APPENDIX D

SAV Depth, Area and Water Quality Data Used and Details of Statistical Analysis Performed

SAV AREA BY DEPTH AND WEIGHTED MEAN DEPTH

SAV area by depth data were examined to see if they were correlated with water quality data. This was done by generating depth contours at 0.5, 1 and 2 meters MLLW and overlaying SAV polygons on them. The SAV area within four depth ranges was calculated for each Chesapeake Bay Program segment and year, and the areas were converted to percentages by dividing each by the total area in that segment and multiplying by 100. The depth ranges, area variables and percent variables for each are listed in Table D-1.

These areas were also used to calculate a weighted mean SAV depth for each segment and year (SAVDEP). This was done with the usual formula for weighted mean, multiplying the area in each depth range by the midpoint of each range, summing them and dividing their sum by the total area:

SAVDEP = [(AREA05)*0.25 + (AREA1)*0.75 + (AREA2)*1.5 + (AREAGT2)*2.5] / (Total SAV area)

Since the Area > 2 category has no upper bound, 2.5 meters was chosen as the midpoint, assuming that very little of the mapped SAV was growing in water more than 3 meters deep MLLW. This assumption was based on ground truth observations that SAV is rarely found below this depth and the limited ability to see below this depth in aerial photos taken in the normally turbid Chesapeake. This mean depth was used in Spearman rank correlations with water quality parameters, along with the four percentages in different depth categories.

SAV AREA DATA AND GROWTH CATEGORIES

SAV area by Chesapeake Bay Program segment came from the Chesapeake Bay SAV aerial survey. The latest table of hectares by segment by year was downloaded from the VIMS web page (http://www.vims.edu/bio). SAV growth categories were used for some analyses, which represented average conditions over all years with SAV area data. For the York and Choptank rivers, the same ‘Persistent,’ ‘Fluctuating’ and ‘None’ categories were used that were used before (Batiuk *et al.* 1992). These categories were based on observations of the persistence over time of either natural or transplanted SAV near the monitoring stations. For the Chesapeake Bay SAV Aerial Survey data, the three different categories for SAV area by USGS quad were applied to SAV area by CBP segment instead of quad, using 1978-97 SAV hectares by segment by year. The three categories were expanded to five and were considered equivalent to the categories used in Batiuk *et al.* (1992), as show in Table D-2.

Adding two more categories to the ones defined by Hagy (unpublished data) helped separate the ‘best’ and ‘worst’ segments from the others. These were the ‘Always Abundant’ and ‘Always None’ categories respectively. The results of this analysis for each Chesapeake Bay Program segment are shown in Table D-3.

WATER QUALITY DATA USED

Data used for SAV habitat requirements were from surface samples (Layer = ‘S’) from selected Chesapeake Bay Water Quality stations in each segment.

TABLE D-1. SAV depth ranges and variable names.

Depth range	Area variable	Percent variable
Less than 0.5 meters deep	AREA05	PCT05
0.5-1 meter deep	AREA1	PCT1
1-2 meters deep	AREA2	PCT2
Greater than 2 meters deep	AREAGT2	PCTGT2

TABLE D-2. Five categories used for characterizing SAV growth status by segment based on 1978-1997 aerial survey data.

New category (based on aerial survey data)	Criteria used for category (using SAV area by year by segment)	SAV TSI growth category (based on transplant success)
Always Abundant (AA)	Minimum > 200 ha	Persistent
Always Some (AS)	Minimum > 0	Persistent
Sometimes None (SN)	Minimum = 0 and Median > 0	Fluctuating
Usually None (UN)	Median = 0 and Maximum > 0	None
Always None (AN)	Maximum = 0	None

When there was more than one station per segment, stations that were too far from SAV were dropped from the analysis (Table D-5). Nearshore data collected in the York and Choptank rivers for the first SAV Technical Synthesis (Batiuk *et al.* 1992) were also used. Volunteer monitoring data were not used because they were only available for a few years and segments.

Data were used only from the SAV growing seasons: April-October for tidal fresh, oligohaline and mesohaline regimes and March-May and September-November in polyhaline. Raw data from all stations used in each segment were used for the Wilcoxon test. Monthly means were not calculated since each month had two samples (where sampling is twice a month) and this would reduce the sample size. For consistency, light attenuation (K_d) was calculated from K_d = 1.45/Secchi even if K^d data from light measurements were available.

TESTING ATTAINMENT OF HABITAT REQUIREMENTS

The attainment of SAV habitat requirements was tested by segment or station and year with the Wilcoxon one-sample test, using the difference between each observation and the habitat requirement for that salinity regime as the data for the test. A custom SAS program to perform the test was written for this application (see Appendix C). When done by segment, data from all the stations used in that segment were used for the test without any averaging, so the sample size was larger if there were more stations. The results were classified in three categories using a two-tailed significance level (P) of 0.05:

Met: median was significantly below the requirement

Borderline: median did not differ significantly from requirement

Not met: median was significantly above the requirement

This test was more sensitive to the consistency of the differences (positive or negative) than to their magnitude.

Tidal range data were used to adjust the restoration depth (Z). This number is critical to both PLW and PLL calculations since it determines the path length for light passing through the water, and thus how much the light is attenuated passing through the water. For any two sites, the one with greater tidal range will on average have more water above the 1 meter depth contour which is referenced to MLLW, the bottom elevation for the tidal range used (semi-diurnal or greater tropic range).

TABLE D-3. New CBP segments classified according to SAV growth category (GROWTH) using 1978-1997 SAV area data: MAX = maximum, MED = median, MIN = minimum (hectares).

SEGMENT	SAVH_MAX	SAVH_MED	SAVH_MIN	GROWTH
APPTF	0	0	0	AN
BACOH	0	0	0	AN
BIGMH	192.12	156.98	0	SN
BOHOH	15.09	1.67	0	SN
BSHOH	39.04	0.26	0	SN
C&DOH	0.62	0	0	UN
CB1TF	2714.04	2076.51	833.98	AA
CB2OH	127.49	17.69	4.02	AS
CB3MH	554.83	327.82	22.21	AS
CB4MH	102.57	5.63	0	SN
CB5MH	1666.81	751.63	275.12	AA
CB6PH	512.84	367.43	241.92	AA
CB7PH	4597.91	3442.21	2452.12	AA
CB8PH	4.4	0	0	UN
CHKOH	89.17	0	0	UN
CHOMH1	2792.59	1168.68	57.75	AS
CHOMH2	94.31	0	0	UN
CHOOH	0	0	0	AN
CHOTF	0	0	0	AN
CHSMH	1050.3	309.18	32.45	AS
CHSOH	0	0	0	AN
CHSTF	0	0	0	AN
CRRMH	178.46	36.85	0	SN
EASMH	1848.32	781.91	67.93	AS
ELIPH	0	0	0	AN
ELKOH	355.81	81.01	0.87	AS
FSBMH	25.88	1.32	0	SN
GUNOH	637.36	74.95	0	SN
HNGMH	1845.44	893.09	13.42	AS
JMSMH	1.05	0	0	UN
JMSOH	0	0	0	AN
JMSPH	75.74	3.68	0	SN
JMSTF	0	0	0	AN
LCHMH	529.39	102.7	18.35	AS
LYNPH	43.2	29.65	0	SN
MAGMH	141.27	7.3	0	SN
MANMH	156.74	90.73	0	SN
MATTF	60.65	33.24	0	SN
MIDOH	117.37	16.47	0	SN
MOBPH	4465.86	4134.99	2736.2	AA
MPNOH	0	0	0	AN
MPNTF	0	0	0	AN
NANMH	0	0	0	AN
NANOH	0	0	0	AN
NANTF	0	0	0	AN
NORTF	7.96	0.17	0	SN
PATMH	48.96	0	0	UN
PAXMH	53.74	1.27	0	SN
PAXOH	40.08	0	0	UN
PAXTF	63.93	0	0	UN
PIAMH	438.2	143.16	10.23	AS
PISTF	319.35	54.3	0	SN
PMKOH	0	0	0	AN
PMKTF	0	0	0	AN
POCMH	783.8	597.92	87.3	AS
POCOH	0	0	0	AN
POCTF	0	0	0	AN
POTMH	666.84	109.42	43.12	AS
POTOH	1501.15	1121.46	217.09	AA
POTTF	1874.69	1209.05	0	SN
RHDMH	5.92	0	0	UN
RPPMH	348.69	31.44	7.75	AS
RPPOH	0	0	0	AN
RPPTF	0	0	0	AN
SASOH	179.79	36.75	6.41	AS
SBEMH	0	0	0	AN
SEVMH	133.78	0	0	UN
SOUMH	20.59	0	0	UN
TANMH	7330.38	5094.61	2927.4	AA
WICMH	0	0	0	AN
WSTMH	46.65	0	0	UN
YRKMH	0	0	0	AN
YRKPH	339.5	269.68	106.68	AS

The tidal range data used was obtained from the "benchmark" data on the NOAA home page:
http://www.opsd.nos.noaa.gov/bench.html

The station listings for Maryland and Virginia on this web page include the number we want, MHHW elevation, which is the same as the semi-diurnal range or greater tropic range (MHHW-MLLW) since MLLW is zero in the NOAA benchmark data. However, there do not appear to be any benchmark MHHW data for the following rivers or areas:

Upper Western Shore Maryland-Bush, Gunpowder, Middle, Back rivers

Lower Western Shore Maryland-Rhode, West rivers and Patuxent above Solomons, Potomac-from Colonial Beach upriver to DC

Eastern Shore-Wicomico, Pocomoke rivers (Maryland)

VA Western shore-Rappahannock and York rivers above their mouths

The published commercial tide tables have data for at least one site in or near all of these rivers. However the tide table (Reed's) lists the "spring range," not the semi-diurnal range. The spring range in this table differs from the semi-diurnal range at the benchmark stations as follows:

1. Spring range > semi-diurnal range, south of a line running diagonally across the Bay, from Fishing Bay (Eastern Shore) SW to Smith Point (just South of Potomac). Differences about 0.2-0.3 feet.
2. Semi-diurnal range > spring range, north of this line, differences about 0.1-0.5 feet (larger differences farther north).

To fill in the spatial gaps in benchmark data, we adjusted spring ranges to estimate semi-diurnal ranges. Since the relationship varies spatially, but has a strong positive correlation (R-square for linear regression was 78 percent), we adjusted the spring range to approximate the semi-diurnal range as follows: Estimated semi-diurnal range at site without benchmark data equal spring range at that site * (semi-diurnal range at nearest benchmark site/spring range at benchmark site).

For example, for the Gunpowder River, closest benchmark is Tolchester (Eastern shore mainstem), estimated semi-diurnal range = 1.4 ft * (1.74/1.4) = 1.74 ft., since spring range is the same at both sites; for West River, using South River benchmark, estimated semi-diurnal range = 1.0 * (1.48/1.1) = 1.35 ft. We used this method to estimate semi-diurnal range from spring range for one point near the middle of any segments that lacked benchmark data. If no spring range data were available (e.g. the Bush River) the closest point with spring range data was used. The resulting semi-diurnal tidal ranges in feet and half tidal range in meters are listed in Table D-4.

TABLE D-4. Semi-diurnal tidal range for 77 CBP segments, calculated from NOAA data.

SEGMENT	Semi-diurnal range (ft)	Half range (meters)	SEGMENT	Semi-diurnal range (feet)	Half range (meters)
APPTF	3.5475	0.54243	MIDOH	1.84333	0.28186
BACOH	1.58	0.24159	MOBPH	2.65	0.4052
BIGMH	2.16	0.33028	MPNOH	3.4428	0.52642
BOHOH	2.68	0.40979	MPNTF	3.9724	0.6074
BSHOH	1.99579	0.30517	NANMH	2.34	0.3578
CB1TF	2.37	0.36239	NANOH	2.17286	0.33224
CB2OH	1.74	0.26606	NANTF	2.50714	0.38336
CB3MH	1.72	0.263	NORTF	2.45667	0.37564
CB4MH	1.6	0.24465	PATMH	1.62	0.24771
CB5MH	1.41867	0.21692	PAXMH	1.51	0.23089
CB6PH	1.86	0.2844	PAXOH	2.32308	0.35521
CB7PH	2.53	0.38685	PAXTF	3.25231	0.49729
CB8PH	3.255	0.49771	PIAMH	1.26	0.19266
CHKOH	2.3876	0.36508	PISTF	2.968	0.45382
CHOMH1	1.76	0.26911	PMKOH	2.7366	0.41844
CHOMH2	2.05	0.31346	PMKTF	2.8248	0.43193
CHOOH	2.17059	0.33189	POCMH	2.555	0.39067
CHOTF	2.29118	0.35033	POCOH	2.64625	0.40463
CHSMH	2.15	0.32875	POCTF	1.825	0.27905
CHSOH	2.65588	0.4061	POTMH	1.755	0.26835
CHSTF	3.54118	0.54146	POTOH	1.3479	0.2061
CRRMH	1.44	0.22018	POTTF	2.57818	0.39422
EASMH	1.745	0.26682	RHDMH	1.43	0.21865
EBEMH	3.2455	0.49625	RPPMH	1.74	0.26606
ELIMH	3.15	0.48165	RPPOH	1.62	0.24771
ELIPH	2.9591	0.45246	RPPTF	1.98	0.30275
ELKOH	2.68	0.40979	SASOH	2.15	0.32875
FSBMH	2.36	0.36086	SBEMH	3.3	0.50459
GUNOH	1.84333	0.28186	SEVMH	1.43	0.21865
HNGMH	1.57333	0.24057	SOUMH	1.43	0.21865
JMSMH	2.75	0.42049	TANMH	2.04	0.31193
JMSOH	2.18	0.33333	WBEMH	2.9591	0.45246
JMSPH	2.8	0.42813	WBRTF	3.3	0.50459
JMSTF	2.15	0.32875	WICMH	2.42357	0.37058
LAFMH	2.9591	0.45246	WSTMH	1.3	0.19878
LCHMH	1.87733	0.28705	YRKMH	3.0014	0.45893
LYNPH	1.68	0.25688	YRKPH	2.645	0.40443
MAGMH	1.49	0.22783			
MANMH	2.16	0.33028			
MATTF	1.86632	0.28537			

TABLE D-5. Mainstem Chesapeake Bay Water Quality Monitoring Program stations used in analysis of the SAV habitat requirements.

Segment	Stations used	Notes
CB1TF	CB1.1, CB2.1	Only stations in segment, all used
CB2OH	CB2.2, CB3.1	Only stations, all used
CB3MH	CB3.2, CB3.3W, CB3.3E	Dropped CB3.3C (see below)
CB4MH	CB4.1W, CB4.2E, CB4.3E, CB4.4	Dropped all stations in center of Bay (ending in 'C') and all but one of the west ('W') stations, because they do not characterize SAV habitat
CB5MH	CB5.1, CB5.2, CB5.3, CB5.4, CB5.4W, CB5.5	Only stations (none are very close to SAV habitat but no other data are available)
FSBMH	EE3.0	Only station
TANMH	EE3.1, EE3.2	EE3.4 dropped because it does not characterize SAV habitat
POCMH	EE3.3	Only station in segment
WE4PH	WE4.1, WE4.2, WE4.3, WE4.4	Only stations, all used
CB6PH	CB6.3	CB6.1, CB6.2 and CB6.4 dropped because they do not characterize SAV habitat
CB7PH	EE3.5, CB7.1, CB7.1S, CB7.2E	CB7.1N, CB7.2,, CB7.3E, CB7.3, and CB7.4N dropped because they do not characterize SAV habitat

Note: Data from all of the Chesapeake Bay Water Quality Monitoring Program's tidal tributary monitoring stations were used. In addition, data from segment CB8PH, mouth of Chesapeake Bay, were dropped from analyses relating SAV growth categories or SAV area to water quality, because none of the water quality monitoring stations in that segment characterize the small tidal creek (Little Creek) that contains the only SAV found in that segment.