Final Report

To

Virginia Coastal Zone Management Program

By

THE VIRGINIA INSTITUTE OF MARINE SCIENCE
COLLEGE OF WILLIAM AND MARY

May 15, 2006

Task 11.04 Restoration of seagrasses in Virginia Coastal Bays – Year 3

By

Robert Orth, Kenneth Moore, Britt Anderson, Scott Marion, David Wilcox

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INTRODUCTION

The system of barrier islands, coastal bays, and salt marshes along the Atlantic coast of Virginia's portion of the Delmarva Peninsula represent some of the most natural, unspoiled coastal habitat along the U.S. East Coast. Historically, finfish and shellfish resources in this region supported large fisheries. However, during the 1930s, this region underwent a dramatic ecological shift, and seafood harvests declined dramatically.

Seagrasses, primarily eelgrass, Zostera marina, were once very abundant in these coastal bays, covering most of the subaqueous bottom. In the 1930s eelgrass underwent a massive decline attributed to a wasting disease pathogen, Labyrinthula sp. (Rasmussen, 1977). The decline was pandemic, affecting not only populations in the coastal bays but also populations on both sides of the Atlantic. In August 1933, this region was affected by one of the most destructive hurricanes to influence the area in the twentieth century, contributing to the decimation of seagrasses in the bays. Natural recovery of seagrasses has been limited primarily to Chincoteague, Sinepuxent, Isle of Wight and Assawoman bays with little or no recovery in the Virginia coastal bays. This may be due to limited propagule supply and dispersal ability. Today, the Virginia coastal bays are primarily salt marsh and macroalgal dominated.

One of the most notable consequences of the loss of seagrass habitat in the coastal bays was the immediate collapse of a previously productive commercial bay scallop fishery, which is dependent on seagrasses as primary habitat. Almost certainly this loss of seagrass habitat resulted in declines in production of other commercially and ecologically important species, but little documentation of these impacts is available

We initiated a seagrass restoration program in the coastal bays, with efforts in Magothy Bay initiated in 1997, and South Bay in 1998, using test plots of adult transplants. The success of the test plots and the discovery of several natural patches in South Bay led us to conduct seed addition experiments there in 1999 and 2000. The success of the seed experiments and the sustained growth of previous transplants in South Bay led the Virginia Marine Resources Commission (VMRC) to designate a 400 acre area of subtidal habitat in South Bay to be set aside for seagrass restoration. In the fall of 2001, we broadcast 3.8 million seeds into 24-one acre parcels in the 400-acre set aside area. In addition we broadcast 600,000 seeds into 4 one-acre parcels in lower Cobb Island Bay and 600,000 seeds into 6 one-acre plots in Magothy Bay. We continued the large scale restoration of seagrass in South Bay in 2002 by broadcasting 1.8 million seeds into an additional 24 one acre plots at seed densities of 50 and 100K seeds (12 one acre areas at each seed density). In 2003 we broadcast 1.7 million seeds into 35 0.5 acre circular plots at 4 seed densities in both Cobb and Spider Crab bays. In 2004 we distributed approximately 7 million seeds in spring and plantings into 39 acres. In 2005, we broadcast 1.5 million seeds into 22 ½ acre plots (11 acres). To date, eelgrass in these plots are growing and expanding (see below).

A notable milestone of the seaside restoration effort in 2005 was the request to, and subsequent approval by the Virginia Marine Resources Commission of a 500 acre set aside in Hog Island Bay for 5 years (Fig. 1). This mirrors the 400 acre set aside in South Bay that was approved in 2001, and allows the continued successful seagrass restoration efforts without issues relating to clam dredging and aquaculture leases. Much of the area in Hog Island Bay is leased either to aquaculture or to individuals involved in clam dredging with little area in public grounds suitable for eelgrass restoration

This final report details accomplishments in each of the stated objectives for year 3 of the seagrass restoration program.

TASK 1 - ESTABLISHMENT OF TEST PLOTS FOR ADDITIONAL LARGE SCALE EFFORTS IN THE HOG ISLAND BAY AREA

Replicate test plots (1 m^2) of adult plants (8 planting units (PU), 2-3 adult shoots per PU) and seeds (1000 seeds) were planted or broadcast in the fall, 2005, at three locations in the set aside area, as well as at three additional sites in the 'Public Grounds' area near Rams Horn Marsh, where 9 sets of test plots were planted in 2004 and monitored through 2005 (see below) (Fig. 1). Locations represented the depth range found in both the set aside area and public ground. The planting of adult plants and seeds followed previously established protocols established by VIMS and used in the 2002 and 2003 plantings.

TASK 2 – MONITOR SUCCESS OF TEST AND ESTABLISHED SEAGRASS AREAS

Test Plots. Test plots of adult plants and seeds established in the fall of 2004 at Rams Horn Marsh (Figure 1) were monitored in the spring and fall, 2005 (Figure 2). Both adult plants and seedlings survived through the spring and appeared to be robust in some plots. However, by the fall 2005, only one single plant remained in one adult plant plot. This lack of survival was in contrast to previously successful test plots established in South, Cobb, and Spider Crab bays in previous years. Factors that may have contributed to this loss may be complicated given the hot temperatures of 2005, and while the records for South Bay show slightly reduced temperatures compared to Chesapeake Bay, the location of this new site and the distance from the inlet may have caused temperatures to be slightly higher that could have led to plant death. Test plots have been repeated at three of these sites so that we could have two years of data to better understand the variables that could affect eelgrass success in this one bay.

Large scale previously established plots. In 2004 we employed two different techniques for placing seeds into the large acre plots: 1. flowering shoots with seeds contained in seed bags deployed in the spring, and 2. the VIMS traditional method of fall broadcasting. Thirty five acres were seeded with seeds from the seed buoy technique with floats and a weighted block during the spring period. While seeds in the fall broadcast method required additional effort in holding time, the percentage of seedlings that developed and were observable in 2005 were 2-3 times the number of seedlings from the buoyed method (Figure 3). The low number of seeds shown for the broadcast method for 'MD Seeds' was a result of seed mortality issues in the holding system at MD's Piney Point facility. VIMS has not encountered these issues in our holding system.

TASK 3 – COLLECT SEEDS FOR 2005 EFFORTS

In 2005, we collected seeds using a combination of mechanical harvesters and hand collection. In collaboration with scientists from MD DNR, we obtained some seeds from a site in the Little Annemessex River using the large scale mechanical harvester that was used in 2004. In addition, we designed a portable mechanical harvester using a cutting head designed for removing exotic vegetation in small ponds or lakes. In total, we collected approximately 1.5 million seeds for distribution in the coastal bays.

TASK 4 – WATER QUALITY MEASUREMENTS USING FIXED STATION CONTINUOUS MONITORS AND SURFACE MAPPING OF WATER QUALITY WITH DATAFLOW

During 2005, continuous underway sampling (DATAFLOW) and fixed station water quality measurements were made in the Virginia Coastal Bays restoration area. The DATAFLOW cruise track conducted in 2005 (Figure 4) transversed transplant restoration areas in South Bay, Cobb Bay, Spider Crab Bay, and Hog Island Bay. Cruises were conducted monthly throughout the growing season on April 26, May 26, June 27, July 25, August 24, September 21, and October 18. A YSI 6600 was deployed at a fixed monitoring station at the Wreck Island restoration site in South Bay at bi-monthly intervals throughout the growing season over the following range of dates; May 19 to June 16, July 20 to August 4, and September 19 to September 28.

The DATAFLOW underway sampler recorded in vivo measurements of surface water quality taken at 2-3 second intervals (0.25 m depth; approximately every 50 m) along each cruise track. Measurements included turbidity (NTU), chlorophyll fluorescence, temperature, salinity, pH, dissolved oxygen, GPS location and depth using a YSI 6600 EDS sensor array (Yellow Springs Instruments, Inc.). In addition to the continuous underway sensor measurements, eight calibration and verification stations were sampled at discrete stations along each cruise track for total suspended solids, light attenuation profiles, secchi disk measurements, extracted pigment chlorophyll and dissolved oxygen via Winkler Titration. Concurrent with every other cruise (bi-monthly), two week deployments of a YSI 6600 EDS sensor array identical to that used in the DATAFLOW sampler were undertaken at the South Bay Wreck Island restoration site. Here, water quality was measured at 15-minute intervals throughout each 2-week deployment. These deployments bracketed, by approximately one week, each DATAFLOW water quality, monitoring cruise.

Figures 5, 6, and 7 present the continuous underway cruise tracks of water quality measurements for turbidity, chlorophyll, and salinity for the three monthly cruises that were paired with fixed monitoring station deployments. Results of the other cruises showed similar trends. The location of the fixed, continuous monitoring station is highlighted with a circle, and the transplant areas are highlighted with rectangles on each cruise figure. Salinities were found to be very consistent over the course of the 2005 SAV growing season and rarely dropped below 30 ppt throughout the Coastal Bays area. Low water column turbidity and chlorophyll levels were typical of the transplant sites throughout 2005. In the Chesapeake Bay chlorophyll levels of 15 μg/l or greater have been associated with SAV habitats that are under stress or in decline. Here the chlorophyll levels were typically below 5 μg/l. Turbidity levels of 10 NTU or less in the Virginia Coastal Bays are equivalent to a light attenuation coefficient (K_d) of $\leq 1.5\ m^{-1}$. In the Chesapeake Bay these light attenuation levels have been associated with shallow water areas where SAV have been found growing to depths of 1m at MLW. During most of 2005, DATAFLOW monitored turbidity levels were usually just above this threshold. This may have been due, in part, to the weather conditions on the days of the cruises. For example, during the May and July cruise dates winds speeds were generally above 10 – 15 mph, potentially causing re-suspension of sediment particles in the shallow restoration sites. Higher levels of NTU were often observed in the western Coastal Bays region near Oyster, VA. Turbidity levels were usually lower over the four restoration areas.

Continuous records of turbidity, chlorophyll, and depth for the bi-monthly fixed monitoring station deployments are presented in Figures8, 9, and 10. Tides ranged from 1 – 2 meters. Tidal cycles and waves appear to play important roles in affecting both turbidity and the phytoplankton component of the turbidity in the South Bay restoration area. Average levels of turbidity over the deployment of the fixed monitoring station in South Bay were approximately 17 NTU. Interestingly, this restoration area appeared to have slightly higher turbidity levels than the other restoration sites (Figures 5, 6, and 7). These, higher levels of turbidity seem to be short lived. On most low tides both turbidity and phytoplankton levels dropped (Figures 8, 9, and 10), suggesting that a rapid settling of particles and clearing of the water was occurring. Slack water near high tide at South Bay was characterized by little drop in turbidity or chlorophyll. This suggests that the increase in suspended particles may have been more related to physical disturbance by waves than by currents. Possibly, wave propagation across the flats is greatly reduced as the tide level drops and re-suspension of sediments and benthic micro algae are reduced. This parallels our qualitative observations in the field. It may also be that higher phytoplankton concentrations with incoming ocean water may be elevating levels across the restoration sites at high tide. Uptake by benthic filter feeders or settling of phytoplankton with in the transplant areas may then be reducing levels on ebbing tides. These observations suggest that the continued establishment and spreading of restored seagrass beds with their extended canopies and enhanced infauna will greatly increase water clarity over the flats during lower tidal periods, further improving conditions for additional seagrass recovery.

Given the many efforts in SAV restoration in Virginia's coastal and estuarine waters it can be useful to compare water quality across regions that have had varying degrees of success to improve our restoration results. In Table 1 the median, minimum, and maximum observed turbidity and chlorophyll levels for the bi-weekly monitoring periods at South Bay are compared to the Goodwin Island and Clay Bank SAV sites in the York River. Goodwin Island is located at an area near the mouth of the York River that has been persistently vegetated with eelgrass. Clay Bank is located approximately 26 km upriver from Goodwin Island in an area that historically had eelgrass beds until the early 1970s, but since then has remained unvegetated. Water quality of these sites is monitored as part of NOAA's CBNERRVA System-wide Monitoring Program. Restoration efforts there have not had any long-term success. Seasonal water clarity criteria for eelgrass growth in each of these sites are approximately 22% of surface irradiance to the leaf surface. To attain this level for growth to a depth of 1 meter MLW a light attenuation coefficient (K_d) of 1.45 is required. The K_d to NTU relationship has been found to vary between regions due, in part, to the nature of the components of turbidity in each region. In the York River, a K_d of 1.45 would correspond to an NTU of 7, while in South Bay, as discussed above, it would correspond to a NTU of 10. It is interesting then, to compare these goals with actual data from fixed stations in these regions while also considering restoration success and/or failure. Healthy seagrass growth in early 2005 at Goodwin Island was associated with turbidity levels of approximately 7 NTU, which marginally met the water clarity goals for eelgrass growth in this region. At Clay Bank, where SAV restoration and natural growth has been largely unsuccessful, median turbidity greatly exceeded that goal. At the South Bay coastal lagoon site where eelgrass restoration has been successful, median turbidity levels were typically higher than the goal of 10 NTU. Reasons for this may be related to the quality of light or Photosynthetically Usable Radiation (PUR) for seagrass growth in this region may be greater than areas in the lower Chesapeake Bay due to the lower levels of phytoplankton or dissolved material. There may also be less epiphyte accumulation on the seagrass leaves and the effective light at the leaf surfaces is greater in the coastal bays than the Chesapeake Bay.

During the late summer of 2005 an extensive dieback of eelgrass was observed in most areas of the lower Chesapeake Bay. This was not observed in the restored or newly transplanted beds in South Bay. Eelgrass is a cool water seagrass species that is near the southern limits of its range in Virginia. Prolonged periods of water temperatures above 28 ºC can cause significant plant diebacks in the summer. Water temperatures above 35 ºC can cause death in a period of 1-2 days. Figure 11 presents continuous temperature records for the late July-early August monitoring period at South Bay in comparison with the Goodwin Island and Clay Bank sites in the York River. Average water temperatures at South Bay during this period were approximately 2-3 ºC lower than the York River sites. At the Goodwin Island site peak water temperatures in late July exceeded 33 ºC, while at South Bay water temperatures rarely exceeded 30 ºC. In addition, a distinct cooling of the water could be observed with each high tide at South Bay (especially during the July 20-25 period). In contrast, little tidal variation was evident at either of the York River sites, where the temperature variation was principally diurnal. This suggests that slightly cooler overall as well as peak water temperatures in the coastal bays restoration areas may have contributed to the continued success of the eelgrass restoration efforts there.

TASK 5 – LARGE SCALE SEAGRASS RESTORATION
In 2005 we used the VIMS broadcast method of deploying seeds in both South Bay and Spider Crab Bay. In South Bay, 500,000 seeds were broadcast into 8 ½ acre plots (total of 4 acres): 6 - ½ acre plots with 50,000 seeds and 2 - ½ acre plots with 100,000 seeds (Fig. 12). In Spider Crab Bay, 1,000,000 seeds were broadcast into 14 ½ acre plots (total of 7 acres): 8 - ½ acre plots with 50,000 seeds, and 6 - ½ acre plots with 100,000 seeds (Fig. 13). These plots will be assessed in the spring of 2006 as part of the year 4 project.

TASK 6 – MAPPING OF SEAGRASS FROM OF AERIAL PHOTOGRAPHS
High-level black and white aerial photographs were taken in Nov., 2005, and February, 2006. The late photography was due to very poor atmospheric conditions restricting the acquisition phase to much later than anticipated. They will be orthorectified and combined to form a mosaic for the seaside heritage region. However, they do show the presence of our eelgrass plots in South and Cobb Bay indicating that they survive the 2005 summer defoliation event.

LIST OF FIGURES