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Climate Change and Submerged Aquatic Vegetation in Virginia

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Submerged Aquatic Vegetation in Coastal Virginia

Submerged aquatic vegetation or "SAV" includes both flowering and non-flowering plants that grow completely underwater. In the Chesapeake Bay region, the term "SAV" usually refers to various rooted aquatic angiosperms or "underwater grasses" found growing in shallow areas ranging from high salinity to freshwater tidal environments. Approximately 20 species are commonly found throughout Chesapeake Bay and Eastern Shore coastal bays.

Beds of both freshwater and marine SAV are important habitats in the Chesapeake Bay region and have been found to provide habitat, protection, nursery areas, and other functions for economically valuable fishery species (www.dnr.state.md.us/bay/sav/about.asp; www.chesapeakebay.net/baygras.htm).

SAV has habitat requirements that are closely linked to water quality conditions likely to be influenced by climate change. Climate change may have significant impacts on SAV through increases in temperature, atmospheric and weather changes, and sea level rise. Based on extensive knowledge obtained on SAV over the last three decades, the following scenarios related to climate change impacts are distinct possibilities for SAV populations in Chesapeake Bay:

- Increased rainfall will result in increased sediment and nutrient inputs, further decreasing light availability for SAV populations and leading to additional losses in many areas of the Bay.
- Increased frequency of high-intensity storms such as hurricanes with their associated storm surge and wave action will lead to erosion of SAV in the most exposed locations.
- Increased temperatures, but especially higher than average summer-time temperatures, could lead to catastrophic losses of eelgrass, the species that dominates the lower, higher-salinity portions of the Bay.
- Alterations of normal temperature and salinity patterns could have indirect negative affects by subtle alterations in animal-plant interactions that have been demonstrated to be positively related to growth of SAV.

Because of the value of SAV the Commonwealth should support enhanced monitoring efforts of both SAV populations and associated water quality in order to predict the scale and rate of changes in SAV with coming climate change.

Chesapeake Bay SAV Communities

The freshwater and marine SAV species that inhabit Chesapeake Bay and its tributaries can be divided into three zones reflecting different SAV community types, each characterized by a particular mix of species (Table 1, next page) (www.dnr.state.md.us/bay/sav/key/; www.chesapeake.org/SAV/fwsav.html) whose broad distributions are generally constrained by salinity (Figure 1). The highest diversity (up to 14 species) is found in the

Environmental conditions determine the distribution of SAV species:

- Salinity
- Light
- Temperature
- Nutrient levels
- Sediment type (e.g., sandy vs. muddy)
- Physical setting (e.g., waves, currents, etc.)

SAV Beds:

- Serve as primary sources of food for waterfowl
- Serve as indicators of local water quality conditions
- Affect key sediment processes
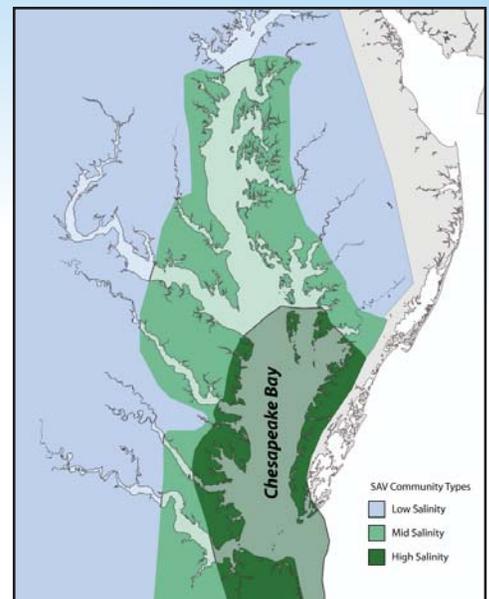- Decrease the potential for shoreline erosion by dampening nearshore waves and water flow

Figure 1. General distribution of SAV communities by salinity.

Wild celery is commonly found in low-salinity SAV communities.

Widgeon grass is most abundant in medium-salinity communities.

Eelgrass dominates in high-salinity regions.

Heavy growth of epiphytes on SAV can smother the host plant.

High salinity (polyhaline)	Medium salinity (mesohaline)	Low salinity/fresh water (oligohaline)
Zostera marina	Ruppia maritima	Vallisneria americana
Ruppia maritima	Potamogeton perfoliatus	Hydrilla verticillata
	Zostera marina	Myriophyllum spicatum
	Stukenia pectinatus	Elodea canadensis
	Zannichelia palustris	Stukenia pectinatus
		Heteroanthera dubia
		Najas quadilupensis
		Najas minor
		Potamogeton perfoliatus
		Potamogeton pusillus
		Ceratophyllum demersum
		Zannichelia palustris

Table 1. Typical SAV species found in the three Chesapeake Bay salinity zones. (www.dnr.state.md.us/bay/sav/key/; www.chesapeake.org/SAV/fwsav.html); and www.vims.edu/bio/sav)

low salinity community type.[1] The medium salinity community type supports up to five species (tolerating salinities of 5-10), although recently widgeon grass (*Ruppia maritima*) has become the most dominant throughout this zone. The lowest SAV species diversity (two co-occurring species) is found in the high-salinity community type.

SAV Habitat Requirements

SAV distribution and abundance are affected by habitat conditions that are influenced by a variety of water quality characteristics (Figure 2), of which light availability is the most important[2] (www.dnr.state.md.us/bay/sav/about.asp). Light transmission through the water column is reduced by dissolved materials, suspended sediments, and phytoplankton. The concentrations of phytoplankton, in turn, are enhanced by excess water column nutrients such as nitrogen and phosphorus. Light reaching the SAV leaf surfaces is also reduced by the accumulation of epiphytes and other attached material growing on the leaf surface, which can also be increased by high levels of water column nutrients and suspended sediments.[3] Small invertebrate grazers, such as amphipods and snails, help to clean the leaves of this fouling material, however their abundance can be reduced by both fish and crabs that prey on the invertebrates, as well as water quality conditions such as dissolved oxygen, temperature and salinity that may be affected by climatic conditions or other physical factors.[4]

Because of the diversity of SAV community types across the different salinity regions,
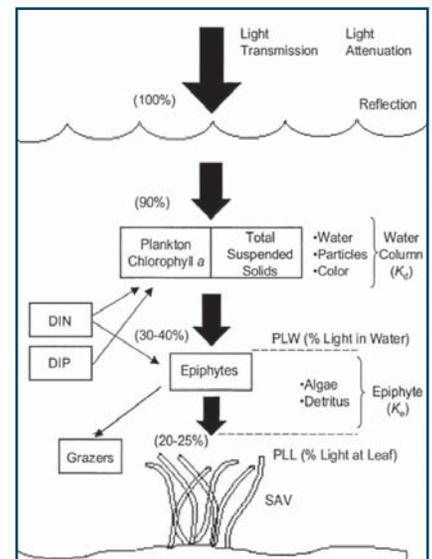

Figure 2. Conceptual representation illustrating how availability of light to support photosynthesis of SAV is influenced by different factors in the water column and on the surface of the leaves (see text). (Reprinted from Kemp et al, 2004)

requirements for a number of important water quality parameters can vary slightly by region.[2] For example, freshwater SAV have been found to have a greater tolerance for low light levels than high salinity species.[3] These requirements represent the minimum seasonal conditions necessary to maintain established populations of SAV. Habitat requirements for restoring SAV beds to formerly vegetated areas may be significantly higher, due in part to the loss of capacity of an existing bed to improve water quality within the bed itself. Climate change effects on these habitat conditions will be critical drivers for the future of SAV throughout Chesapeake Bay.

Potential Effects of Climate Change on SAV

Climate change may have significant impacts on SAV through increases in temperature, atmospheric and weather changes, and sea level increases.[5] A projected 1°C (1.8 °F) increase in average temperature has been associated with short-term pulses of high water temperatures and low oxygen levels,[6] which can have adverse effects on seagrass survival.[4,7] Trend analysis of historical monitoring data from Chesapeake Bay shows that the estuary has warmed approximately 0.8-1.1°C (1.4-2.0°F) since the mid-20th century.[8] Increased frequency of storms and increased rainfall have been projected for the Chesapeake Bay region[9,10] as a result of climate change over the next 30 to 100 years. Increased rainfall[6] will likely result in increased sediment and nutrient inputs,[9,10] further decreasing light availability for SAV populations in the Chesapeake Bay.[11,12] Sea level rise associated with climate warming will be observed locally.[13] As shorelines in Chesapeake Bay are hardened as a result of human occupation, landward transgression of intertidal and shallow subtidal regions will be likely reduced,[9] limiting SAV and other nearshore habitats. In Chesapeake Bay, eelgrass is already growing near its southern limits along the western shore of the Atlantic, and it is likely that the effects of climate change on eelgrass populations will first be evident here.

Recent studies suggest that climate change in the Chesapeake Bay region may already be adversely affecting SAV populations, especially eelgrass. The year 2005 was one of the warmest years on record with summer temperatures exceeding a critical upper threshold for eelgrass of 30°C (86°F) for a significantly greater proportion of time than 2004 or 2006 (Figure 3). This resulted in a massive, bay-wide decline of eelgrass during 2005[4] (Figure 4) from which the bay has not yet recovered.   Continued temperature increases, greater runoff of sediments and nutrients, and increased hypoxia will all likely interact in a negative way to increase eelgrass mortality and decrease its success here.

Alternative strategies for the growth of SAV in the bay are few. Annual forms of eelgrass have been observed in other regions of the world and this strategy of reproduction, where there is seed production during the first year of growth, followed by die-off during the stressful summer, may be one. Little is yet known about why or how these annual populations develop. In Chesapeake Bay, no annual populations have yet been observed. Other species more tolerant
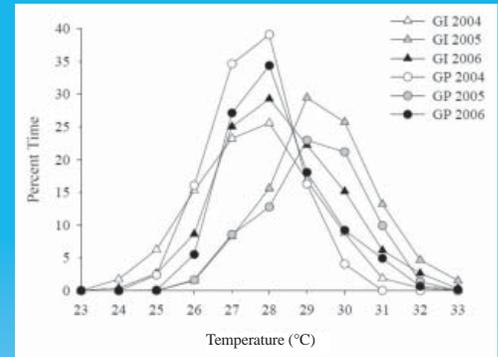

Figure 3. Frequency distribution of water temperatures in eelgrass beds during July and August of 2004, 2005, and 2006. (Reprinted from Moore and Jarvis, 2008)

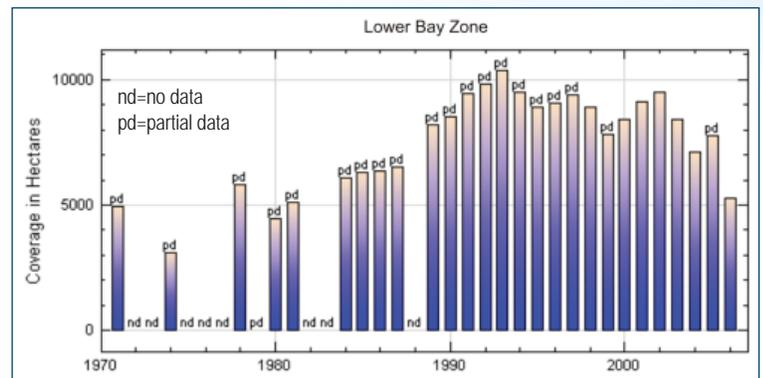*The introduced SAV Hydrilla can reach very high densities in some areas.*

Figure 4. SAV abundance since 1970 in lower bay zone dominated by eelgrass. Note the large decline between 2005 and 2006. (www.vims.edu/bio/sav/sav06/index.html)

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of high temperatures such as *Ruppia maritima* may expand and more southern species such as *Halodule wrightii* may become established; however their lack of effective root structure and other aspects of their growth hinders their survival in many areas currently vegetated by eelgrass. Freshwater SAV in the Chesapeake Bay may be less sensitive to temperature increases than eelgrass, however, increased nutrients, turbidity, and salinity can all have negative effects on their growth.[3] A stressed system may also be more susceptible to colonization of non-native SAV species such as *Hydrilla verticillata* and *Myriophyllum spicatum*. Although these species can have some habitat value in their own right they can reach nuisance levels not generally characteristic of more native SAV species.

Social and Economic Consequences of SAV Loss

Because SAV serves multiple functions in the shallow-water Bay ecosystem, reduction or loss of these habitats and shifting environmental conditions may have serious consequences for both water quality and important organisms such as fish and blue crabs that use them. In addition,

- SAV readily absorbs nutrients from the water column and binds fine sediments such as silt and clay. Thus the loss of SAV will further reduce water quality.

- Since SAV beds are important habitat for both adult and juvenile crabs, their loss will further inhibit blue crab recovery from current low levels.

- Some areas of the lower Bay were once important fishing locations for speckled trout, an important game fish, however, numbers of citation-size speckled trout were reduced dramatically in locations where SAV populations were lost (unpublished data).

While the precise economic values of SAV are difficult to estimate, their overall production and habitat value are noteworthy and critical for a healthy and productive Bay system.

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