FINAL REPORT

Seaside Special Area Management Plan: Spatial Information Analysis and & Interpretation for Shellfish Grounds and SAV Beds

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May 15, 2011

Grant #: NA08NOS4190466
Task # 96.02

This project was funded by the Virginia Coastal Zone Management Program at the Department of Environmental Quality through Grant #NA08NOS4190466 of the U.S. Department of Commerce, National Oceanic and Atmospheric Administration, under the Coastal Zone Management Act of 1972, as amended. The views expressed herein are those of the authors and do not necessarily reflect the views of the U.S. Department of Commerce, NOAA, or any of its subagencies.

Virginia Coastal Zone
MANAGEMENT PROGRAM

EXECUTIVE SUMMARY

The coastal bays along the seaside of Virginia's Eastern Shore support valuable natural resources and economic activities which are vital to the region's economy and culture. The submerged bottomlands in this area—the mudflats, subtidal bottom, oyster reefs and seagrass meadows—serve many important functions, including essential fish habitat, foraging areas for shorebirds, commercial and recreational wild shellfish harvest, and commercial shellfish aquaculture. Balancing these multiple uses by promoting the economic and cultural uses of these habitats, while protecting the resource base on which they depend is the challenge facing resource managers.

Over the past century significant changes have occurred in the seaside coastal bays. Sea level rise and westward movement of the barrier islands have altered habitats. Wild shellfish stocks (oysters, clams and scallops) have declined dramatically. In recent decades commercial shellfish aquaculture (clams and oysters) has replaced wild shellfish harvest as the predominant seafood industry. More recently, seagrass beds, which were largely absent from the region for over 70 years, are being successfully restored to the coastal bays, holding out the promise that bay scallop populations, which are dependent upon the grass beds, may be restored as well. These changes in the natural system and the changing human uses suggest a need to examine the manner in which space in the coastal bays are allocated to various uses.

Currently, the primary determinant of use allocation for submerged bottomlands is based largely upon a survey conducted nearly 120 years ago. The Baylor survey, which was conducted in the early 1890's, defined the boundaries of the public shellfish beds at the time. Those areas, not included with survey boundaries, were available for lease from the state for Virginia citizens to plant and grow shellfish. These leases, which were formerly used for transplanting wild oysters, now serve as the grow-out sites for hatchery-based, intensive aquaculture of clams and oysters. As aquaculture has grown in recent years, availability of new leases has become one of the factors limiting the growth of the industry. At the same time, a recent survey of wild oysters reveals that the majority of the population is no longer found within the boundaries of the old Baylor survey. Both of these situations point to the need to re-examine the approach towards managing use of the submerged bottomlands in the coastal bays.

Building on the results from earlier work in which we mapped oyster populations, Baylor survey boundaries and shellfish leases, and made preliminary assessments of habitat suitability, in this study we refined our habitat suitability assessments in representative areas within the coastal bays. We then compared these habitat suitability assessments to current use designations to provide a quantitative evaluation of the efficacy of the current management approach.

Our findings reveal some significant mismatches between current designations for submerged bottomlands in the coastal bays and habitat suitability. Fifty-seven percent of the natural oyster reefs that we mapped are located outside of the Baylor survey. Approximately 34% of the area within the Baylor survey was found to be unsuitable for wild oyster or clam populations or fisheries, while roughly 10% of the area within the Baylor survey appears to be suitable for commercial shellfish aquaculture. We estimate that 57% of the potential area for seagrass restoration lies within the Baylor survey boundaries. Meanwhile, we know, but did not quantify as part of this study, that large areas of current shellfish leases are not suitable for shellfish aquaculture using current cultivation techniques.

This study points to the need to re-evaluate current use designations for state-owned submerged bottomlands in the coastal bays of Virginia's Eastern Shore. We advocate for the development of a more flexible management system for allocating use of submerged bottomlands in the coastal bays. Such a system should be based upon current habitat suitability, a balanced allocation among various stakeholders and science-based management of critical natural resources.

ACKNOWLEDGEMENTS

We thank Drs. Jim Wesson and Bob Orth for their assistance in characterizing habitat suitability for oysters and SAV, respectively. Pete Terry, Joe Peirson and Tim Rapine provided critical assessments of habitat suitability for shellfish aquaculture. Field and laboratory assistance was provided by Edward Smith and Alan Birch. This project was funded by the Virginia Coastal Zone Management Program at the Department of Environmental Quality through Grant #NA08NOS4190466 of the U.S. Department of Commerce, National Oceanic and Atmospheric Administration, under the Coastal Zone Management Act. We are especially grateful to Laura McKay from the Virginia Coastal Zone Management Program for her leadership in guiding the multi-institutional partnership on the development of the Virginia Seaside SAMP.

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Introduction

The coastal bays along the seaside of Virginia's Eastern Shore are an extraordinarily productive environment. The lagoons, marshes, sea grass meadows, mudflats and oyster reefs in this ecosystem provide important ecological functions, including nursery grounds for numerous fish species, foraging and nesting grounds for shorebirds, nutrient removal and maintenance of water quality. They also have a long history of providing economic benefits to the residents of the region. Historically, wild oyster, clam and scallop harvests, along with commercial fin fisheries were a mainstay of the economy. Over the past few decades, the emergence of shellfish aquaculture, primarily of the hard clam *Mercenaria mercenaria*, has been a valuable addition to the economy of the region. Additionally, tourism and recreational fishing, both of which utilize the coastal bays, are increasingly important for the economy of the region.

Managing these multiple uses of the coastal bays in a way that optimizes economic return while protecting both the natural resources on which they depend and important traditional cultural activities poses a challenge for resource managers that are common to most coastal regions of the U.S. Though a variety of approaches are available to resource managers, at some level management of such areas requires the designation of specific uses for particular locations.

In Virginia management of submerged bottom habitat in this and other coastal areas is based upon several historical regulations, laws and constitutional designations. Private ownership of intertidal bottom is accorded to landowners who own adjacent uplands. Remaining submerged bottom is owned by the state. The constitution of Virginia (Article XI, Section 3) requires that the state maintain the natural shellfish beds in these state-owned submerged bottoms for the benefit of the citizens of the Commonwealth. By statute these public shellfish beds are defined based upon a survey commissioned by the VA General Assembly in the late

19th Century and conducted by Lt. Baylor from the United States Navy. The polygons drawn by Lt. Baylor around productive shellfish grounds have served to define the public shellfish ground for nearly 120 years (Baylor 1894) and the term Baylor Grounds has come to be synonymous public shellfish beds. Those areas of state-owned submerged bottom not included in the Baylor Grounds, or otherwise protected, are available for leasing by citizens of the Commonwealth for the "purpose of planting and propagating shellfish" (VA Code §28.2-603).

This system of public shellfish beds (defined by the Baylor survey) and leased bottom has served for over a century to allocate areas of the state-owned bottom for wild shellfish harvest and cultivation, respectively. Traditional shellfish cultivation practices in Virginia typically involved transplanting of wild "seed" oysters (1 – 2 year-old animals) onto leased bottom for an additional year of growth prior to harvesting and marketing. Over the past 30 years, alternative methods of cultivating shellfish based upon the use of hatchery-produced and field grow-out in predator exclusion structures has expanded rapidly. In the coastal bays along the seaside of the Eastern Shore and in high salinity areas (generally > 20‰) in the lower Chesapeake Bay this cultivation has primarily involved the hard clam, *Mercenaria mercenaria*. In hard clam aquaculture hatchery-produced "seed clams" (10 – 20 mm in size) are planted under plastic netting in low intertidal or shallow subtidal areas of leased bottom for a grow-out period that averages approximately two years. This practice is critically dependent upon good water quality and the availability of appropriate bottom habitat for leasing.

The clam aquaculture industry experienced rapid growth during the 1980s and '90s and now represents a mature industry with a dockside value varying between $20 and $30 million dollars annually (Murray and Oesterling 2010). Hatchery-based oyster aquaculture in Virginia has a shorter history—roughly 20 years—but it is expanding rapidly (Murray and Oesterling

2010) and because of the wider salinity tolerance of the native oyster, *Crassostrea virginica*, has the potential to greatly exceed the value of clam aquaculture within the state.

In the coastal bays on the seaside of Virginia's Eastern Shore sustainable shellfish aquaculture is dependent, among other things, on availability of suitable areas for leasing. Members of this industry have raised concerns in recent years that the lack of available new leases in one of the impediments to growth and sustainability of the industry. Coincident with this, significant changes have occurred in the coastal bay habitats, their natural resources and the wild shellfisheries that they support. Dramatic declines in the wild oyster fishery have occurred over the past 40 years in the coastal bays as a result of overfishing, habitat destruction, disease and changing market demands. Extensive seagrass beds within the coastal bays, which once supported a valuable bay scallop fishery, largely disappeared from the coastal bays in the early 1930's, resulting in the local extinction of scallops. Success over the past decade in restoring seagrass to the coastal bays (Orth et al. 2006) and promising results from recent efforts to restore bay scallops to this habitat (Luckenbach, unpubl. data) suggest that it may be possible to restore significant areas of shallow submerged bottom habitat to its former condition. This mix of potential uses—wild shellfisheries, aquaculture and seagrass restoration—each of which has similar, but not precisely the same, habitat requirements, points to the need to develop good habitat suitability evaluations and appropriate management structures. Moreover, these changing uses are taking place against a backdrop of significant, and apparently accelerating, habitat change. In the nearly 120 years since Baylor conducted his survey of the region's shellfish beds (which were comprised largely of intertidal oyster reefs and shallow subtidal seagrass meadows with scallops) sea level in the region has risen about 35 cm (1 ½ feet), the barrier islands have

shifted, in some cases moving several hundreds of meters westward, and large areas of marsh have been lost to erosion, subsidence and sea level rise.

Recognizing these changes in habitat and resource utilization, a collaborative research program was initiated under the leadership of the Virginia Coastal Zone Management (CZM) Program to develop a Special Area Management Plan (SAMP) for the region. Partners in the program include The Nature Conservancy, the Virginia Institute of Marine Science (VIMS), the Virginia Marine Resources Commission, the Virginia Eastern Shorekeeper, and representatives of the shellfish aquaculture industry. The goals of this SAMP are (1) to map, analyze, and interpret the current status and trends in the uses, economic values, and beneficial ecosystem functions associated with state-owned and other habitats in the seaside bays of Virginia's Eastern Shore, (2) to re-evaluate these uses in light of current and projected conditions, and (3) to recommend guidelines for managing these resources in a manner that optimizes the environmental and socio-economic benefits derived. These three goals are being addressed in three sequential phases, roughly corresponding to each goal. During the first two phases (funded with FY 2008 and 2009 funds) the partners used existing GIS data, combined with stakeholder/user information, management agency input and additional field-collected data to evaluate the effectiveness of current use allocation patterns in the context of current stakeholder uses and needs, and current ecological conditions. In its final phase, to be completed in the coming year, the effort will employ a consensus-building process to develop a plan which recommends regulatory and other guidelines to (1) increase economic productivity, (2) enhance ecosystem health, and (3) resolve potential conflicts.

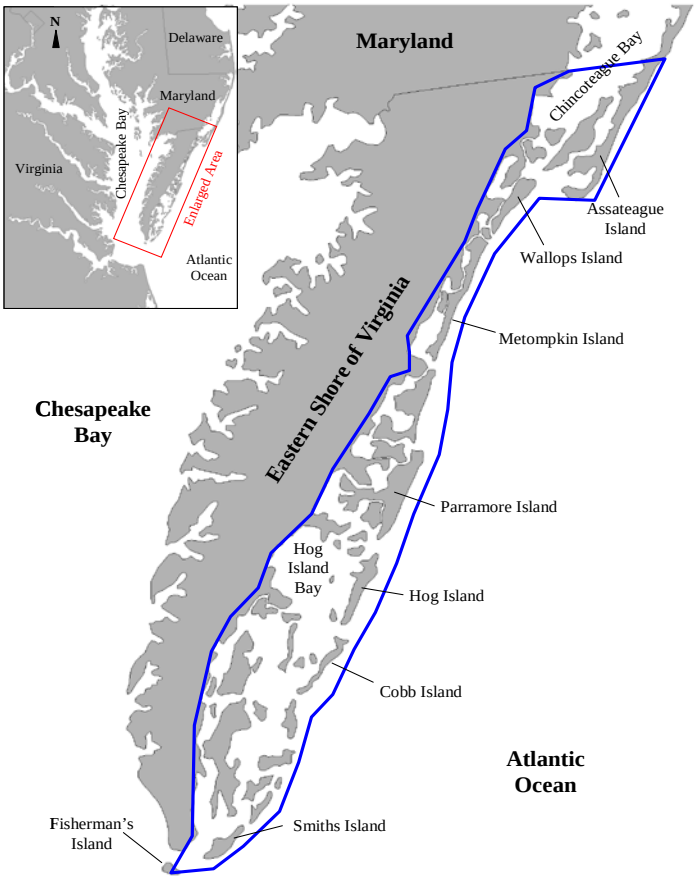
The role for the VIMS' Eastern Shore Laboratory staff in this partnership has been to develop assessments of habitat suitability for wild shellfisheries, shellfish aquaculture and

seagrass beds (henceforth SAV) and to compare these suitability estimates to current use designations. Coarse-scale maps of habitat suitability produced during Phase 1 of this work revealed, among other things, that as much as 53% of the currently designated public shellfish grounds (i.e., Baylor Grounds) are no longer suitable habitat for wild shellfish populations. This report covers Phase 2 of the SAMP project during which these coarse-scale habitat-suitability assessments for the entire seaside bay complex were refined and finer scale suitability designations developed for representative areas within the coastal bays. Finer-scale resolution of habitat suitability in selected areas was deemed necessary by the project partners because of the highly complex nature of the habitats and the current lack of appropriately-scaled environmental data. The goal of this effort was not to establish fixed boundary lines for recommendations on use, but rather to generate statistical estimates of suitability of current use designations and to develop "working maps" which can serve as a starting point for developing a consensus-building approach towards developing recommendations for management policies that best achieve the goals outlined above.

Study Area

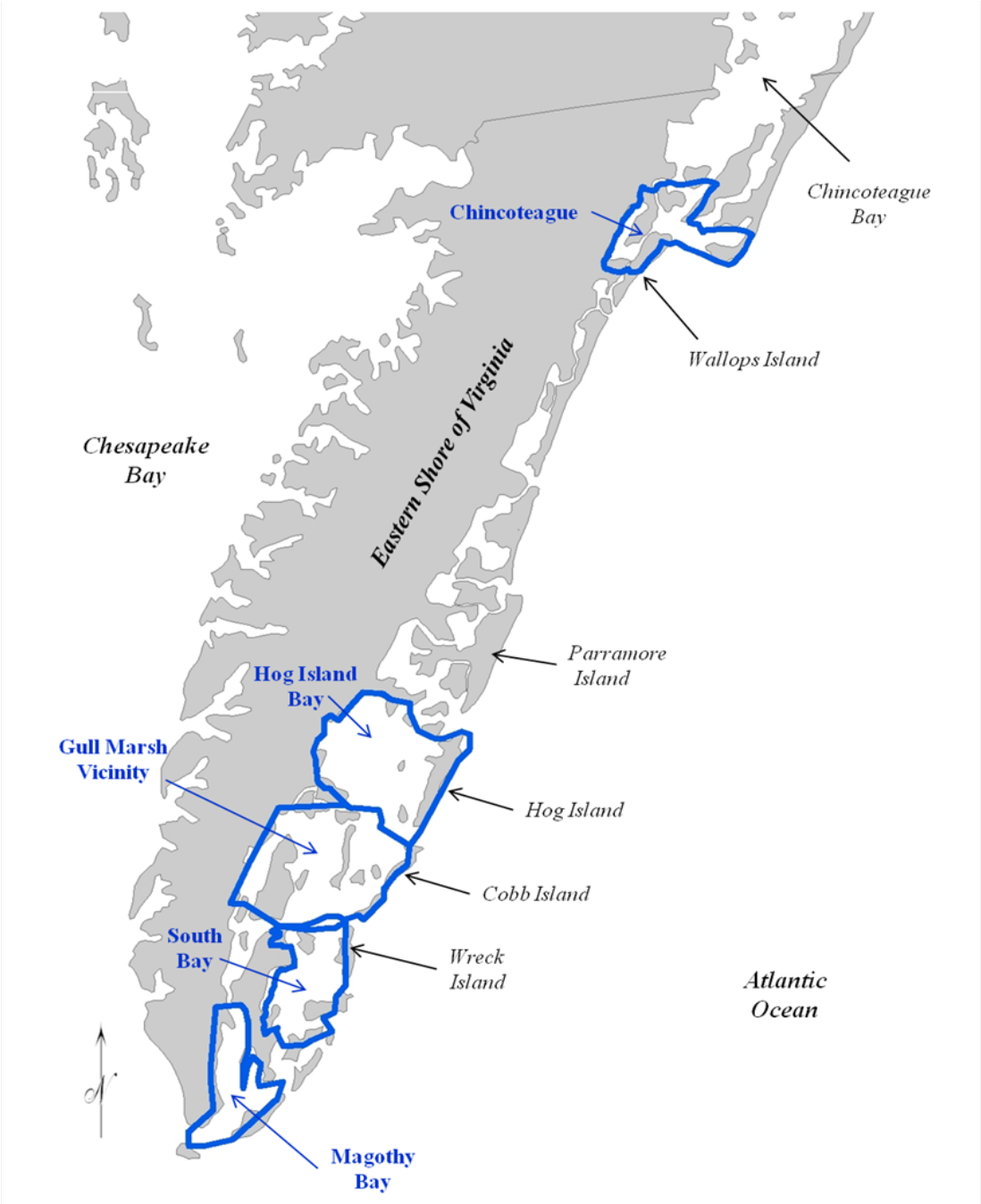
The focus of our study was the coastal bay system on the seaside of the Eastern Shore of Virginia (Fig. 1). This system is composed of barrier islands, salt marsh dominated by *Spartina* spp., broad and shallow coastal bays, intertidal mud flats, and deeper water channels. The area encompasses approximately 900 km^2 (350 mi^2) and is bounded by Fisherman's Island in the south to mid-Chincoteague Bay in the north (bounding latitudes of N 37º 06' to N 38º 01').

Figure 1. Study area (outlined in blue) consisting of the coastal bays system on the seaside of the Virginia portion of the Delmarva Peninsula.



At the outset of this study we had detailed spatial data on public shellfish grounds, private leases and oyster reefs throughout this region from a previous study CZMP-funded study (Grant # NA06NOS4190241, Ross and Luckenbach 2009). In the current study we began by first selecting five areas for which we gathered additional information: 1) the southern portion of Chincoteague Bay, 2) Hog Island Bay, 3) Gull Marsh, 4) South Bay and 5) Magothy Bay (Fig. 2). For each of these regions we combined data layers on public shellfish grounds, private leases and existing oyster reefs with data on the suitability of areas within the public shellfish grounds oyster restoration, existing submerged aquatic vegetation (SAV) and suitability for SAV restoration.

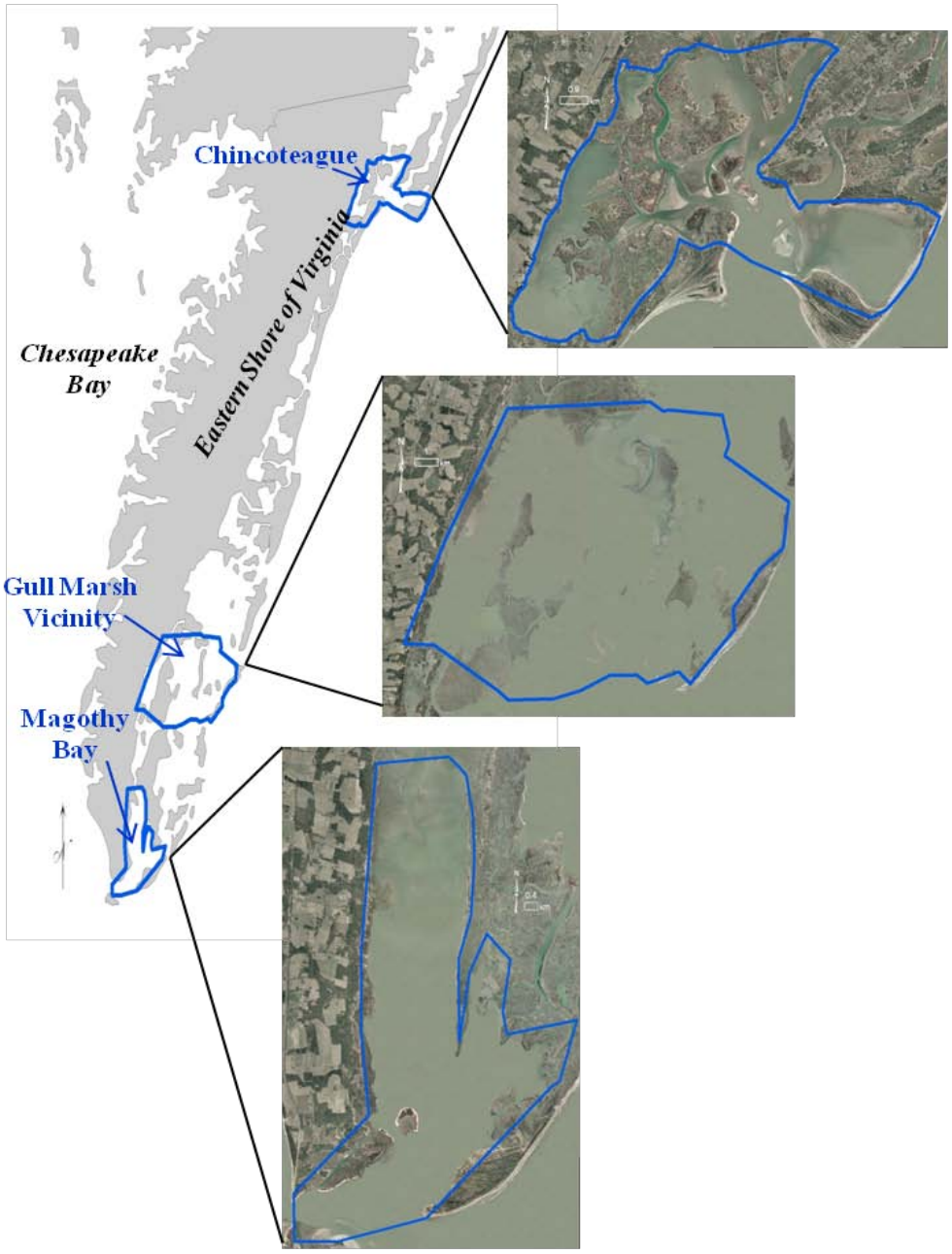
Figure 2. Regions within the study area for which more detailed habitat suitability for oysters and SAV were assessed



Three of these areas (Chincoteague, Gull Marsh and Magothy Bay) were selected for further in depth evaluation of the potential for multiple uses for existing Baylor ground (Fig. 3).

Time and logistic constraints forced us to focus in depth on these three areas rather than all five areas. In each of these areas, we gathered additional data on bathymetry, sediment characteristics and habitat suitability for shellfish aquaculture from local experts.

Figure 3. The three study areas where a more detailed inventory of potential uses was acquired from aquaculture experts.



Methods

Existing Geo-spatial tools--We utilized the following GIS products from external sources: 1) National Wetlands Inventory (NWI) maps for the region (http://www.fws.gov/nwi/, see also Cowardin et al. 1979) with some habitat modifications described in Ross and Luckenbach (2009); 2) 2007 and 2009 digital 1-m resolution areal imagery from the Virginia Base Mapping Program (VBMP); 3) Baylor ground and private lease polygons from the Virginia Marine Resources Commission; 4) existing SAV polygons (R. Orth et al., VIMS); and 5) bathymetry raster contours for portions of two of the areas (G. Ortel et al., Old Dominion University). We also utilized oyster reef mapping data from a previous project (Ross and Luckenbach 2009). These data were collected and analyzed for all five of the study areas in Figure 2.

Expert Input--We solicited input from several experts in research, resource management and aquaculture industry backgrounds regarding potential uses of various habitats within study areas. While not all stakeholder groups are included at this point, this initial phase of the project focused on three widespread and potentially ecologically significant components: SAV, oysters and shellfish aquaculture

Representatives of the VIMS-SAV research and restoration program, led by Dr. Robert Orth, collaborated to estimate areas of potential SAV restoration or expansion over the coming decades. Dr. Orth is an internationally recognized expert in SAV, has been actively involved SAV restoration in the coastal bays for the past 12 years, and directs SAV mapping and assessment program throughout the Chesapeake Bay and coastal bays of Virginia and Maryland. It is important to note that these recommendations are based on experience and some field data that, while generally informative to this study, are not meant to be delineations appropriate for

defining maps map boundaries or making management decisions about specific uses as particular sites.

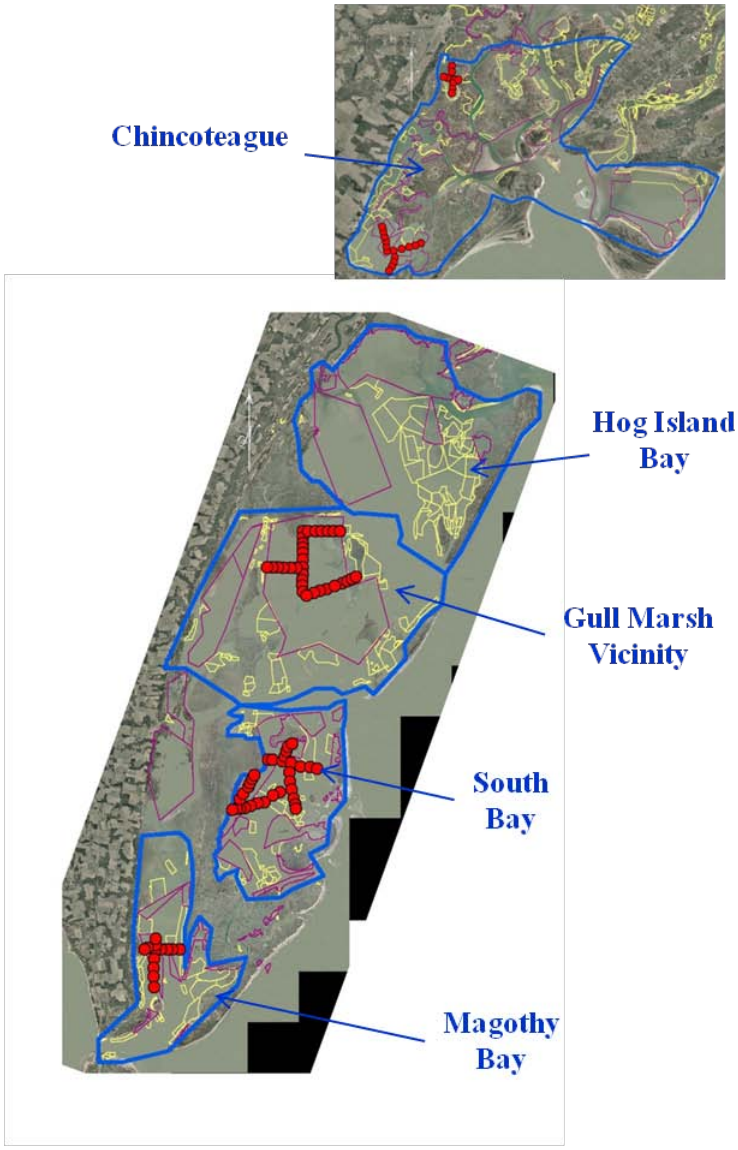
Dr. Jim Wesson (VMRC) provided an algorithm based upon bathymetry and the presence of existing oyster beds to identify areas within the Baylor grounds that would be appropriate for oyster restoration over the coming decades. Dr. Wesson is the director of the oyster restoration program in Virginia and has nearly 20 years of experience conduction oyster restoration in the coastal bays of Virginia. We applied his basic algorithm to develop a GIS-layer which included existing oyster resources and potential restoration areas. The resulting maps were reviewed by Dr. Wesson and iterative changes made to develop as set of maps which were suitable for our objectives of evaluating current designations and suitability. Again, these maps are not intended to serve as final recommendations for use designations, but merely an indication of the efficacy of current designations.

We also solicited input from different aquaculture experts from each of the three areas in Figure 3. Generally, the following potential uses were identified by these experts: wild clam fishery (either dredge or hand harvest), hard clam aquaculture on the bottom and oyster aquaculture in various off-bottom systems. Some also suggested areas that were unfit for any type of bivalve aquaculture or restoration due to physical characteristics. Input from these experts was combined with our own personal knowledge of the area and data from the field sampling described below to develop data layers for each region for habitat suitability for shellfish.

Field Sampling—Habitat suitability judgments by the experts we consulted were based upon numerous factors, but water depth and sediment characteristics were among the most important habitat characteristics. Therefore, we chose strategic sites to sample both of these in

the four study areas delineated in Figure 4. We also utilized similar samples from Hog Island Bay that were collected for a recent project (Fig. 5).

Figure 4. Benthic sample locations (red dots) in 4 of the 5 study areas. Blue, purple and yellow lines delineate study areas, Baylor Ground and Private Leases, respectively.

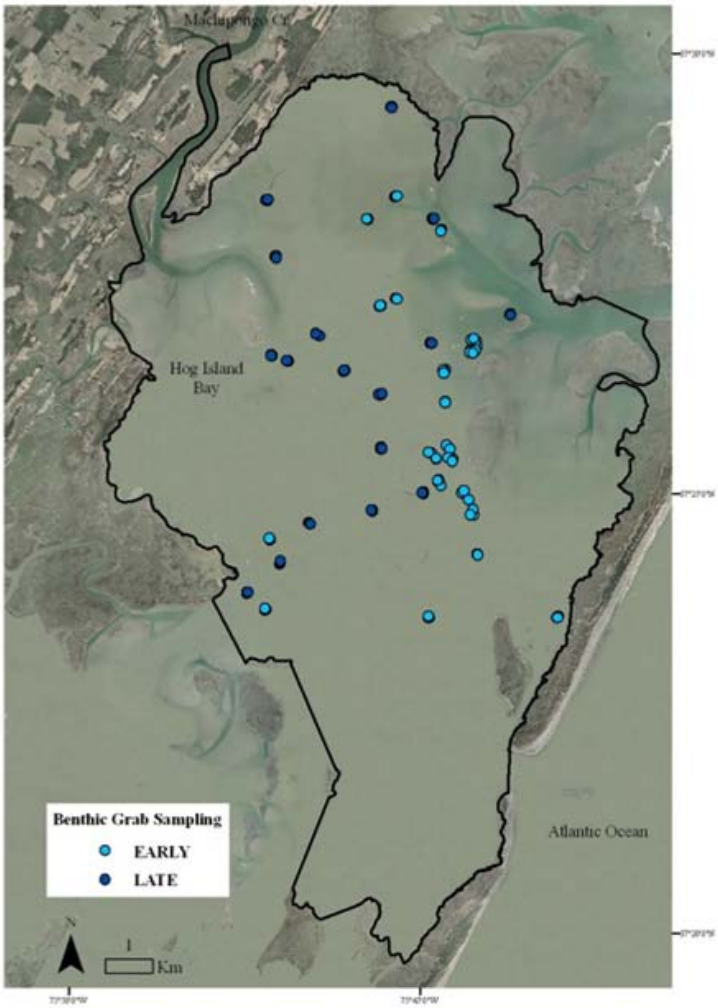


We collected surficial sediment to 5 cm depth using a Ponar grab sampler. Samples were brought back to the laboratory and dried to a constant weight at 90º C. A sub-sample was weighed, combusted in a muffle furnace (~550º C) for 5 hr and re-weighed to determine organic

matter content. Another sub-sample was gently homogenized with mortar and pestle and passed through stacked sieves to determine gross sediment fractions.

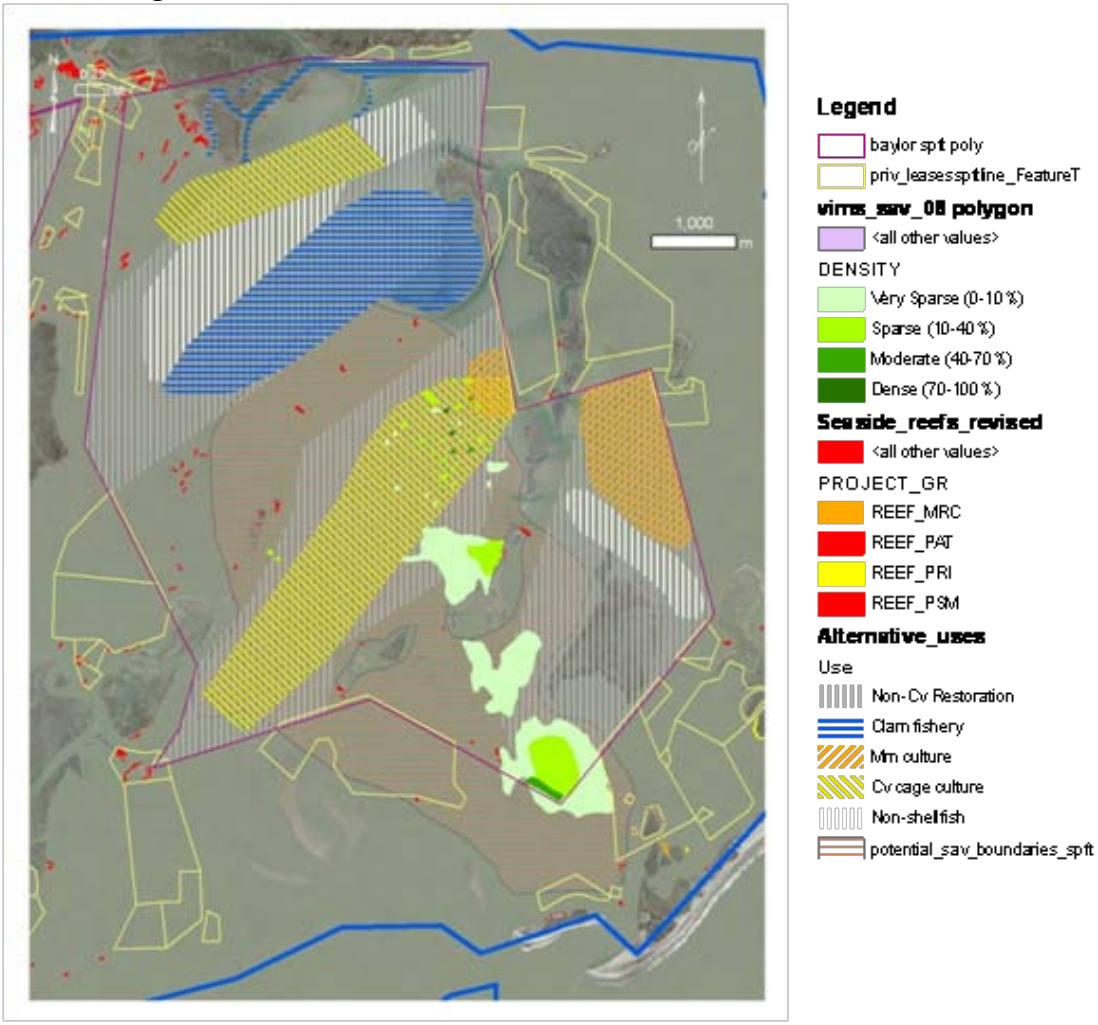
We also measured water depth at each site using a 200 kHz fathometer. Water depth data was post-processed and referenced to Mean Higher High Water (MHHW). These data are not reported in this narrative report, but are incorporated into the GIS data bundle accompanying it.

Figure 5. Benthic sampling locations from Hog Island Bay in early (light blue) and late (dark blue) winter 2008/2009. Samples taken as part of a study examining winter foraging ecology of seaducks.



GIS Analysis--All pertinent GIS layers were incorporated in a project using ArcGIS 9.3 (e.g. see Fig. 6). An additional layer was developed incorporating a "Union" of all of these data. This union data layer was then used for the data summary presented in the results.

Figure 6. Example of a map resulting from the union data layer of a portion of Gull Marsh delineating existing management themes, existing natural resources and input from multiple stakeholders. This map is <u>not</u> intended to delineate "hard' map lines, but rather to serve as an example of the types of data that can be incorporated into future management discussions and decisions.



Results

GIS Products--Eight GIS shapefiles are delivered along with this narrative report (Table 1). Two of these, *Baylor Ground* and *Private Leases*, originated from VMRC and are provided for context. The others were generated by our lab based on expert input and field sampling as described above.

Table 1. GIS products delivered for this study.

Description (Source)	GIS File name	File Type	Metadata
Baylor Ground (source:VMRC)	baylor spft poly.shp	polygon	no
Private Leases (source:VMRC)	priv_leasesspftline_FeatureT.shp	line	no
Study area delineations	Study_areas.shp	polygon	yes
Potential SAV (source: VIMS-SAV Program)	potential_sav_boundaries_spft.shp	polygon	yes
Alternative uses	Alternative_uses.shp	polygon	yes
Union of all pertinent data for analysis	SAMP_Union.shp	polygon	yes
Benthic & bathymetry sampling (SAMP)	SAMP_benthic_sample_points.shp	point	yes
Benthic & bathymetry sampling (Sea Ducks)	Sea Duck Study-benthic sample polygon centroids.shp	point	yes

Existing & Potential Uses—Overall, we inventoried 472 km^2 in the five study areas that individually ranged from 58-155 km^2, some of this area included marsh or adjacent barrier islands. Gull Marsh had the most Baylor Ground and Magothy Bay had the least (Table 2). Hog Island Bay had the largest area of private leases and Chincoteague had the smallest (Table 2). Relative abundance of these bottom designations were also quite variable between study areas (Fig. 7), and we believe provide a good representation of the entire seaside lagoon system.

Table 2. Total Baylor Ground and private lease areas (km^2) within each study area.

Study Area	Total Area (km^2)	Baylor Ground (km^2)	Private Lease (km^2)
Chincoteague	67	14	7
Gull Marsh	156	69	15
Hog Island Bay	125	42	28
Magothy Bay	58	8	10
South Bay	66	18	8

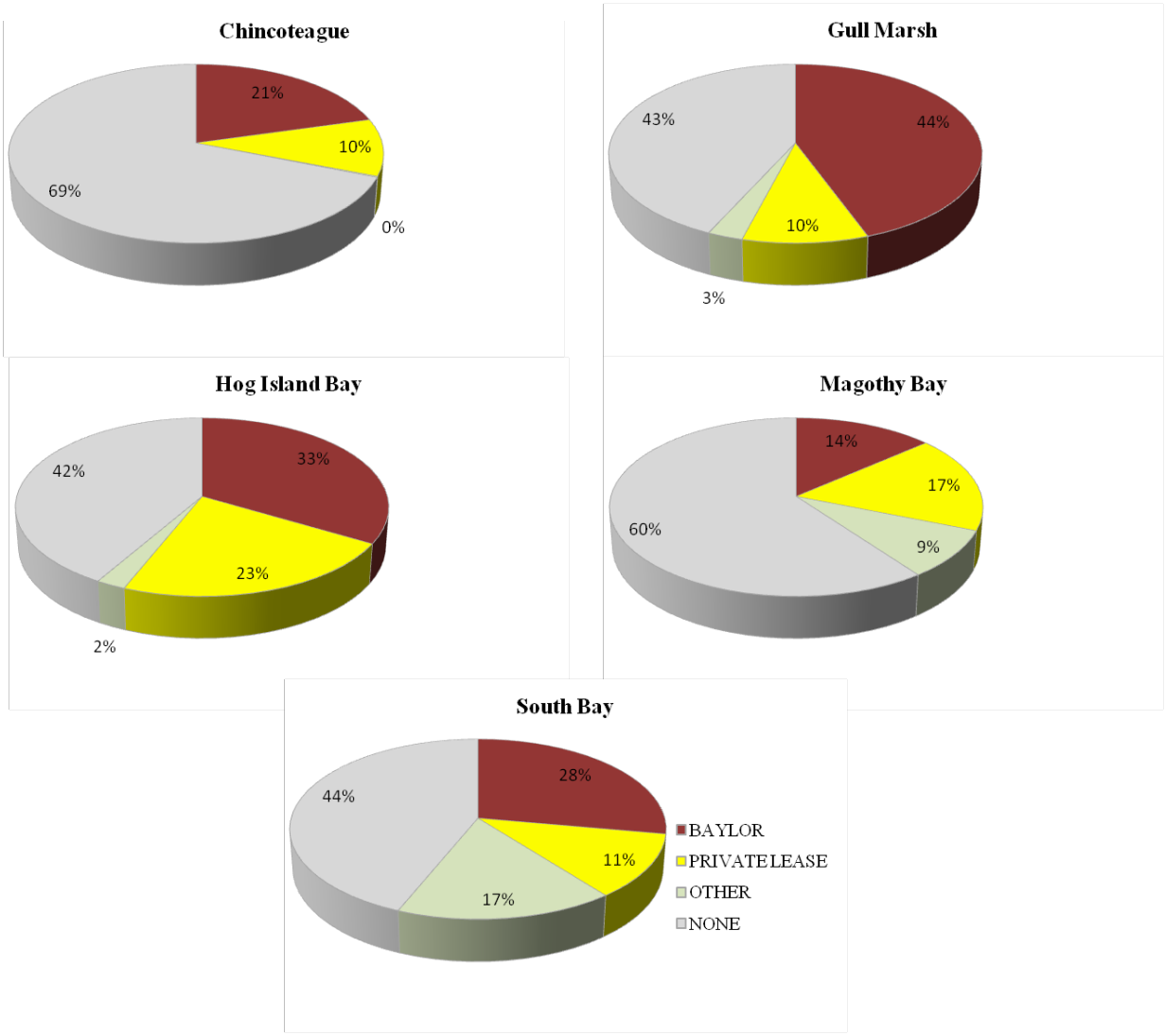
The areal extent of oyster reefs varied across study areas (Table 3). Reefs classifications are from a previous study (Ross and Luckenbach 2009). *REEF_PAT*, *REEF_PSM* and *REEF_FRI* stand for Patch Reefs, Small Patch Reefs and Fringing Reefs, respectively, and are all basically "natural" reefs

Table 3. Areal extent (km^2) of existing oyster reefs and SAV and potential SAV (see Methods for descriptions) for study areas.

Study Area	Existing Oyster Reefs (km^2)	Existing SAV (km^2)	Potential SAV (km^2)
Chincoteague	0.3	0	0
Gull Marsh	0.6	2.3	27.1
Hog Island Bay	0.7	0.6	31.5
Magothy Bay	0.1	0	11.5
South Bay	0.3	7.0	15.8

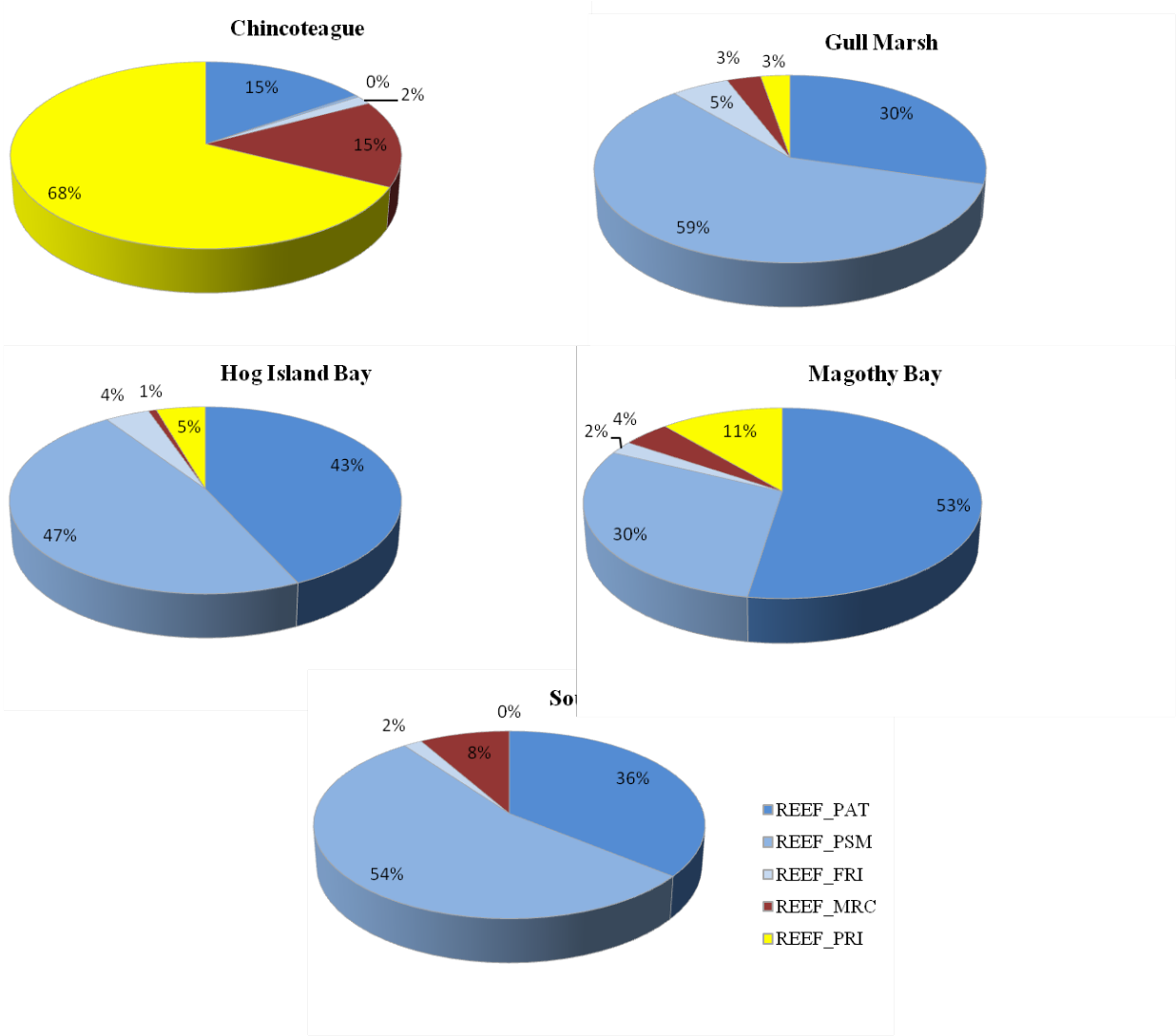
of various types while *REEF_MRC* are VMRC restoration reefs and *REEF_PRI* are private reefs that are either commercially managed or private restoration efforts (e.g. The Nature Conservancy).

Figure 7. Relative abundance of various types classifications for each study area: Baylor Ground (red), Private Leases (yellow), Other (light green) and None (gray). "Other" denotes either areas of reefs or SAV outside of Baylor and Private Leases, while "None" refers to either "Unassigned Bottom" or emergent marsh/uplands.



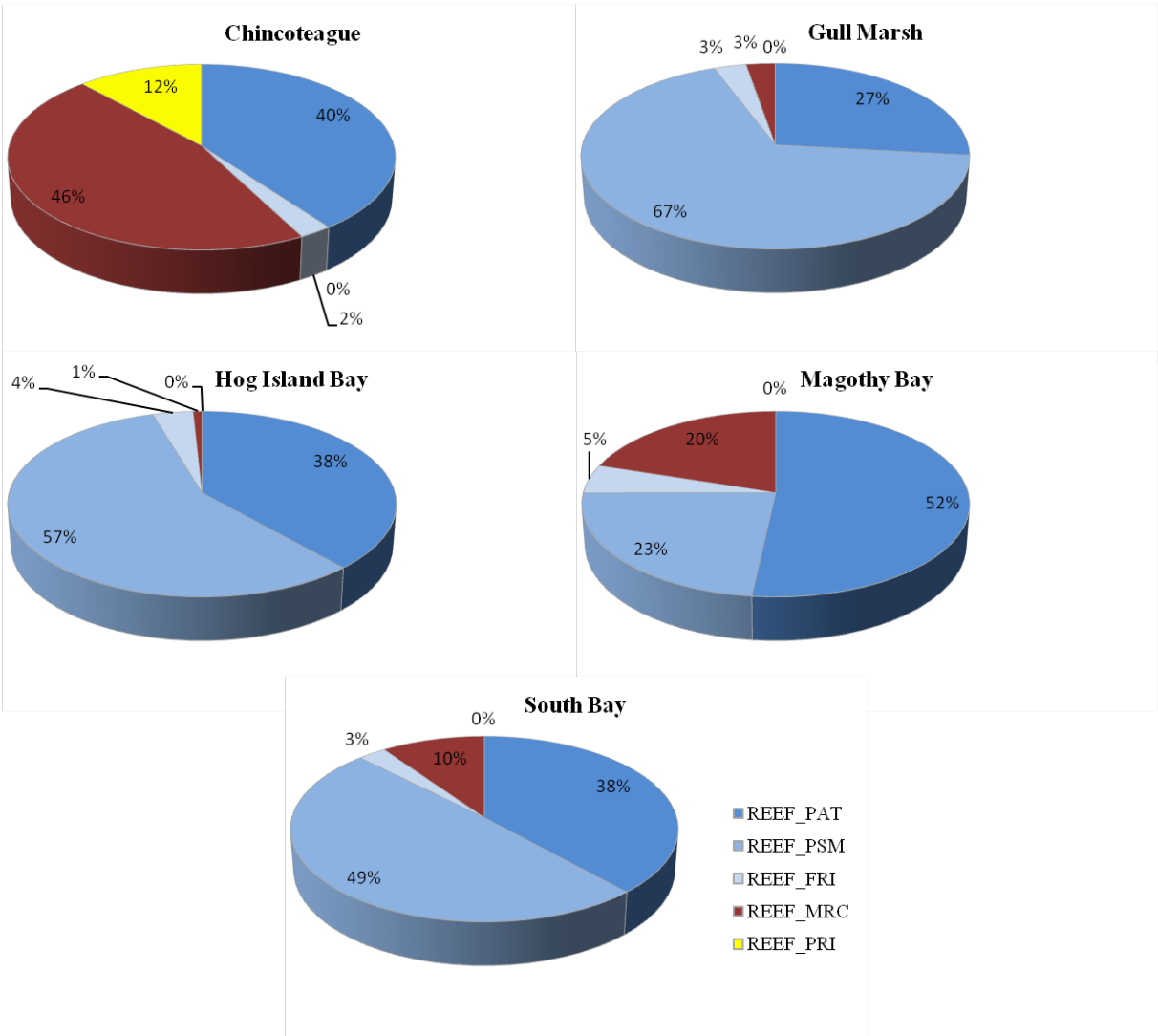
Oyster populations in most of the study areas were located primarily on natural reefs with Chincoteague being a major exception (Fig. 8).

Figure 8. Relative abundance of various types of oyster reefs in each study area. Note that those denoted by varying shades of blue are generally different types of natural reefs, whereas those in red are VMRC restoration reefs and those in yellow are private reefs (either commercial or private restoration).



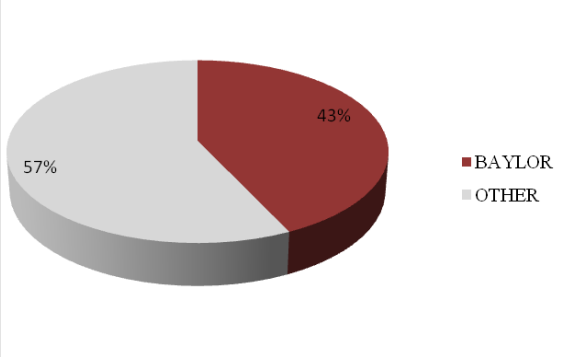
When only the Baylor Grounds are considered, the relative abundance of the different reef types showed similar patterns, with Chincoteague again being distinct (Fig. 9).

Figure 9. Relative abundance of various types of oyster reefs within Baylor Ground only for each study area. Varying shades of blue are different types of natural reefs (REEF-PAT=patch reef, REEF_PSM=small patch reefs, REEF_FRI=fringing reefs, red are VMRC restoration reefs and yellow are private reefs located on bottom either leased from the state or in private ownership; some are for commercial production, others are private restoration.



When data were pooled for all the study areas, we found that 43% of natural oyster reefs were located within Baylor (Fig. 10).

Figure 10. Relative abundance of "natural" reefs (i.e. REEF_PAT, REEF_PSM & REEF_FRI in previous graphs) in Baylor Ground vs. Other bottom designations pooled across study areas.



Three of the five areas had SAV present in 2008 (Table 3) with only two of these having it present on Baylor Ground (Table 4). Estimates suggest that four of the five study areas can potentially support SAV over substantially larger footprints than currently observed (Table 3 & Fig. 11), especially on Baylor Ground (Table 4 & Fig. 12).

Table 4. Areal extent (km^2) of existing oyster reefs and SAV and potential SAV within *Baylor Ground only* for study areas.

Study Area	Existing Oyster Reefs (km^2)	Existing SAV (km^2)	Potential SAV (km^2)
Chincoteague	0.04	0	0
Gull Marsh	0.3	2.0	22.8
Hog Island Bay	0.3	0	19.8
Magothy Bay	0.02	0	3.8
South Bay	0.1	1.0	2.4

Figure 11. Area of existing and potential SAV for each entire study area.

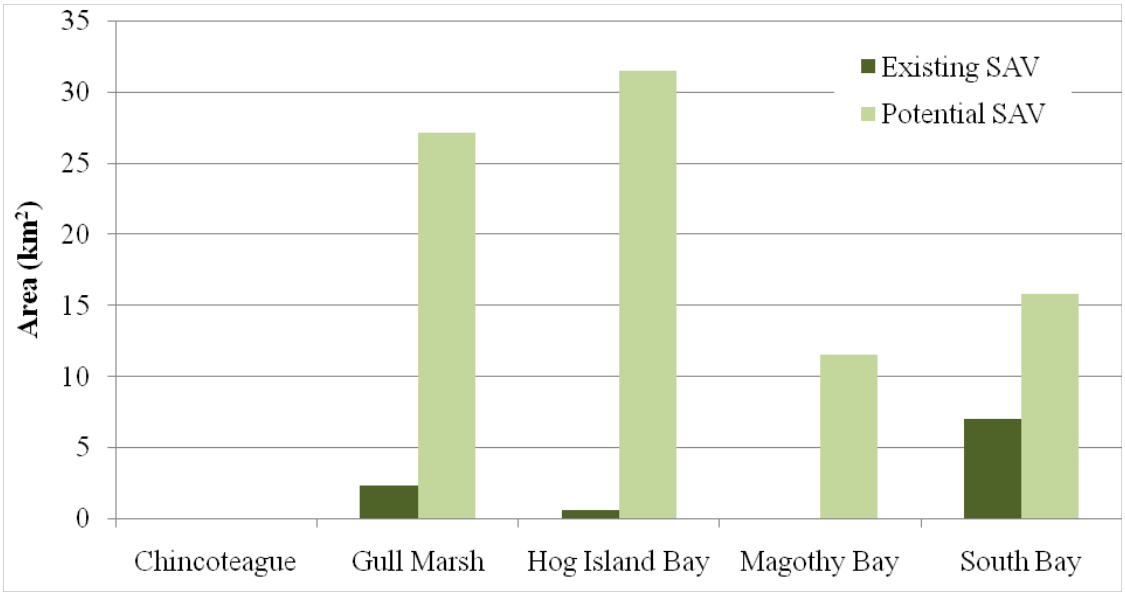
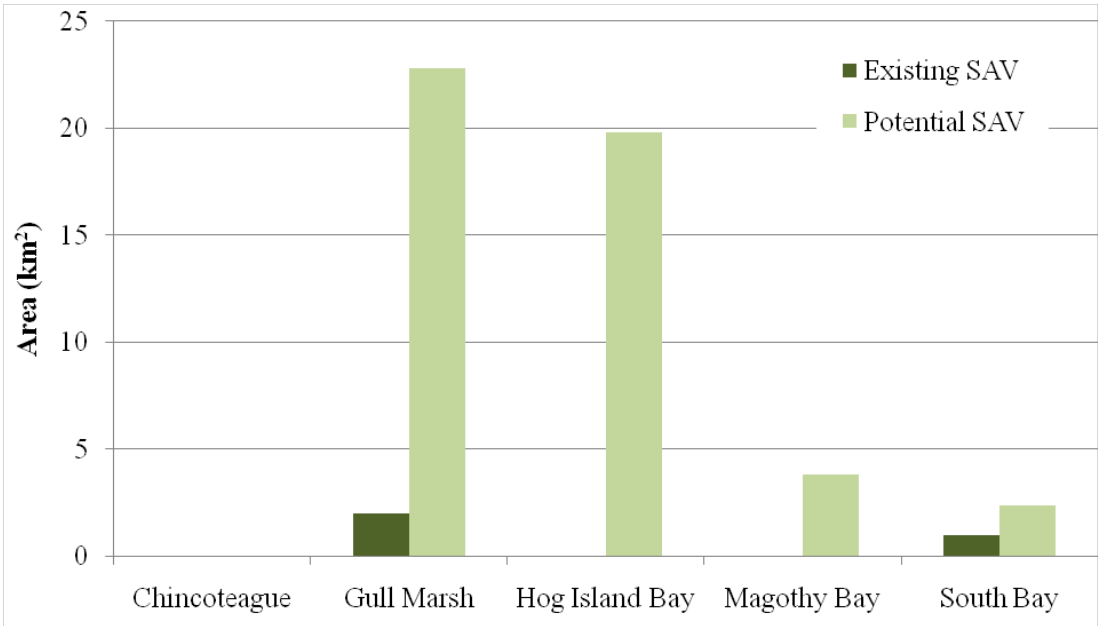


Figure 12. Area of existing and potential SAV within Baylor Grounds in each study area.



Over half of existing SAV is found outside of Baylor Ground and Private Leases, with about 1/3 on Baylor Grounds (Fig. 13). However, 57% of the potential areal extent of SAV lies within the Baylor Grounds (Fig. 13).

Figure 13. Relative area of existing and potential SAV pooled across study areas.

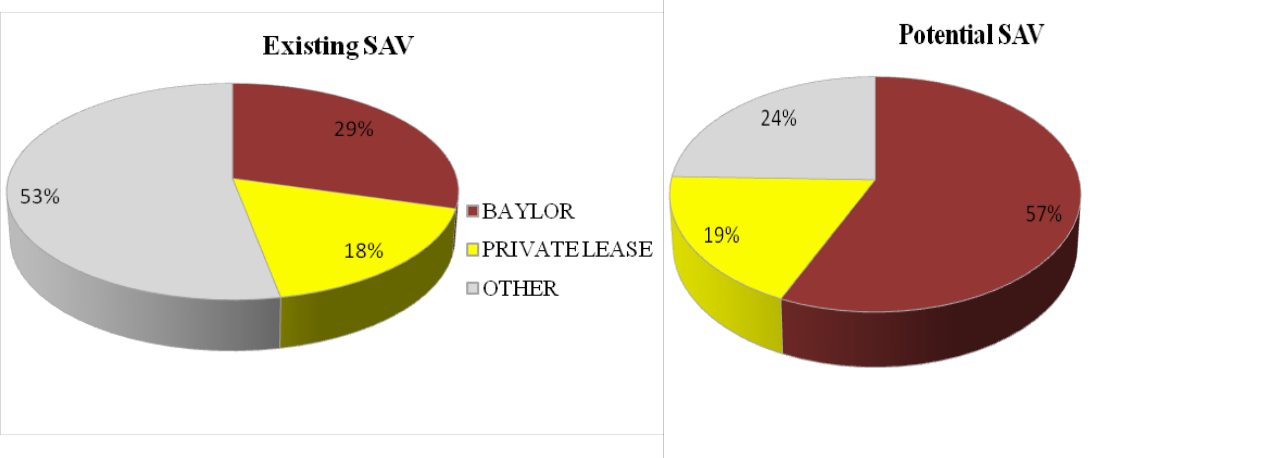
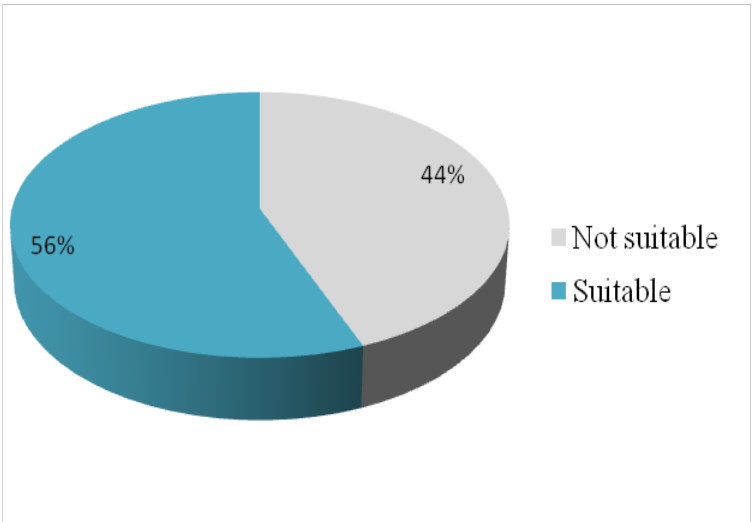


Figure 14. Relative amount of Baylor Ground suitable for oyster restoration pooled across study areas.



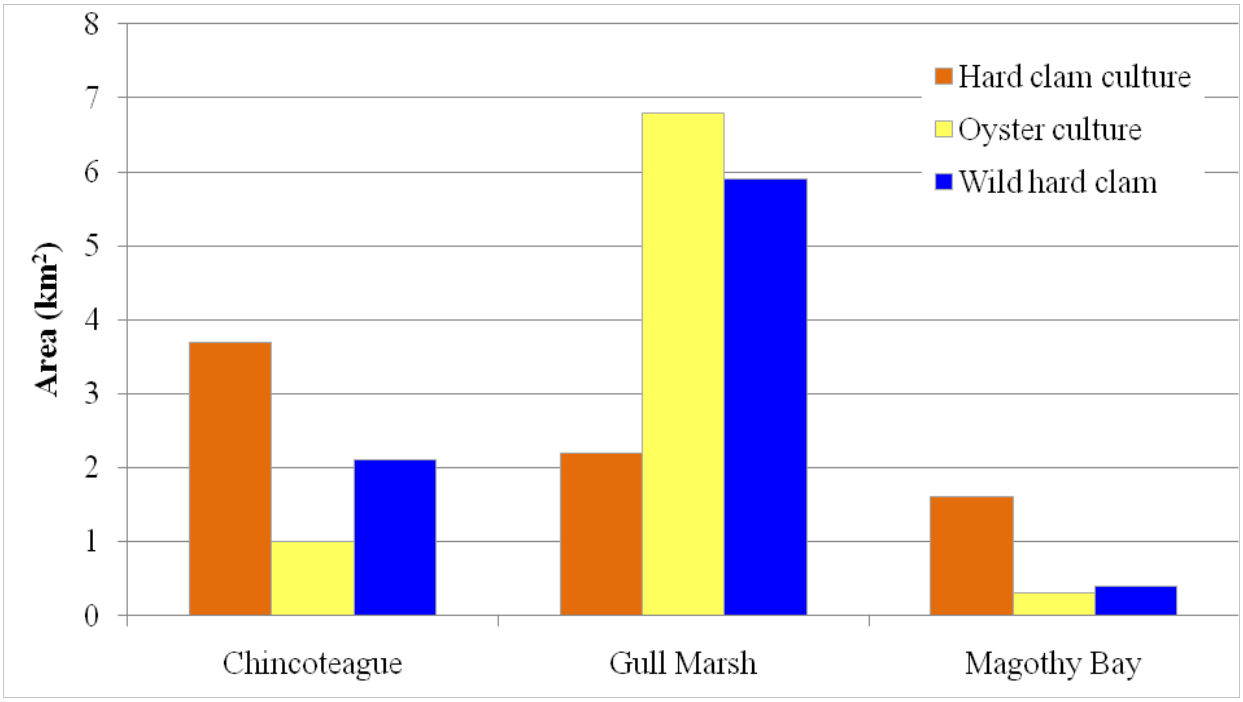
Within Baylor Grounds, we identified areas unsuitable for shellfish, either wild or cultured, in two ways. First by digitizing obvious areas such as marsh/beach/barrier island uplands that are currently included in Baylor Ground polygons either erroneously or because of landscape changes since the late 1800's when the survey was undertaken (e.g. barrier island migration). Secondly, several of the experts we utilized suggested unsuitable areas due to geographic and/or physical aspects of certain places. The areal extent of such areas ranged from 0-3.3 km^2 (Table 5).

Table 5. Areal extent (km^2) of habitats deemed unsuitable for shellfish in general and for oyster restoration within *Baylor Ground only* for each study area.

Study Area	Area Unsuitable for Shellfish (km^2)	Area Unsuitable for Oyster Restoration (km^2)
Chincoteague	0.2	5.2
Gull Marsh	3.3	31.2
Hog Island Bay	0	15.7
Magothy Bay	0.6	2.9
South Bay	0.2	7.1

Additionally, based on input from VMRC, we identified areas within the Baylor Grounds where they will not pursue oyster restoration in the coming decades. The extent of Baylor Grounds that were deemed unsuitable for oyster restoration varied across area from ~ 3 – 31 km^2 (Table 5). In total ~ 44% of Baylor was deemed not suitable for oyster restoration (Fig. 14).

Figure 15. Area of potential aquaculture and wild hard clam harvest within Baylor Ground only in each study area. Colors graph correspond to those in the GIS project depicting these areas.



Three main potential uses of Baylor Grounds without oysters were noted by aquaculture experts: bottom cultivation of clams, off-bottom oyster culture and wild hard clam fishery. Varying amounts of area for each category were identified for the three study areas (Table 6 & Fig. 15). When data was pooled for all study areas, approximately 10% of Baylor was assumed to be appropriate for clam or oyster cultivation (Fig. 16), and this may be a conservative estimate.

Figure 16. Relative amount of Baylor Ground suitable for hard clam and oyster cultivation.

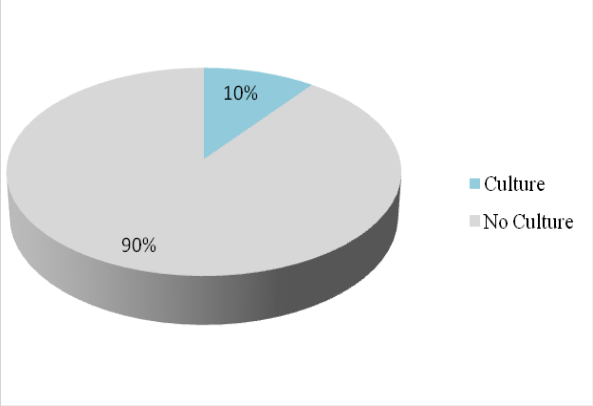


Table 6. Areal extent (km^2) of habitats deemed suitable for shellfish culture and harvest within *Baylor Ground only* for each study area.

Study Area	Potential Hard Clam Culture (km^2)	Potential Caged Oyster Culture (km^2)	Estimated Wild Clam Fishery (km^2)
Chincoteague	3.7	1.0	2.1
Gull Marsh	2.2	6.8	5.9
Magothy Bay	1.6	0.3	0.4

Discussion

Our findings reveal that 57% (by area) of what we categorize as "natural" oyster reefs are located outside of the Baylor survey boundaries (Fig. 10). We recognize that many of these reefs have been subjected to some manipulation, including shell planting and perhaps seed transplants in the past, but they do not appear to be the result of current cultivation activity. Within our study areas only 56% of the area within the Baylor Grounds was deemed suitable for wild oysters (i.e., either it had existing oyster reefs or the bathymetry and bottom characteristics were suitable for oyster restoration) (Fig. 14). Less than 10% of the area within the Baylor Grounds was considered suitable for commercial wild clam harvest (compare Tables 2 & 6). There are several reasons why such a large proportion of the Baylor Grounds are currently not suitable for wild shellfish production. First, significant areas within the Baylor Grounds are subtidal and thus will not support extensive oyster reefs, which in the coastal bays are found almost exclusively in the intertidal zone where the oysters have a partial refuge from predation. Second, there are numerous areas in the outer portions of the coastal bays where the barrier islands have moved westward since Baylor undertook his survey, resulting in some Baylor survey boundaries now being located on barrier islands or even in the surf zone. Further, a combination of

bathymetry and sediment type makes much of the Baylor Grounds unsuitable for wild clam fisheries. Finally, it seems clear that substantial areas included within the Baylor survey were actually seagrass beds, which at the time supported a bay scallop fishery. In our study, those and other areas are characterized a suitable for SAV restoration and are presumed to be suitable for shellfish only after successful reestablishment of the seagrass beds and scallop populations.

Currently, a little under 10 km^2 of SAV exists within the five areas we examined (Table 3). Our analysis suggests that areas could support approximately 85 km^2 of SAV (Table 3, Fig. 11). Twenty-nine percent of current and 57% of potential SAV area within the study areas are located within the Baylor Grounds (Fig. 13). As with our others estimates of potentially suitable habitat, we do not mean to imply that SAV will spread to all of these areas or that efforts to restore it to all of these areas should be pursued. What these analyses do suggest is that serious consideration needs to be given how to manage these areas. If SAV restoration is achieved in these areas and scallops populations are reestablished, do these areas become public fishing grounds for scallops? Or, if these area lack shellfish resources now, should they continue to be designated as part of the public shellfish grounds?

Much of the socio-economic pressure to re-evaluate our current use designations has come from the shellfish aquaculture industry, members of which have suggested that the limited availability of new lease areas is a major impediment to the growth of the industry. Our assessments from the Chincoteague, Gull Marsh and Magothy Bay areas, which are based largely on input from aquaculture industry members in those areas, suggest that only about 10% of the Baylor Grounds may be appropriate for clam or oyster culture. It is possible that this estimate is conservative because we received input only from a limited number of people and because the various ways in which the industry cultures oysters is likely to continue to expand.

Though this estimate of 10% of the Baylor Grounds as being suitable for aquaculture of clams or oysters is relatively small, it represents total area of approximately 21 km^2, which is almost a quarter of the 86 km^2 currently under lease in the coastal bays. Equally important, however, is the finding mentioned above that 57% of the areas that we identified as have "natural" oyster reefs were located outside of the Baylor Grounds.

These findings point to a need to re-evaluate the use designations for state-owned submerged bottomlands in the coastal bays of Virginia's Eastern Shore. One approach for achieving this might be to commission another survey conducted in greater detail than was possible here to replace Baylor's survey of the public shellfish beds. Such an approach, however, would again lead to fixed boundaries for use designations which would likely be outdated within a few decades and would not directly provide a means for accommodating other uses, including modern shellfish aquaculture and SAV and scallop restoration. Alternatively, we suggest that a more flexible management system is needed for the submerged bottomlands in the coastal bays along the seaside of Virginia's Eastern Shore. In recognition of the dynamic nature of this environment, this system should allow for ongoing and case-by-case assessment of current habitat suitability, input from various stakeholders and science-based management of critical natural resources.

We re-iterate that the maps of habitat suitability generated as part of this study and included in the accompanying GIS product are not intended to be used to draw fixed boundaries for habitat suitability or re-define current uses. For those purposes higher resolution mapping of bathymetry and bottom characteristics will be required at a much higher density within an area than we were able to achieve in this study. Rather, our maps and analyses were intended to provide some quantification of the scale of mismatch between current use designations and use

suitability in an effort to guide policy decisions about the need for a re-evaluation. Even prior to completion of this work, they appear to have done so. Within the past few months the Virginia General Assembly passed Senate Joint Resolution 330 which directs the Virginia Institute of Marine Science and the Virginia Marine Resources Commission to conduct a study that will "make recommendations for legislative and regulatory actions required to implement a more flexible and effective management approach towards managing submerged bottomlands on the seaside of the Eastern Shore." A report with these recommendations is required to be submitted to the Governor and the General Assembly by the end of 2011. The work described in this report and that of other collaborators in our SAMP project will provide critical input into that process.

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