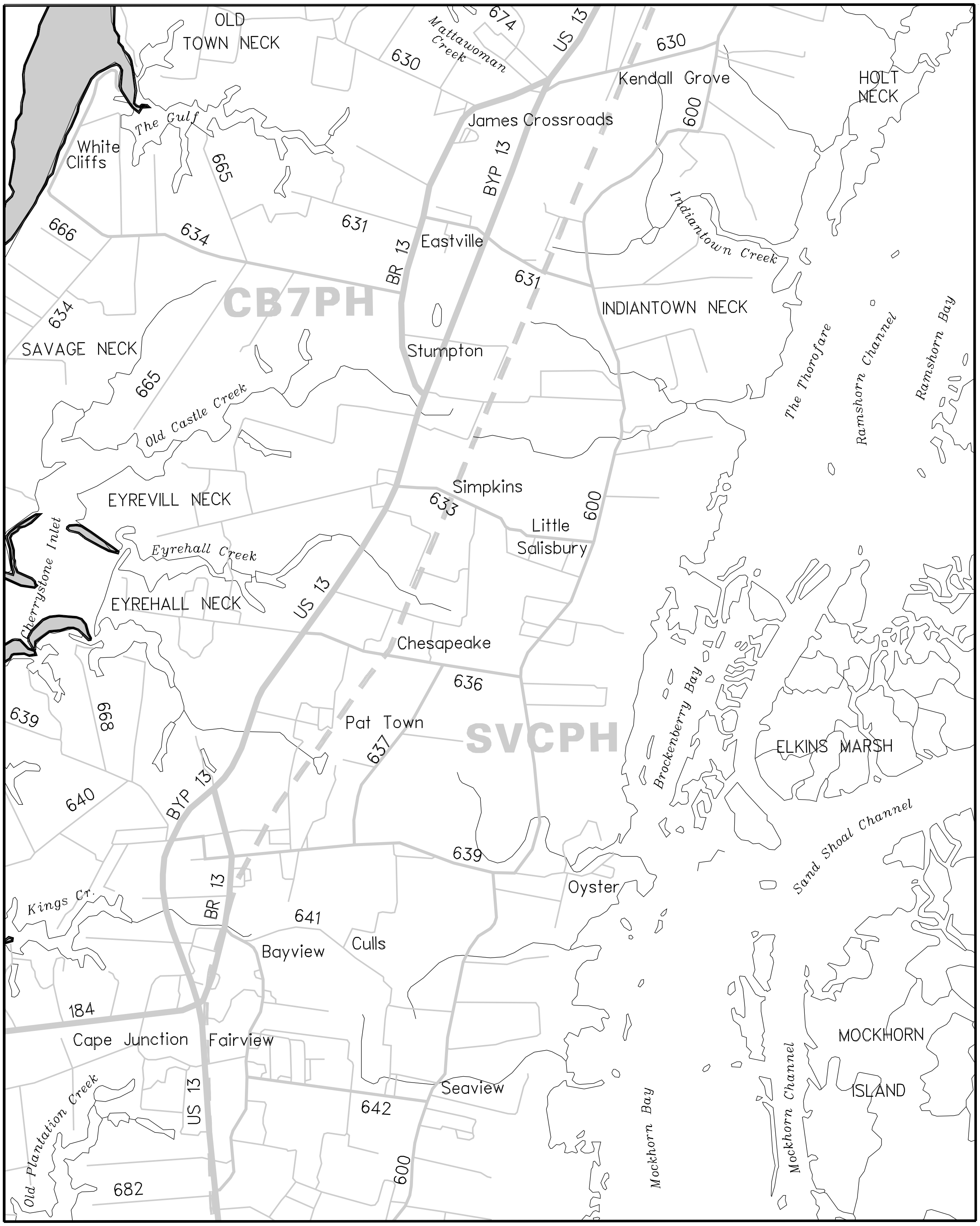
1000 0 1000 2000 meters

Historical SAV Coverage

Sources: VIMS,USGS

Historical Submerged Aquatic Vegetation

Cheriton, Va. (134)



Hectares of SAV: 199.80

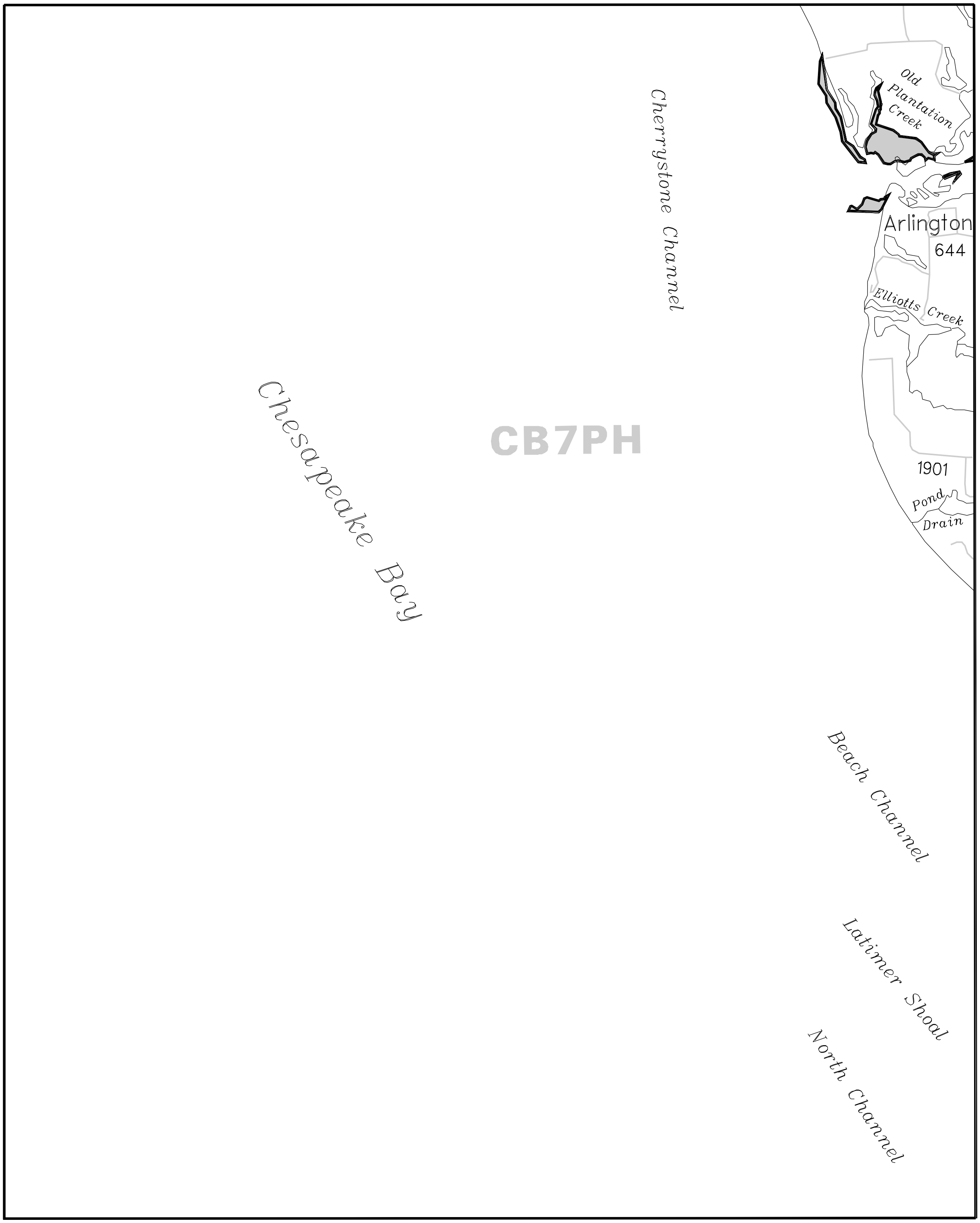
Historical SAV Coverage

1000 0 1000 2000 meters

Sources: VIMS,USGS

Historical Submerged Aquatic Vegetation

Elliotts Creek, Va. (142)



Hectares of SAV: 33.89

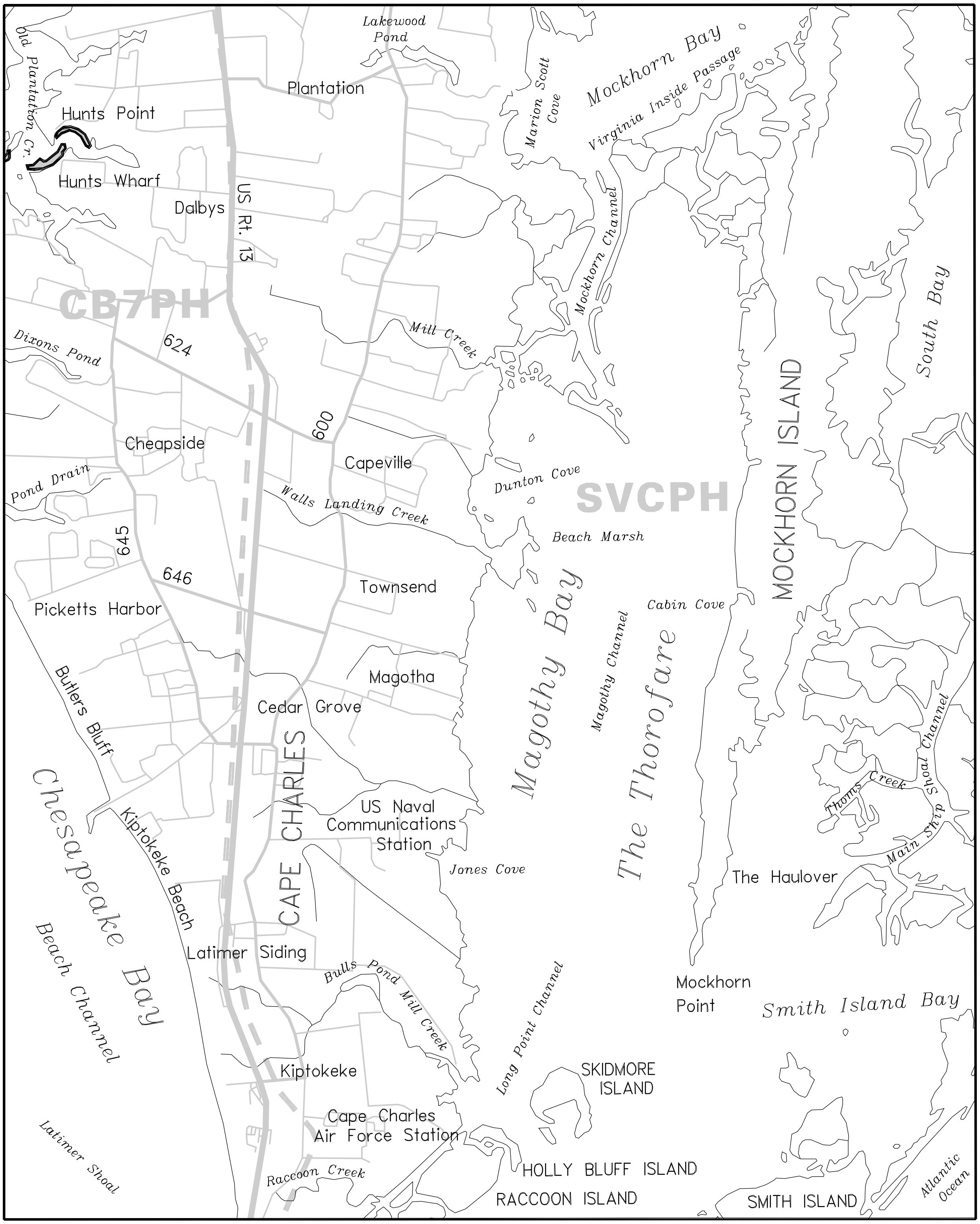
Historical SAV Coverage

1000 0 1000 2000 meters

Sources: VIMS,USGS

Historical Submerged Aquatic Vegetation

Townsend, Va. (143)



Hectares of SAV: 6.34

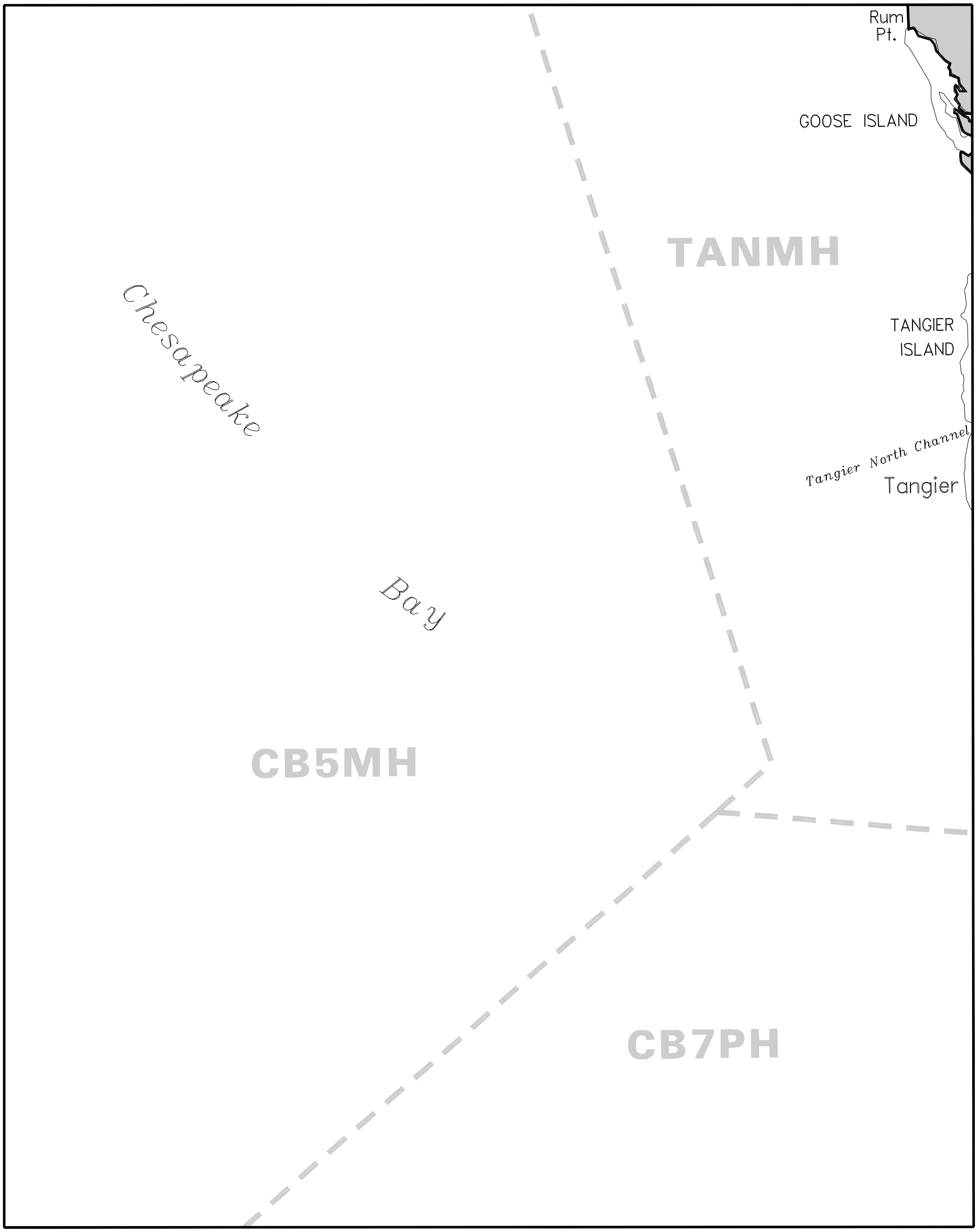
Historical SAV Coverage

1000 0 1000 2000 meters

Sources: VIMS,USGS

Historical Submerged Aquatic Vegetation

Goose Island, Va. (179)



Hectares of SAV: 52.89

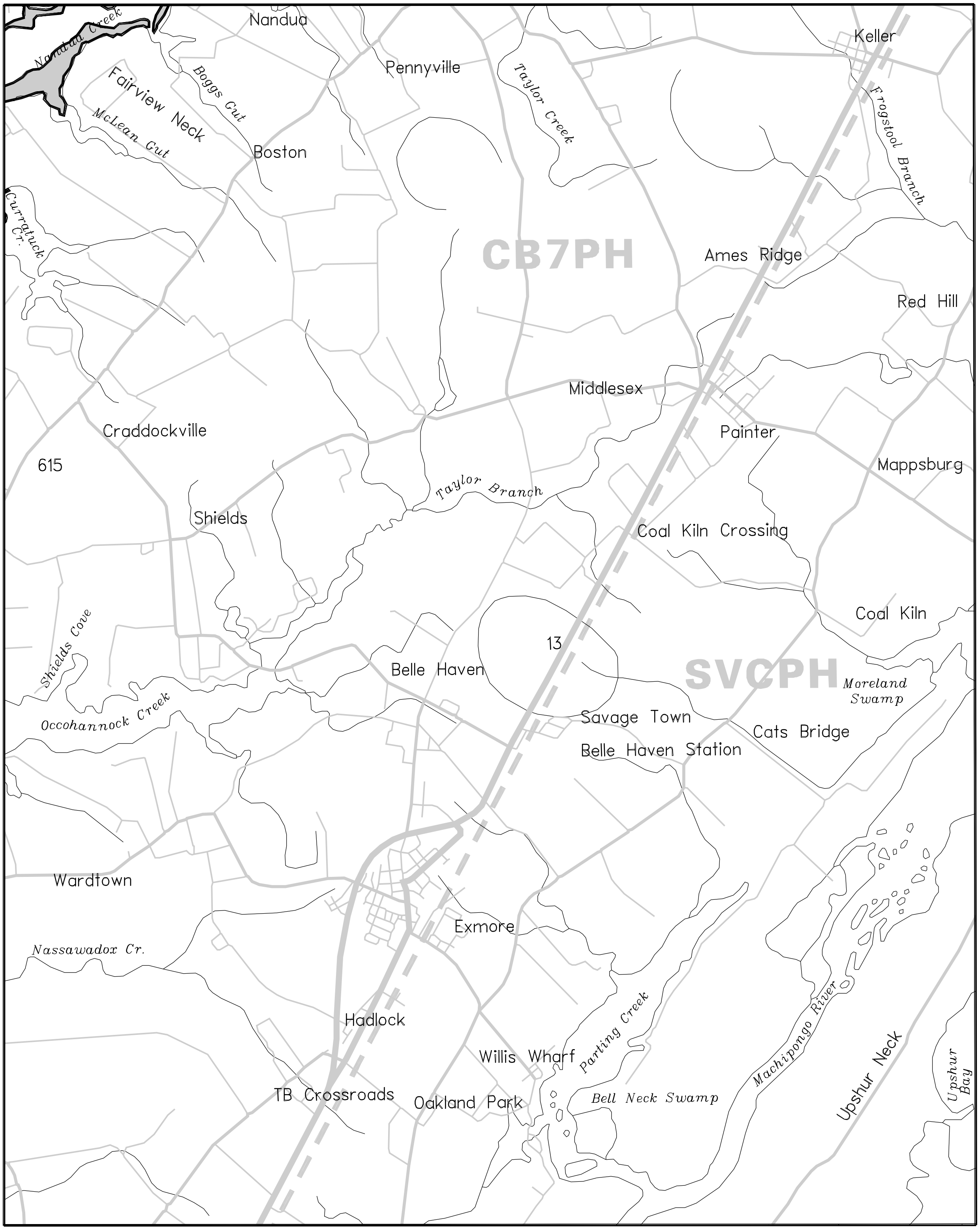
1000 0 1000 2000 meters

Historical SAV Coverage

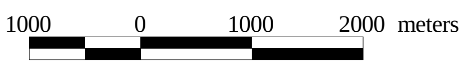
Sources: VIMS,USGS

Historical Submerged Aquatic Vegetation

Exmore, Va. (187)



Hectares of SAV: 47.63



Historical SAV Coverage

Sources: VIMS,USGS