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Submerged Aquatic Vegetation (SAV) Restoration Using Innovative Seed Based Technology

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BACKGROUND

The Chesapeake Bay and other shallow water coastal systems have historically supported large areas covered by submerged aquatic vegetation, or SAV. These beds provide critical ecosystem functions including sediment stability (thereby reducing erosion), habitat (for blue crabs and other valuable finfish species), and water quality improvement (through the direct uptake of nutrients from the water column). Through the deterioration of water quality (and clarity), SAV in the Chesapeake Bay and other coastal systems has declined considerably over the past 50 years (~10% of the original 600,000 acres). This deterioration in water quality and clarity has spurred excess algal growth that blocks sunlight in the water column, which stresses and eventually kills off plants that require light for photosynthesis. Since the landmark 1983 Chesapeake Bay Agreement (further ratified by the 2000 Chesapeake Bay Agreement), efforts have been made to remove excess nutrients and sediments from coastal waterways in order to improve conditions to a level that will allow SAV to recover and once again cover large areas of the bay. The dominant species found in the lower Bay (higher salinity) is eelgrass (*Zostera marina*) and is of considerable importance in this region due to the life cycle of the blue crab which requires it in order to reach maturation. Some areas in the Bay have witnessed improved water quality to the point where they can support eelgrass growth, yet the plants have not returned. One of the reasons lies in the fact that there are no natural beds nearby to assist in colonization of these areas. Scientists have spent the past 15-20 years developing techniques to restore eelgrass habitat. Adult transplants can fare well, but are time and labor consuming (thereby increasing costs) and can only cover small areas. Recent approaches have used seeds to restore larger areas; however, with the low germination rate of eelgrass, coupled with predation on the seeds by blue crabs, this technique is also demonstrating limited success. Our approach uses an innovative agricultural model that treats seeds to improve handling and increase germination rates by adding weight to the seeds to allow them to sink and settle in specified areas and discouraging predation, which can potentially double or triple the success rate of restoration over standard practices currently employed.

OBJECTIVE

The objective of this study was to use an innovative technology to coat eelgrass seeds for restoration at two sites in the Chesapeake Bay watershed. By utilizing this technology, and honing in on the best mixture for the seed coating technology, we will be able to make seagrass restoration more efficient and cost effective for not only installation natural resource managers, but also the general public.

SUMMARY OF APPROACH

Seed Coating

Seeds used for this project were collected during the Spring of 2010 from Chincoteague Bay, MD. After collection, we stored the seeds in seawater until the time of encapsulation at the United States Plant Materials Center, Beltsville, MD. To encapsulate seeds, we used a mixture of clay and other constituents, including distilled water and symbiotic bacteria, and coated the seeds until the desired layering was achieved. Seed encapsulation is shown to help slow desiccation, improve ease of transport, improve settlement rates, discourage predation, and enhance germination. Seeds were coated no longer than five days prior to planting, counted, weighed, and stored in 20 ml scintillation vials.

Seed Planting

To determine if the seed coating technology would enhance germination rates, we planted the coated seeds during October 2010 at two sites in the Chesapeake Bay watershed. We chose these sites because of adequate water quality and clarity and previous restoration success. Site 1 (Figure 1) was located at Bloodsworth Island, Patuxent River (Naval Air Station Patuxent River) MD. Site 1 was characterized with soft bottom sediments of sand and organic muds with a depth of approximately 0.6 meters. Tidal range at the site is approximately 0.5 meters. Seeds were planted in Great Cove at Bloodsworth Island, a sheltered area on the southeastern portion of the island. Site 2 (Figure 2), was located at Little Creek Cove (Joint Expeditionary Base), Little Creek, Virginia. This site was characterized with a soft bottom (sand/silt) and depth of approximately 1 meter. The tidal range at the site is approximately 0.5 meter. This site was also being used by NAB Little Creek for oyster restoration, and as such was an ideal restoration location because oyster beds and eelgrass coexist in natural conditions in the Chesapeake Bay. Seeds were planted in the southeastern portion of the cove.

To plant the seeds, we used a 1 meter diameter ring placed at random locations within the planting location. The ring was placed in the sediment, and a density of 100 seeds placed within each planting circle, with 22 treatment plots at each site (11 untreated/11 treated). Individual planting circles were marked with PVC pipe labeled with marking tape to denote treated versus untreated seeds. Any remaining treated seeds were spread on the perimeter of the planting areas for additional coverage. In total, approximately 2000-3000 seeds were planted per site. Seeds are dispersed in such a manner that they fall onto the sediment surface and are incorporated into the sediment through natural processes.

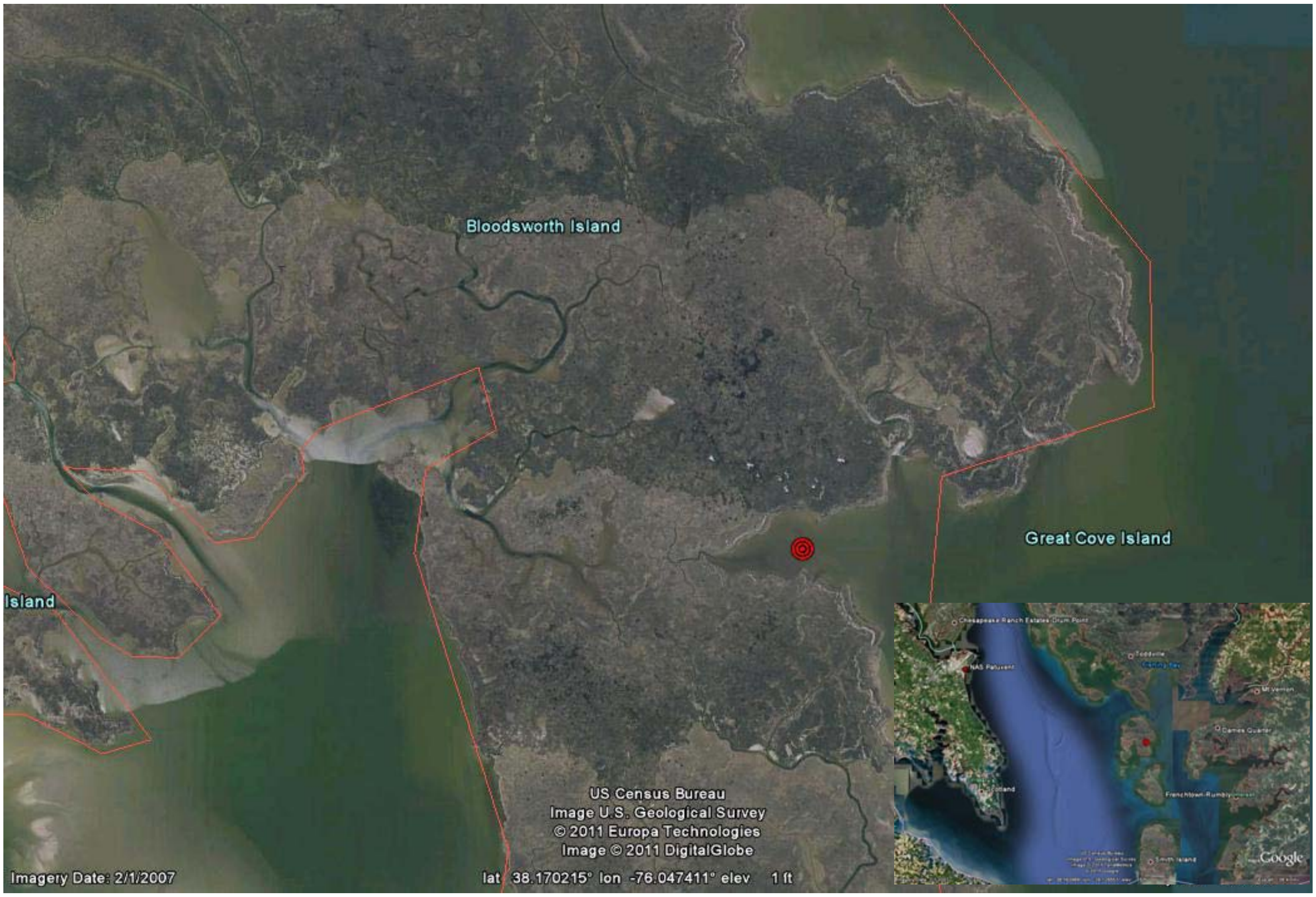

Figure 1: Planting site at Bloodsworth Island, Deale, MD. Inset map shows Bloodsworth Island, located across the main stem of the Chesapeake Bay across from NAS Patuxent River.

Figure 2: Site 2. Planting site at JSB Little Creek, Little Creek, VA. Inset map shows Little Creek in relation to the Hampton Roads are to the west.

Monitoring

In order to determine the germination rates of planted seeds, we returned to the Bloodsworth Island site in the spring of 2011. Due to base access issues we have not been able to return the planting site at JEB Little Creek. We are still working with new natural resource personnel to gain access to the area for monitoring.

To monitor the planting area at Bloodsworth Island, we worked in conjunction with the National Oceanic and Atmospheric Administration (NOAA) Chesapeake Bay Program office. Since we could not access the site using SCUBA or snorkeling (due to unexploded ordnances), we used a viewscope to count seedlings within the planting circles. A viewscope is simply an apparatus that allows the user to look under the surface of the water from a boat, without having to be in the water. ESI personnel assessed all planting circles within the planting area and counted seedlings using the viewscope. Data was entered on underwater tablets and transferred to an Excel database.

RESULTS

JEB Little Creek

There are no results to date for JEB Little Creek. Since we could not access the planting site, we were unable to determine the germination rates of seeds at this time.

Bloodsworth Island, NAS Patuxent River

There were no observed eelgrass seedlings present in the planting area at Bloodsworth Island. Our ability to identify and count seedlings may have been limited by the viewscope and not being able to use SCUBA/snorkeling gear. However, there was a considerable population widgeon grass (*Ruppia maratima)* seedlings present within our planting area. Widgeon grass is a competitor with eelgrass for resources in the lower middle and lower portions of the Chesapeake Bay.

Laboratory Results

In addition to the field tests, we ran laboratory experiments to determine the effect of encapsulating seed on germination rates. This portion of the project was funded under separate contract with the Maryland Technology Development Corporation (TEDCO), in collaboration with Salisbury University. Conducting these trials was important to evaluate treatment effects under controlled conditions, particularly since field trials were compromised by environmental variables and access concerns.

An Analysis of Variance (ANOVA) showed that there was a significant difference ($p < 0.05$) in germination rates between treated and untreated eelgrass seed (Fig. 3).

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
TREATMENT	26.889	1	26.889	5.882	0.046
Error	32	7	4.571		

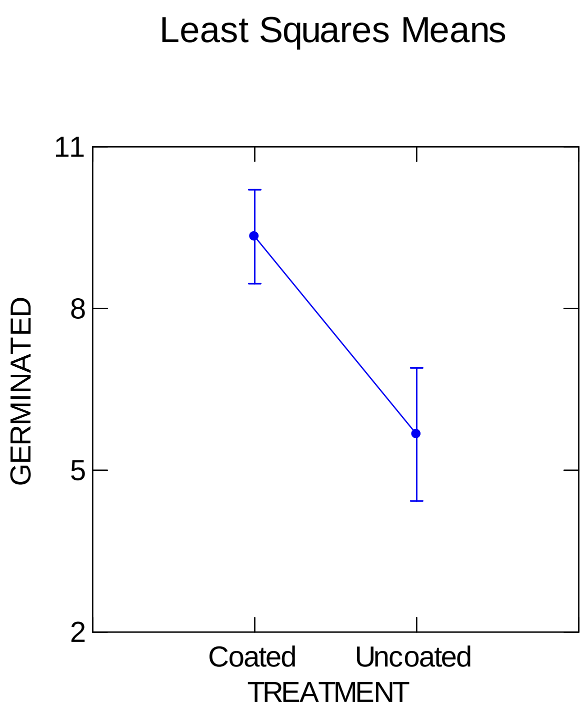

Fig. 3: ANOVA results with Least Square Means for treatment effects on germination.

DISCUSSION

While results were not as positive as we would have hoped, we still need access to JEB Little Creek to determine germination rates at a site with higher salinity. Low germination rates at the Bloodsworth Island site may have been due to out-competition by widgeon grass. In the middle and lower portions of the Chesapeake Bay, widgeon grass is a direct competitor for resources with eelgrass. Oftentimes, widgeon grass is more successful because it has a wider salinity and temperature range, giving it the ability to withstand greater environmental fluctuations. Widgeon grass is also a more prodigious seed producer, allowing more seeds to be present in the sediment for germination. The seed bank at Bloodsworth Island may have been ripe with widgeon grass seeds from past years, and with the donation of seeds from adjacent beds, may have spurred a successful year for widgeon grass. Widgeon grass and eelgrass can be found together, with widgeon grass being the dominant plant in shallower areas and eelgrass being dominant in the adjacent deeper waters. Because of the above-mentioned reasons, depth, seed production, temperature and salinity tolerance, and the ability to better tolerate environmental fluctuations, widgeon grass seedlings may have simply out-competed the eelgrass seedlings. This is not necessarily a negative outcome, as any growth of seagrass in the Chesapeake Bay region is a positive outcome. For purposes of this project however, a 0% germination rate for eelgrass was not our intended outcome. As with any project taking place in the natural environment, unexpected, uncontrollable conditions occur that can impact intended results, but this is why we intend to continue work in this environment, to learn all possible outcomes and be better able to act. At the Bloodsworth Island site, while past restoration success and good water quality led us to believe this was a good site for restoration, this site may now have too much variability for eelgrass to coexist with widgeon grass, making this area now an ideal location for successful widgeon grass survival.

Coating seed also aids in the process of restoration because coated seeds sink faster and thereby one is able to exert more control on targeting a particular region. This project did not specifically address this question, but previous work in the laboratory has confirmed increased sinking rates with treated seeds. We presume that seeds that sink faster are also less likely to be subjected to drift due to water currents. In this way, seeds are more likely to be incorporated into the sediments at the intended sites.

Restoring eelgrass populations was historically done using adult plants harvested from natural beds and transplanted to areas targeted for restoration. This approach, while seeing limited success, is labor intensive (requiring divers, handlers, greater space needs) and therefore costly. While this project did not perform a thorough cost-benefit analysis, the estimate for adult plant restoration is typically placed at $7-9/plant. Our target for restoration is 100,000 plants/acre which translates to > $500,000 if directly planted. Seed-based restoration, on the other hand, can broadcast over a half million seeds across several acres. The cost to harvest, store, and disperse these seeds typically runs < $200,000. The seed-coating technology adds some cost to the process (< $20,000), yet yields close to twice the germination rate, thereby almost doubling the restoration area potential. We conclude that seed treatment is a very attractive option for eelgrass restoration in terms of cost-savings.

Management Recommendations

Our results suggest that seed treatment is a viable option for natural resource managers interested in restoring this vital ecological habitat. Our work suggests that seed treatment has the ability to significantly increase germination rates, thereby providing a cost-effective means of restoring this habitat. Currently, there is no major market for eelgrass seed and therefore restoration projects must be conducted in such a manner where seed is harvested, stored, and dispersed on a project-by-project basis. We recommend that, should the Department of Defense continue to fund seagrass restoration, resource managers in a region collaborate in order to facilitate conducting multiple restoration projects in the same year.

Lastly, this process was only examined for efficacy with regard to eelgrass. In the Chesapeake Bay, like many estuaries, several species of submerged macrophytes provide important habitat. This treatment process should prove beneficial to other species, though further experiments must be completed to prove this. Future work is planned in this field.