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The Restoration of Submerged Aquatic Vegetation in the Chesapeake Bay

Key words

Submerged Aquatic Vegetation

restoration

turbulator

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ABSTRACT

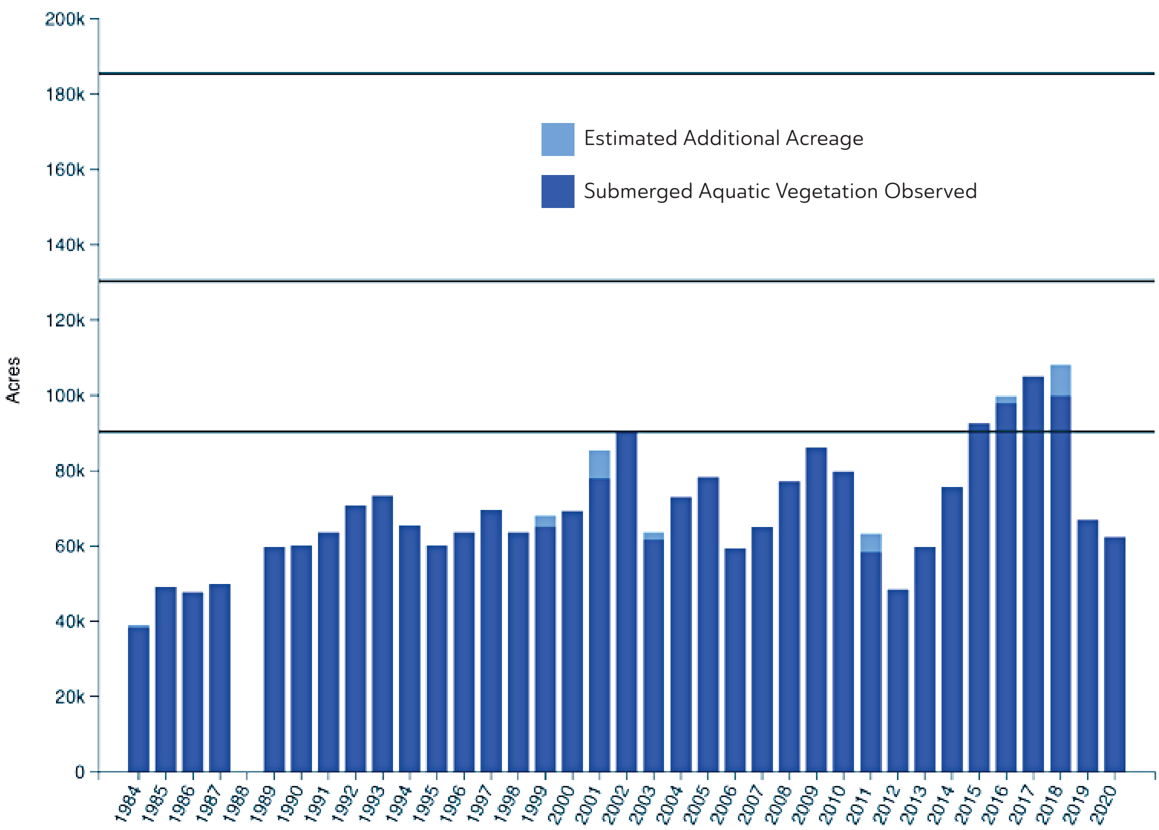
Submerged Aquatic Vegetation (SAV) is critical to maintaining water quality and providing food and shelter for numerous estuarine organisms. As part of a larger project to restore SAV in the Chesapeake Bay, the goals of this research project were to identify healthy beds for seed harvesting, harvest seeds from four native SAV species and refine the seed so that it could be stored until dispersal for restoration purposes. Through collaboration between Shore Rivers, Maryland Department of Natural Resources and the Anne Arundel Community College Environmental Center, seeds collected in the summer of 2021 will be dispersed in 2022, with the ultimate goal of restoring one acre of SAV. Four types of native aquatic plants, *Ruppia maritima* (widgeon grass), *Zannichellia palustris* (horned pondweed), *Stuckenia pectinata* (sago pondweed), and *Potamogeton perfoliatus* (redhead grass) were collected into 20 baskets per species and then processed in a turbulator to separate the seed. After turbulating, the plant material was further processed through a series of screens to refine the pure seed, which was later isolated and placed into jars with a salt solution. Over the winter, seeds were stored in the jars until they will be mixed with sand and dispersed into the bay for future restoration projects. More than 1,000,000 seeds were collected this summer from all four species combined, and over 100 hours of volunteer time went into the seed processing/refining process.

INTRODUCTION

Submerged Aquatic Vegetation (SAV) plays a crucial role in maintaining the health of the bay ecosystem. SAV is composed of a diverse collection of plant species that are located beneath the water surface and are entirely submerged except during low tide. There are over 20 species of SAV located in the Chesapeake Bay watershed (Chesapeake Bay Program, 2020). SAV beds help to absorb excess nutrients and trap particulate matter such as sand and silt that often cloud the water, suffocating and killing marine life (Chesapeake Bay Program, 2020). These beds provide shelter, habitat, and a food source for many organisms, especially waterfowl (Chesapeake Bay Program, 2020). SAV beds serve as a general indicator of the overall health of the Chesapeake Bay due to their sensitivity to water quality changes (Blankenship, 2021). When water quality improves, the abundance and quality of the

FIGURE 1

Abundance of SAV 1984–2020 (Chesapeake Bay Progress).



aquatic vegetation beds are affected positively and tend to improve (Blankenship, 2021).

After several years of continual growth in acreage of SAV beds in the Chesapeake Bay, total acreage of SAV declined 7% in 2020 – the second consecutive year of SAV decline since peaking three years ago (Blankenship, 2021) (Fig. 1). However, the presence of underwater grasses often shows trends of a boom and bust cycle, as some grasses are more sensitive to changes in water quality than others and will rapidly decline one year, but flourish the next year such as *Ruppia maritima* (Blankenship, 2021). According to Brooke Landy, a biologist with the Maryland Department of Natural Resources, "It's important to keep in mind that last year's decrease, and the decrease in 2019, didn't represent a loss of a long-term abundance and distribution, it was a decrease from a relatively recent expansion" (Blankenship, 2021). This emphasizes the importance of protecting and maintaining stable underwater grass populations.

In the Chesapeake Bay, SAV restoration planting efforts began in 1978 with whole *Zostera marina* plants, using sods, cores, or bare-root plants (Ailstock & Shafer, 2006). In the 1980's whole plant cuttings, seeds, and tubers of *Vallisneria americana* and several other low-salinity species were planted in the upper Chesapeake Bay, and in 1985 whole plants of *R. maritima* were transplanted in the mid-bay Choptank River (Ailstock & Shafer, 2006). In the past, it was most common to restore underwater grasses by harvesting the plants from suitable donor beds and transplanting them into the bay as individual shoots, shoot bundles, or sods (Ailstock & Shafer, 2006). This caused SAV restoration to be limited to small projects, typically on a scale of tens or hundreds of square meters due to the high costs and logistical constraints of this method (Ailstock & Shafer, 2006). In addition, approximately 40,500 additional hectares of SAV were needed to reach the restoration goals established by the Chesapeake Bay Program in 2003, therefore a new restoration method had to be identified in order to establish plants at such a scale (Chesapeake Executive Council, 2003).

In 2003, the U.S. Army Corps of Engineers (USACE) Engineer Research and Development Center (ERDC) and the National Oceanic and Atmospheric Administration (NOAA) Chesapeake Bay Office began to plan and implement their respective research programs to promote the development of innovative tools and techniques for the large-scale restoration of SAV (Marion & Orth, 2010). This program represented the first coordinated interagency effort to develop, evaluate, and refine protocols suitable for large-scale SAV restoration (Shafer & Bergstrom, 2010). Since this research initiative began, an average of 13.4 ha/year of SAV has been planted in the Chesapeake Bay, compared to an average rate of 3.6 ha/year during the previous 21 years (1983–2003) (Shafer & Bergstrom, 2010). The new techniques and technologies allow submerged aquatic plants to be planted at scales that would have been unattainable with existing technologies only a few years ago (Busch, 2010). Furthermore, the costs of conducting these plantings declined with increased understanding of the limiting factors and new advances in technology development (Ganassin & Gibbs, 2008).

The most effective approach involves directly sowing seeds into suitable planting areas, a method that emerged as a viable means of planting and restoring large areas of the seagrass, *Zostera marina* (Ailstock & Shafer, 2006). Once an existing healthy, viable underwater seagrass bed is identified, fruiting plants are collected into baskets and then later processed through a turbulator to essentially “shake” the seeds off of them. After turbulating, the plants are processed and refined through a series of mesh screens until just the pure seed is left. After storing the pure seed in various containers under brackish conditions in a cold room over the winter months, the seeds are mixed with sand and redistributed into areas where SAV beds used to be prominent in Chesapeake Bay regions throughout the spring.

The four types of native SAV that are of interest in the local region due to their frequency, abundance and diversity of tolerances and habitat value are *Ruppia maritima* (widgeon grass), *Zannichellia palustris* (horned pondweed), *Stuckenia pectinata* (sago pondweed), and *Potamogeton perfoliatus* (redhead grass). *R. maritima* tolerates a wide range of salinity, from the slightly brackish upper and mid-Bay tributaries through near-seawater salinity in the lower Bay (Maryland DNR, n.d.). *R. maritima* is notorious for disappearing in large quantities when water quality declines but tends to quickly reappear a few years later if conditions are healthy again (Maryland DNR, n.d.). *R. maritima* is most common in areas with sandy substrates, although it occasionally grows on soft, muddy sediments (Maryland DNR, n.d.). *Z. palustris* is found in every state in the continental United States, as well as in Europe and South America (Maryland DNR, n.d.). *Z. palustris* is widely distributed in Chesapeake Bay, growing in fresh to moderately brackish waters, in muddy and sandy sediments (Maryland DNR, n.d.). *Z. palustris* seems to grow most abundantly in very shallow water but may grow to depths of 5m if it receives enough light (Maryland DNR, n.d.). *S. pectinata* is widespread in the Chesapeake Bay, growing in fresh non-tidal to moderately brackish waters as well as in some lakes (Maryland DNR, n.d.). It can tolerate high alkalinity and grows on silty-muddy sediments (Maryland DNR, n.d.). Lastly, *P. perfoliatus* is typically found in fresh to moderately brackish and alkaline waters (Maryland DNR, n.d.). *P. perfoliatus* grows best on firm, muddy soils and in quiet water with slow-moving currents (Maryland DNR, n.d.).

Methods

The first step of SAV restoration was to identify large-scale vegetated beds in the Chesapeake Bay that were healthy enough to be harvested. Potentially viable beds were identified using satellite

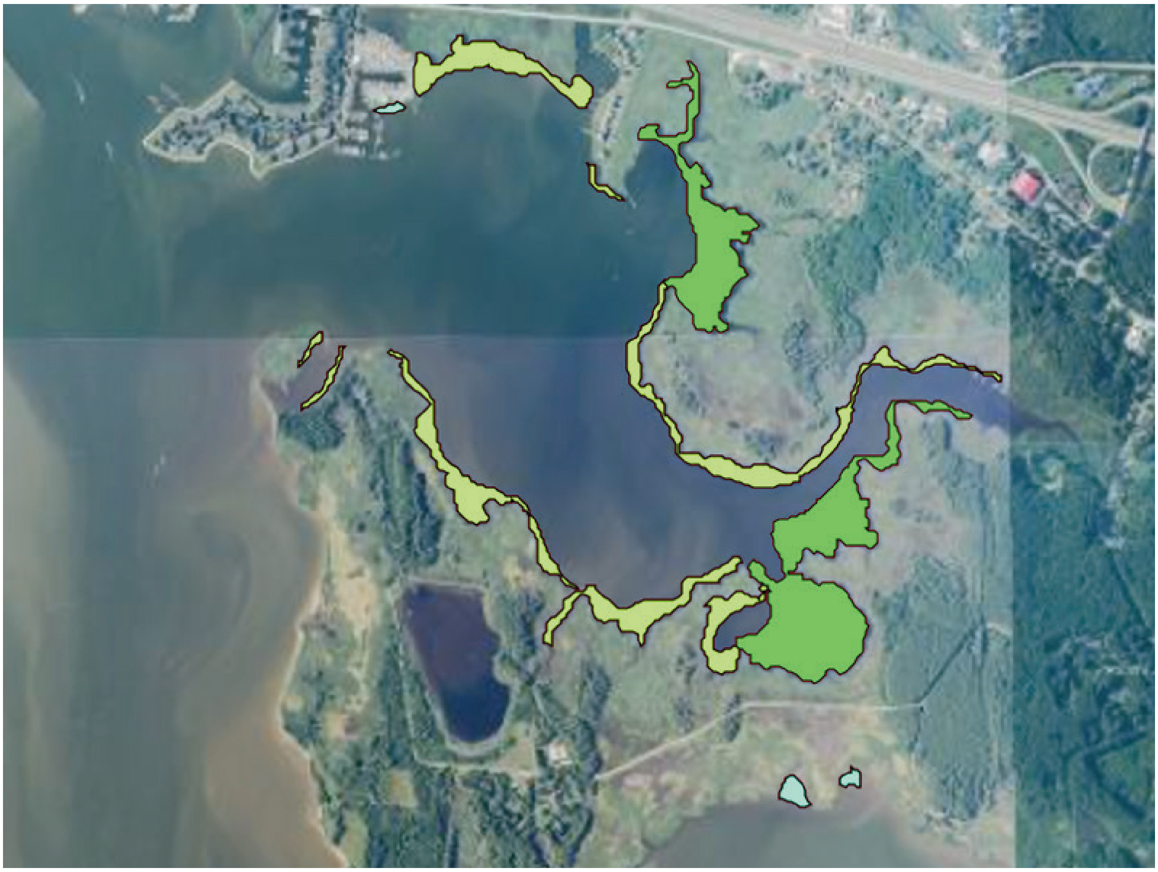


FIGURE 2

2020 Satellite Image depicting high bed density (the dark green area) found in Marshy Creek, MD (Virginia Institute of Marine Science). Light green shows lower-density beds.

imagery from the Virginia Institute of Marine Science (VIMS), and locations of nearby boat launches were recorded (Fig. 2). It was important to identify SAV beds that had high bed density because this ensures the greatest chance of finding an adequately-sized and healthy donor site.

Once a suitable donor bed was identified and an accessible nearby boat launch was found, kayaks were used to gain access to the sites to monitor the growth stage of plants in those beds (Fig. 3). Beds were deemed appropriate for collection when the majority of plants were in fruit (which contain the seeds).

When the plants were ready to collect, volunteers from Anne Arundel Community College (AACC), Maryland Department of Natural Resources, and Shore Rivers visited the identified locations by motorboat and hand collected the plants by removing the

FIGURE 3

Ripe fruits of Ruppia maritima.

upper third of viable stems and placing them into 17” round by 14-1/2” high plastic crab baskets (Fig. 4). After collecting about 20 crab baskets worth of plants, they were stored indoors in an unlit space in the AACC shed for seven days in large bins to achieve after-ripening. The plants were kept moist throughout the seven days and were occasionally churned with a metal rake in order to prevent rotting. All four species were processed twice: seven days after they were harvested, and then again after 14 days.

A turbulator was used to separate the seeds from the stems (Fig. 5). There are three turbulators in the state of Maryland and AACC has two of them. The turbulator is a large six-foot by six-foot round tank that has a series of PVC pipes with vacuums attached to run CO_2 through the water and create a “jet-like” effect. These jets help to churn the plants and shake the seeds off the plants. Plants were turbulated in water for 15 minutes and then the tank was drained into a mesh bag to collect the separated seeds. Typically, 14 days after collection, seeds were processed a second

FIGURE 4

Choptank Riverkeeper, Matt Pluta, harvesting bushels of Stuckenia pectinata (Sago Pondweed) from Broad Creek.

FIGURE 5

Volunteers from Anne Arundel Community College, Shore Rivers and Submerged Aquatic Vegetation Watchers use the turbulator to separate seed from stems of Potomogeton perfoliatus (Redhead grass).

time to collect any seeds remaining on the plants after the first process.

Following the seed processing stage, seeds were refined outdoors to get them into a storage-ready state. The seeds needed to be as clean as possible with little detritus attached, as they were stored in multiple clear gallon-sized plastic jars in a walk-in refrigerator at AACC and Shore Rivers Offices. When seeds have too much extra material on them, they often begin to decompose and can easily become contaminated, and then cannot be dispersed back into the bay for restoration. Storage conditions must provide an environment that allows seeds to remain viable and dormant, since embryo death or premature germination will negate their use for restoration. Aeration during storage was also important for retaining the viability of stored seeds. Research has shown that seeds stored at 4°C with aeration have the highest germination rates (Ailstock & Shafer, 2006).

To refine the seeds, the mesh bag full of seed and detritus collected from the turbulator was emptied gradually onto a series of wire screens with decreasing mesh sizes (Fig. 6). A hose was used to spray water and push the plant material through the screens to separate the detritus from the pure seed (Fig. 7). After refining, seeds were stored in a brackish condition with aeration in a cold room at AACC with the intention to mimic the estuarine environment. Fish tank aeration

FIGURE 6

Spherical seeds of Stuckenia pectinata (Sago pondweed) with detritus attached, ready to be processed.

FIGURE 7

Processing seed through the series of mesh screens to refine it.

pump devices were placed in each jar of seed in order to prevent bacteria and algae from growing in the jars during the storage period. The storage containers were gallon-sized clear plastic jars with a screw-on cap with a hole in it, in order to allow for the aeration pump to be placed inside. All seeds will remain in the dark cold room over the winter months and will be redistributed throughout the Bay in the Spring for restoration (Fig. 8).

FIGURE 8

AACC Faculty (Tammy Domanski, left) and student volunteers distribute seeds on the Magothy River.

Discussion/Recommendations

In 2021, AACC, in partnership with Maryland Department of Natural Resources and Shore Rivers, collected all four native plants with a goal of restoring one acre of underwater seagrass with the seeds collected. Approximately 20 baskets of each of the following species were collected: *R. maritima* was collected from Broad Creek in Talbot County, *S. pectinata* was collected from Rock Hall in Kent County, *Z. palustris* was collected from Tilghman Creek and the Wye River in Talbot County, and *P. perfoliatus* was collected from Marshy Creek in Queen Anne's County.

This project could be improved by increasing monitoring of both previously restored beds and harvested beds. Post-restoration monitoring can be a strain on organizational resources, and therefore most volunteer restoration projects do not include follow-up monitoring to determine their long-term effectiveness (Chesapeake Bay Program Submerged Aquatic Vegetation Workgroup, 2020). In addition, no long-term data has been collected analyzing the health of the harvested beds, some of which have been harvested over several successive years. Monitoring of affected beds (both harvested and restored) is necessary to determine the success rate of restoration efforts and to ensure that healthy beds are not being jeopardized in the restoration process. In conjunction with this effort, it would be helpful to monitor water quality in the areas of restored and harvested beds. Each of the four species of interest in this region have slightly different tolerance limits and growing conditions, therefore water quality data from harvested and restored sites would provide additional information to help explain restoration success rates.

Another area of further study could include analyzing the restoration success rate per species of interest. Low transplant survival and seedling establishment rates at the large-scale planting sites within Chesapeake Bay suggest that current site selection criteria are either not stringent enough or are incomplete, due to a lack of understanding of factors influencing both seed germination and seedling establishment (Shafer & Bergstrom, 2010). Ideally, a series of germination tests would be performed on each seed type collected in order to determine seed viability per species. In addition to lab-based germination tests using terrestrial substrate, an aquatic germination test should be conducted as well. The underwater planting environment differs substantially from terrestrial systems in that conditions such as light and nutrient availability and sediment stability are much less predictable (Koch, 2001). This would provide more information about the specific conditions that support high germination rates for each species.

Proper seed storage conditions also deserve further research, as there is a lack of data in regards to storing seeds with detritus attached. There are currently three methods used to store and disperse seeds for restoration projects involving all species (Ailstock & Shafer, 2006). Two require either no storage or temporary storage under the ambient conditions to which wild populations are generally exposed (Ailstock & Shafer, 2006). The third method focuses on long-term storage, which enables seed availability whenever they are needed (Ailstock & Shafer, 2006). With the possible exception of such plants as *Zostera marina* and *Thalasia testudinum*, information on the variation in storage and germination requirements of the seeds of most underwater grasses is sparse (Ailstock & Shafer, 2006).

These questions remain unanswered because they require an immense amount of resources and volunteer time. In order to collect the necessary data, a large volunteer base is needed to consistently monitor and analyze beds as well as perform lab tests over multiple years. Collaborations between local nonprofits (eg. Shore Rivers), state agencies (eg. Maryland DNR), and academic institutions (eg. AACC Environmental Center faculty, staff and students) provide a great opportunity to seek the answers to these questions.

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