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A perspective on two decades of policies and regulations influencing the protection and restoration of submerged aquatic vegetation in Chesapeake Bay, USA

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A PERSPECTIVE ON TWO DECADES OF POLICIES AND REGULATIONS INFLUENCING THE PROTECTION AND RESTORATION OF SUBMERGED AQUATIC VEGETATION IN CHESAPEAKE BAY, USA

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ABSTRACT

Seagrasses along with many other species of freshwater rooted submerged macrophytes in Chesapeake Bay (collectively called SAV) underwent serious declines in population abundances in the 1970s and have not as yet rebounded to previous levels. Cooperative efforts by scientists, politicians, federal and state resource managers, and the general public have developed policies and plans to protect, preserve and enhance SAV populations of Chesapeake Bay. These include the Chesapeake Bay Agreements (1983, 1987, 1992, 1993, 2000), an SAV Management Policy and Implementation Plan for Chesapeake Bay and Tidal Tributaries (1989 and 1990), Chesapeake Bay Blue Crab Fishery Management Plan (1997), as well as federal and state guidelines for protecting SAV communities from direct human impacts such as dredge and fill operations. The foundation for many of these management efforts has been the recognition of the habitat value of SAV to many fish and shellfish, and the elucidation of linkages between water quality conditions and the continuing occurrence of SAV as established by minimal water quality habitat requirements for growth and survival. Because of these linkages, the distribution of SAV in the Bay and its tidal tributaries is being used as an initial measure of progress in the restoration of living resources and water quality. Restoration targets and goals have been established to link demonstrable improvements in water quality to increases in SAV abundance. The major challenge facing the Chesapeake Bay community will be to restore SAV habitat and ecosystem functions to historic levels. However, the recent success in the development of policies, plans, regulations and laws highlighting the importance of SAV communities in Chesapeake Bay and their protection and restoration, is an excellent example of effective communication linkages and adaptive management principles between scientists, resource managers, politicians and the public in the Chesapeake Bay region. Only through these interactions will SAV restoration become a reality.

Seagrass and other rooted macrophyte beds are increasingly recognized as one of the more valuable habitats in coastal and estuarine ecosystems (Costanza et al., 1997). Unfortunately, they are impacted by direct and indirect human activities worldwide, including anthropogenic inputs of nutrients and sediments from disturbed watersheds which degrade water quality, and commercial and recreational fishing activities that result in significant losses in many regions (Short and Wyllie-Echeverria, 1996). However, there is also increasing emphasis on reversing habitat loss by improving water quality (Dennison et al., 1993), protecting seagrass beds with policies or laws, and restoring seagrass habitat using various transplant methodologies (e.g., Fonseca et al., 1998).

In Chesapeake Bay, seagrasses in saline regions and other submerged angiosperms that have colonized brackish and freshwater portions of the estuary constitute diverse and very productive communities (Table 1). Collectively referred to as submerged aquatic vegetation or SAV (Orth and Moore, 1984), these communities were estimated to once cover over 250,000 ha of shoal areas and are considered one of the major factors that

Table 1. List of the most common species of submerged aquatic vegetation found in Chesapeake Bay and tributaries.

Potamogetonaceae
Potamogeton perfoliatus L.
Potamogeton pectinatus L.
Potamogeton crispus L.
Ruppiaceae
Ruppia maritima L.
Zannichelliaceae
Zannichellia palustris L.
Najadaceae
Najas guadalupensis (Sprengel)
Najas gracillima (A. Braun)
Najas minor Allioni
Hydrocharitaceae
Vallisneria americana Michaux
Elodea canadensis (Michaux)
Hydrilla verticillata (L.f.)
Pontedariaceae
Heteranthera dubia (Jacquin)
Haloragaceae
Myriophyllum spicatum L.
Ceratophyllaceae
Ceratophyllum demersum L.
Zosteraceae
Zostera marina (L.)

contributed to the historically high primary and secondary productivity of Chesapeake Bay (Stevenson and Confer, 1978). Biostratigraphical evidence suggest that humans, through land use changes, have been influencing submerged aquatic populations since post-colonial times (Davis, 1985; Brush and Hilgartner, 2000). However, in the late 1960s all SAV species began an unprecedented, baywide decline in Chesapeake Bay and continued declining through the early 1970s. Additionally, impacts occurring after a major tropical storm (Agnes) affected the Chesapeake Bay watershed in 1972, resulted in the lowest levels of abundance in recorded history (Orth and Moore, 1983, 1984). This SAV decline has been attributed in large part to increasing amounts of nutrients and sediments in the Bay resulting from development of the Bay's shoreline and watershed (Kemp et al., 1983). The interrelationships between SAV, water quality and watershed development, and general declines in many important fisheries highlight the importance of SAV popu-

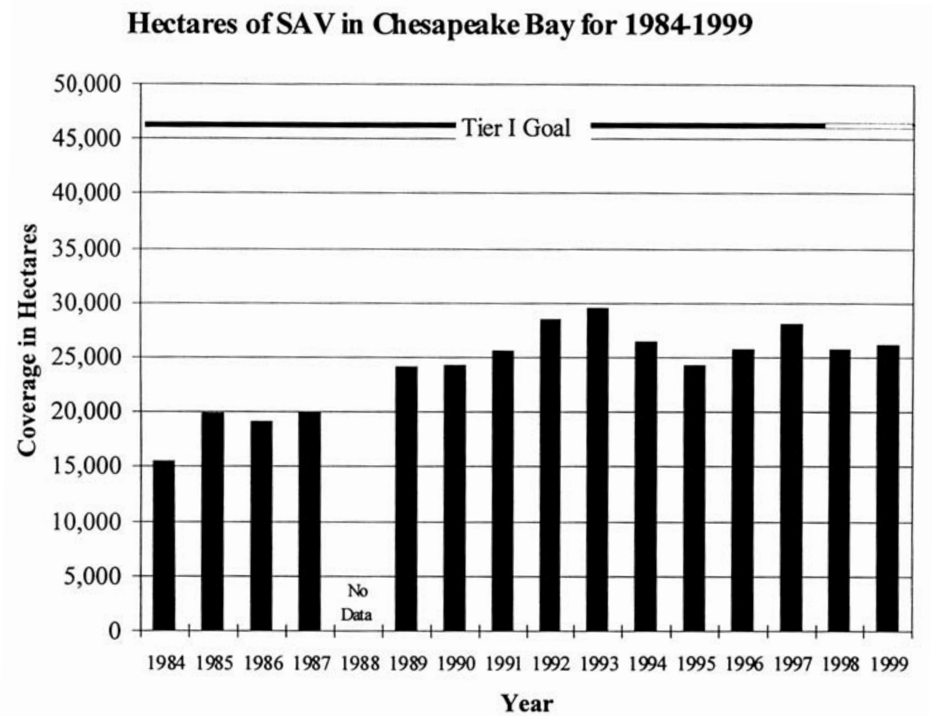

Figure 1. SAV abundance in Chesapeake Bay and its tributaries from 1984 through 1999 in relation to the Tier 1 goal established by the Chesapeake Executive Council in 1993 (the hectares of SAV per year are based on an annual baywide mapping of SAV using aerial remote sensing techniques and Geographic Information Systems software. See Table 3 for an explanation of the Tier I goal).

lations as important indicators of overall bay health. In the last two decades, while there has been some recovery in certain regions (Moore et al., 2000), abundance levels have not exceeded 30,000 ha (Fig. 1) (Orth et al., 2000).

With both global and local concerns over the loss of seagrasses (Short and Wyllie-Echeverria, 1996) and other rooted submerged macrophytes, scientists and managers throughout the world have begun addressing strategies to protect existing beds and restore areas that have lost these valuable communities. Much of the initial efforts for habitat protection are emanating from developed countries, such as the United States, Australia, and various countries in Europe (Coles and Fortes, 2001). This paper presents an overview of more than two decades of effort by scientists, managers, politicians and the public in the Chesapeake Bay region to protect and restore this threatened habitat.

The Chesapeake Bay Agreements and SAV Technical Syntheses

The decline of SAV communities, coupled with other problems associated with the general deterioration of the Bay's water quality (nutrient enrichment, hypoxic and anoxic conditions, toxics) and its other living resources, e.g., oysters, striped bass, and fish, focused enormous political attention to the Chesapeake Bay in the 1970s. This led to an initial five year, $25 million study of Chesapeake Bay, the beginning of the Chesapeake Bay Program, and the establishment of a governance structure to oversee the massive effort of restoring the Chesapeake Bay. This effort included studies focused on the magnitude of the SAV decline and its causes. The synthesis of this work and the recognition that the Chesapeake Bay was in serious decline (U.S.E.P.A., 1983a,b) led to the first Chesapeake Bay Agreement signed in 1983 by the Chesapeake Executive Council. The Council consists of the Governors of the surrounding jurisdictions of Maryland, Virginia, Pennsylvania, the Mayor of the District of Columbia, the EPA administrator representing the United States federal government, and the Chair of the Chesapeake Bay Commission. The Bay Commission, formed in 1980, consists of primarily legislative members of the three signatory states, a member of a Management agency from each state and one citizen from each state. It advises the state legislatures on matters of baywide concern. This agreement highlighted the need to develop and implement coordinated plans "to improve and protect the water quality and living resources of the Chesapeake Bay estuarine system". An elaborate Chesapeake Bay Program management infrastructure was also formed for implementing the recommendations from the agreement that included elected officials, political appointees, scientists, resource managers, and citizens (Hennessey, 1994).

A second Chesapeake Bay Agreement was signed in 1987 that expanded the 1983 commitments to include living resources, water quality, population growth and development, public information, education and participation, public access, and governance (Chesapeake Executive Council, 1987). A firm declaration was made to: (1) reduce and control point and nonpoint sources of pollution to attain water quality conditions necessary to support living resources of the bay; (2) develop, adopt, and begin to implement a strategy to equitably achieve by the year 2000 a 40% reduction of nitrogen and phosphorus entering the mainstem Chesapeake Bay; and (3) determine the essential elements of habitat quality and environmental quality necessary to support living resources and to see that these conditions are attained and maintained. One objective of the living resource goal was to restore, enhance, and protect submerged aquatic vegetation.

A working group of scientists and managers (referred to as the SAV Work Group in the Chesapeake Bay Program management structure) developed the Chesapeake Bay Submerged Aquatic Vegetation Management Policy approved by the Chesapeake Executive Council in 1989 (Chesapeake Executive Council, 1989). The goal of the policy was to achieve a net gain in SAV distribution, abundance, and species diversity through the following actions: (1) protecting existing SAV beds from further losses either from increased degradation of water quality, or physical damage to the plants; (2) setting and achieving water and habitat quality objectives that would result in natural restoration of SAV; and (3) setting regional SAV restoration goals in terms of acreage, abundance, and species diversity that considered the historical distribution records and potential habitat. An Implementation Plan was approved by the Executive Council in 1990 (Chesapeake Executive Council, 1990) that provided a means for developing programs and procedures to ensure the goals and objectives of the SAV Policy were reached. These included detailed plans for assessment, protection, restoration, education, and research.

In 1992, a comprehensive report entitled *Chesapeake Bay Submerged Aquatic Vegetation Habitat and Restoration Targets: A Technical Synthesis* was published (Batiuk et al., 1992) which summarized the research conducted to meet the commitments in the Implementation Plan. This was subsequently revised to reflect the increased understanding of plant habitat requirements, specifically that of the light environment (Batiuk, et al., 2000). The major goal of the first SAV Technical Synthesis was determination of quantitative levels of relevant water quality parameters necessary to support continued survival, propagation, and restoration of SAV (Dennison, et al., 1993). Secondary goals were to establish regional distribution, abundance and species diversity targets for Chesapeake Bay and its tributaries, and to determine the baywide applicability of habitat requirements developed through the case studies in the synthesis. A conceptual model developed in the early stages of the Technical Synthesis of the interactions and interdependence of the SAV habitat requirements illustrated the water quality parameters that influence SAV distribution and abundance. The primary measures of environmental factors contributing to light availability (identified as the major factor controlling SAV distribution, growth and survival) used to formulate SAV habitat requirements were the following: light attenuation coefficient (K_d), chlorophyll a, total suspended solids (TSS), dissolved inorganic nitrogen (DIN), and dissolved inorganic phosphorus (DIP). The appropriate levels of these measures were defined through empirical relationships between these water quality characteristics and SAV distribution, as well as through numerous experimental studies.

The differing species makeup in the various salinity regimes of Chesapeake Bay led to the establishment of somewhat different habitat requirements based on salinity regime. Seasonal water quality conditions that were found to be associated with the growth, survival, and reproduction of SAV to targeted water depths of one meter (MLLW) were used as SAV habitat requirements (Table 2) (Batiuk et al., 1992; Dennison et al., 1993). The results of the first Technical Synthesis were incorporated into the 1992 amendments to the 1987 Chesapeake Bay Agreement, which highlighted "the link between water quality conditions and the survival and health of critically important SAV" (Chesapeake Executive Council, 1992). In addition, it was agreed "to use the distribution of SAV in the Bay and its tidal tributaries as documented by baywide and other aerial surveys conducted since 1970, as an initial measure of progress in the restoration of living resources and water quality". Thus, after 1992, SAV was used as an integral barometer of Chesapeake Bay health.

SAV distribution and abundance restoration goals, approached from a baywide and regional perspective, were quantified through a series of geographical overlays delineating actual and potential SAV habitat (Batiuk et al., 1992, 2000). A tiered set of SAV distribution restoration targets consisted of areas previously vegetated between 1971 and 1990 as documented through aerial monitoring programs (Tier I), potential SAV habitat to 1 m depths at MLLW (Tier II) and 2 m depths (Tier III) were established (Table 3). These provide management agencies with increasing levels of SAV distribution which might be expected in response to the implementation of Chesapeake Bay water quality restoration strategies (e.g. reducing nutrients by 40%). These targets were identified for both the entire Chesapeake Bay and specific segments within the Bay and tributaries. The annual distribution of SAV (Fig. 1) is then compared to these targets and progress can be quantitatively assessed. The Tier I target was officially adopted by the Chesapeake Executive Council in 1993 (Directive 93-3, Chesapeake Executive Council, 1993) as a specific goal in the Bay clean-up process, along with efforts "to restore SAV to their historical levels", and to begin to develop a target "for restoration of SAV to all shallow water areas delineated as existing or potential SAV habitat to the one meter contour".

Building from advances in monitoring, research data, ecosystem processes modeling, and driven by management needs for the next generation of requirements, a group of scientists and managers were assembled in 1997 to produce a second Technical Synthesis (Batiuk et al., 2000). Simplified minimum light requirements for SAV survival and growth

Table 2. Habitat requirements for growth and survival of SAV in different salinity regions of Chesapeake Bay and its tributaries (from Batiuk, et al., 1992, 2000) (Note: The first model of SAV habitat requirements defined light requirements as a function of light attenuation (Kd) (Dennison, et al., 1993). Kd is used in the calculation of PLL and PLW).

	Primary Requirements	Secondary Requirements[a] (Diagnostic Tools)					
Salinity regime	Minimum Light Requirement (assessed with PLL)	Water Column Light Requirement (assessed with PLW)	Total Suspended Solids (mg/l)	Plankton Chlorophyll-*a* (mg/l)	Dissolved Inorganic Phosphorus (mg/l)	Dissolved InorganicNitrogen (mg/l)	SAV Growing Season[b]
Tidal fresh	>9%	>13%	<15	<15	<0.02	none	April–October
Oligohaline (salinity 0–5 ppt)	>9%	>13%	<15	<15	<0.02	none	April–October
Mesohaline (salinity 5–18 ppt)	>15%	>22%	<15	<15	<0.01	<0.15	April–October
Polyhaline (salinity > 18 ppt)	>15%	>22%	<15	<15	<0.02	<0.15	March–May, Sept.–Nov.

NOTE: All the habitat requirements are independent of restoration depth, which is used in calculating the percent light at the leaf (PLL) and percent light through the water (PLW) parameters.

[a] Secondary requirements are diagnostic tools used to determine possible reasons for non-attainment of the primary requirement (MLR) in areas with or without SAV, or as possible reasons for the absence of SAV in an area where the MLR is met.

[b] Data used to calculate any of the habitat requirements should be collected during these growing seasons in Chesapeake Bay, or during the local SAV growing season in other estuaries.

Table 3. Restoration goal (Tier I) and targets (Tiers II and III) for SAV in Chesapeake Bay and its tributaries based on improving water quality (from Batiuk et al., 1992, 2000) and percent attainment of the goal and target based on distribution of SAV in 1998.

Restoration target	Description	Area (ha)	1998 SAV distribution as percent of restoration target
Tier I–composite beds	Restoration of SAV to areas currently or previously inhabited by SAV as mapped through regional and baywide surveys from 1971 to 1990.	46,040	56%
Tier II–one meter	Restoration of SAV to all shallow-water areas delineated as existing or potential SAV habitat down to the one-meter depth, excluding areas identified as unlikely to support SAV based on historical observations, recent survey information and exposure regimes.	165,461	16%
Tier III–two meter	Restoration of SAV to all shallow-water areas delineated as existing or potential SAV habitat down to the two-meter depth, excluding areas identified as unlikely to support SAV as well as several additional areas between one and two meters.	250,515	10%

in different salinity regimes were determined (Table 2). Models were developed using water quality conditions, including dissolved inorganic nutrient levels, K_d, and suspended sediment concentrations, to estimate incident light reaching the SAV leaf surfaces through both the water column and also through projected periphyton growth on the leaves. Managers can apply this model to predict the potential for SAV growth at any depth using the predicted light levels. Also, by applying a simple diagnostic tool they could evaluate what reductions in total suspended solids and/or chlorophyll *a* (phytoplankton) would be needed to reduce water column light attenuation to levels that should allow SAV growth. Quantitative requirements for physical, geological, and chemical factors affecting SAV habitat suitability were also established. An expanded set of tiered restoration goals were documented along with a more in-depth assessment of the applicability of mid-channel monitoring for evaluating water quality in adjacent shallow-water habitats. Maryland, Virginia, Delaware, and the District of Columbia are committed to adopting the minimum SAV light requirements as the basis for specific water clarity standards for their portion of the tidal waters by 2003 (Chesapeake Executive Council, 2000).

The most recent agreement signed in 2000 (the Chesapeake Bay 2000 Agreement; Chesapeake Executive Council, 2000) committed the signatory partners to revising the tiered restoration targets into a set of goals reflecting historical distribution levels from the 1930s through the present. These included specific goals of water clarity required to meet the revised restoration goals.

In addition to efforts to promote recovery of SAV through water quality improvements, the importance of SAV as an essential habitat for the blue crab, *Callinectes sapidus* (Orth and van Montfrans, 1990; Orth et al., 1996) was brought into focus in a Blue Crab Fisheries Management Plan (FMP), also signed into effect by the Chesapeake Executive Council (Chesapeake Executive Council, 1997). As the first FMP that recognized the links between water quality, seagrass habitat, and fishery yields, the plan recommends SAV restoration baywide, but particularly in areas that are the primary settlement sites for blue crab post-larvae recruiting into Chesapeake Bay (Orth et al., 1996).

SAV Protection

While many policies have been promulgated from the Chesapeake Bay Program that underscore the importance of SAV and the need to protect and restore these habitats, the implementation of these policies often requires the adoption of specific rules and regulations by federal and state agencies that have regulatory authority over the regions' natural resources (Chesapeake Bay Program, 1995). They range from broad, over-arching federal guidelines such as the Clean Water Act, to individual state regulations controlling or limiting fishing activities in SAV beds.

Guidelines from Federal Agencies.—SAV is afforded increased protection under Section 404 of the Clean Water Act (33 U. S. C. 1341-1987) and Section 10 of the Rivers and Harbors Act (33 U.S.C. 403), which regulate the discharge of dredged or fill material into U.S. waters. Authority for administering the Clean Water Act rests with the U.S. Environmental Protection Agency. SAV protection under the Act is provided by a federal permit program that is delegated to and administered by the U.S. Army Corps of Engineers. Potential impacts on "Special Aquatic Sites", such as SAV, are considered in the permit review process. Section 10 of the Rivers and Harbors Act, administered by the Corps, regulates also, all activities in navigable waters including dredging and placement of structures.

Permit applications under the Clean Water and Rivers and Harbors Act are routinely reviewed by the U.S. Army Corps of Engineers (USACE), the U. S. Environmental Protection Agency (USEPA), the U.S. Fish and Wildlife Service (USFWS), and the National Oceanic and Atmospheric Administration's (NOAA) National Marine Fisheries Service (NMFS). Comments from the agencies are provided to the Corps of Engineers to recommend approval (often with recommended conditions or project modifications) or denial of individual permits. Consultations among agencies on environmental impacts of federal and other projects are also required through the provisions of the Fish and Wildlife Coordination Act (16 U. S. C. 661-667e) and the National Environmental Policy Act (42 U.S.C. 4231-4370a).

In the permit review and approval processes, special consideration is made for the protection and preservation of SAV. Other than legislative mandates given above, the federal agencies have no written policies specific to SAV protection. Guidelines that the regulatory agency (USACE) and the commenting agencies (USEPA, USFWS, and NMFS) use to make their decisions and recommendations are summarized in Table 4 (based on Chesapeake Bay Program, 1995). These guidelines in most cases are specific to physical alterations accompanying dredging and direct impacts. They do not cover direct physical impacts from fisheries or boating activities, which are regulated by state laws, or may also be evaluated as indirect impacts through the Federal and State regulatory permit process.

In general, all four federal agencies involved in permit review use similar guidelines (Table 4). All consider it desirable to avoid dredging in or near existing SAV beds, in areas that historically supported SAV, and in shallow potential habitat, especially where there is no documented historical boat access. Unfortunately, the majority of requests for new and maintenance dredging are proposed within these areas. This has made it increasingly difficult to allow dredging while still protecting SAV and its habitat. The highest priority for protection is generally for existing SAV beds, then historic SAV, and finally potential habitat. All agencies generally recommend avoiding dredging during the SAV growing season, but specific dates vary. Most of the agencies recommend a minimum one meter horizontal buffer around existing SAV for each vertical 0.3 m of material removed. Most agencies also recommend against depositing dredged material on SAV and often suggest project modifications or alternatives when marine related developments are proposed near SAV beds. The agencies sometimes differ in whether to recommend dredging through SAV beds and shallow areas. The definition of maintenance dredging used by the Chesapeake Bay Program (1995) is "dredging to maintain existing navigation channels with documented historic boat use. In some circumstances, this may include areas not previously dredged".

SAV beds are considered one of several Essential Fish Habitats (EFH, Fluharty, 2000) identified by the National Marine Fisheries Service (NMFS), i.e., habitats necessary to fish for spawning, breeding, feeding, or growth to maturity. The Atlantic States Marine Fisheries Commission (ASMFC), a council of 15 Atlantic States with responsibility to conserve and enhance inter-jurisdictional fisheries of the Atlantic coast of the United States, adopted an SAV Policy in 1997 (ASMFC, 1997). The policy recognizes the importance of SAV as habitat for ASMFC managed species, and "encourages the implementation of its policy by state, federal, local, and cooperative programs which influence and regulate fish habitat and areas impacting fish habitat".

GUIDELINES FROM STATE AGENCIES: VIRGINIA AND MARYLAND.—The states of Maryland and Virginia, which are the only two states that contain tidal waters of Chesapeake Bay and its tributaries, each have separate regulatory agencies to oversee activities that could be injurious to SAV populations (Table 4). Both Maryland and Virginia are committed to protecting SAV habitat, while maintaining viable commercial fisheries and aquaculture operations.

Maryland State Code COMAR 4-213 specifically prohibits damage to SAV for any reason except for commercial fishing activities and certain specific situations such as clearing SAV from docks, piers, and navigable waters. If SAV will be adversely affected, a permit is required, which includes a plan showing the site at which the activity is proposed, a dated map of current SAV, and the extent of SAV to be removed. The Maryland Department of the Environment (MDE) and Natural Resources (MD DNR) are responsible for issuance of the permit. Maryland does prohibit one type of commercial fishing activity, hydraulic clam dredging, in specific regions of its state waters. Hydraulic clam dredging is prohibited both within a specified distance from shore, which varies by political boundaries (NRA 4-1038), as well as in existing SAV beds (NR4-1006.1) as determined by annual aerial mapping surveys (Orth, et al., 2000).

In Virginia, permits to use State-owned submerged lands now include SAV presence as a factor to be considered in the application process (Code 28.2-1205 (A) (6) amended in 1996). On-bottom shellfish aquaculture activities requiring structures are now prohibited from being placed on existing SAV (4 VAC 20 335-10 effective January 1998). In 1999, the Virginia Marine Resources Commission (VMRC) was directed (Code 28.2-1204.1) to develop guidelines with criteria to define existing beds of SAV and to delineate potential restoration areas. Dredging for clams (hard and soft) in Virginia is prohibited in wa-

Table 4. Summary of guidelines for SAV protection used by the federal regulatory and commenting agencies, as well as the state agencies of Maryland and Virginia (modified from CBP, 1995).

Categories	Maryland	Virginia	US Army Corps of Engineers (Baltimore District)	US Environmental Protection Agency	US Fish and Wildlife Service	National Marine Fisheries Service
Dredging of new channels	Not allowed in water ≤ 3 ft. at MLW.	Limit channels to minimum dimensions necessary; avoid SAV.	Not allowed in waters ≤ 2 ft. MLW in main channel, ≤ 1.5 ft. MLW in spurs; presence of SAV overrides these parameters.	Generally, no new dredging except in historic channels.	Avoid shallow water habitats; not recommended in areas without piers and historical deepwater access.	Not recommended within existing SAV beds or adjacent shallows with potential for bed expansion.
Dredging in SAV beds	Allowed in areas where there were historic channels.	Usually not allowed.	Prohibited upstream of 1.5–2 ft. contour and in existing beds (see text for exceptions); channel dimensions may be restricted where slumping occurs.	Allowed in channels or historic channels only; not recommended otherwise.	Not recommended.	Not recommended.
Timing restrictions on dredging	Prohibited within 500 yards of SAV beds, April 15–October 15.	Restrictions may be placed if in proximity to living resources.	April 1–June 30; April 15 – October 15 (species with two growing seasons).	March 31–June 15.	March–June.	Species-dependent; April 15–October 15 for most species; April 1–June 30 for horned pondweed.
Dredging in areas that historically supported SAV	Not recommended where SAV occurred during the previous growing season.	Considered during the application review process.	Depends on depths and why SAV disappeared. Check soils.	Not recommended.	Not recommended.	Not recommended where SAV has been documented during the past 2–3 growing seasons.
Dredging near SAV beds/buffer zones	See timing restrictions on dredging above.	Considered during the application review process.	3 ft. buffer/1 ft. dredged below existing bottom; 15 ft. buffer from MHW & for SAV w. dense tuber mats.	3 ft. buffer/1 ft. dredged.	3 ft. buffer/1 ft. dredged below existing bottom.	Recommend buffers around existing beds; no dredging in areas with potential bed expansion.
Depositing dredged material on SAV	Prohibited.	Locate to minimize impacts.	Recommend against.		Recommend against.	Recommend against.
Pier Construction	Pier out to avoid dredging of SAV beds; minimize pier dimensions.	Limit to minimum necessary for water access, locate to avoid SAV.	Pier out, construct community piers or mooring piles to avoid dredging of SAV beds; maintain suitable pier height above SAV.		Pier out to avoid dredging of SAV beds; construct community rather than multiple individual piers.	Maintain 1:1 ratio of deck width to deck height above MLW.
Marina development near SAV	Prohibited in areas ≤ 4.5 ft. unless dredged from upland and adverse impacts to SAV are minimized.	Undesirable near SAV, or in waters less than 3ft. at MLW.	Avoid historical SAV beds for new marina construction; maintain buffer for marina expansion.	Avoidance of SAV recommended.	Avoid	Recommend against new marinas or expansion in existing beds or adjacent shallows with potential for bed expansion.
SAV harvest	Permit required.	Permit required.				Limited harvest of Hydrilla in the Potomac.
Fishing activity	No hydraulic clam dredging in existing SAV.	No clamming in water depths < 4ft.				
Aquaculture activities		No new permits in existing SAV.				

ters less than 1.2 m. A special regulation was passed for SAV in the Virginia portion of Chincoteague Bay (4-VAC 20-1010), a coastal bay of Virginia and Maryland, where clam and crab dredging is prohibited within 200 m of SAV beds.

SAV Restoration

Restoration of SAV to Chesapeake Bay is one of the ultimate goals of the Chesapeake Bay Program as highlighted in the Chesapeake Executive Council's Bay Agreements. The "Chesapeake 2000 Agreement" is the most notable in that it requires the implementation of a "strategy to accelerate protection and restoration of SAV beds in areas of critical importance to the Bay's living resources". The major issue influencing the return of SAV to historical limits will continue to be improving water quality by reducing both nutrient and sediment inputs, both from point and non-point sources. Small gains at improving water quality and habitat conditions have been hypothesized to generally result in large areas of shallow water becoming available for SAV recolonization (Batiuk, et al., 1992; Dennision, et al., 1993). Notable in the attempt to reduce sediments and nutrients is the recognition that different watersheds have different growth characteristics and that each tributary needs tributary-specific goals for the reduction of sediments and nutrients, again with SAV communities as a focal point in the restoration process.

The 1987 Bay Agreement set a goal to reduce controllable loads of nutrients by 40 percent by the year 2000 and maintain those reduced levels into the future. Phosphorus loads delivered to the bay tidal waters from all its tributaries declined 6.8 million pounds per year between 1985 and 2000. Nitrogen loads were reduced by 48 million pounds per year over the same time period. Driven in part by the need to improve water quality for bay SAV, these loading reductions have resulted in declining nutrient concentrations in many of the major rivers entering the bay tidal waters. Under the Chesapeake 2000 agreement, further nutrient and sediment reduction goals for 2010 will be set by the end of 2001 to result in attainment of specific levels of dissolved oxygen for fish and shellfish, chlorophyll a as fish food, and water clarity required by bay SAV over the next decade.

While water quality has been presumed to limit SAV, regrowth of SAV into denuded areas may be also a function of the inability of propagules of some species to reach sites distant from source or established populations. This possibility has fueled interest in transplanting adult plants or seeds to these sites by state and federal agencies and by non-profit environmental organizations. While transplant successes with SAV remain problematic (Fonseca, et al., 1998), interest in restoration programs lies in several general areas: (1) increasing diversity of species at sites that historically supported a diverse array of dense plant populations but currently harbor only one species; (2) increasing existing, but currently small populations to ameliorate natural spread, assuming large beds are more resistant to episodes of reduced water quality; (3) mitigation for those activities allowed by law to disrupt existing SAV populations; and (4) education of the populace as to the relevance of SAV. This latter aspect has spawned interest by management and environmental groups to work with primary and secondary school children, such as the Maryland Department of Natural Resources and Chesapeake Bay Foundation's "Bay Grasses in Classes" program. Here, school groups are provided necessary materials for raising certain species of SAV in the classroom and later assist in the transplanting of those species in appropriate habitat when the plants have attained adequate size.

Conclusions

Legislative, statutory, scientific, management, and educational efforts towards protection and restoration of SAV in Chesapeake Bay has been ongoing and successful, beginning approximately ten years after their unprecedented decline in the late 1960s and 1970s (Orth and Moore, 1983). This has been facilitated by the public and political recognition of their overall value to the bay ecosystem and because they have been considered as indicators of changing water quality conditions and overall bay health (Dennison et al., 1993). Most importantly, continuing interactions between scientists, managers, politicians, and the general public have allowed for adaptive management policies to be implemented as part of an overall plan to improve conditions for all living resources in Chesapeake Bay.

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