

SAV Workgroup Member Updates

Summer 2018 SAV Workgroup Meeting
Chesapeake Bay Program
Annapolis, MD
June 26, 2018

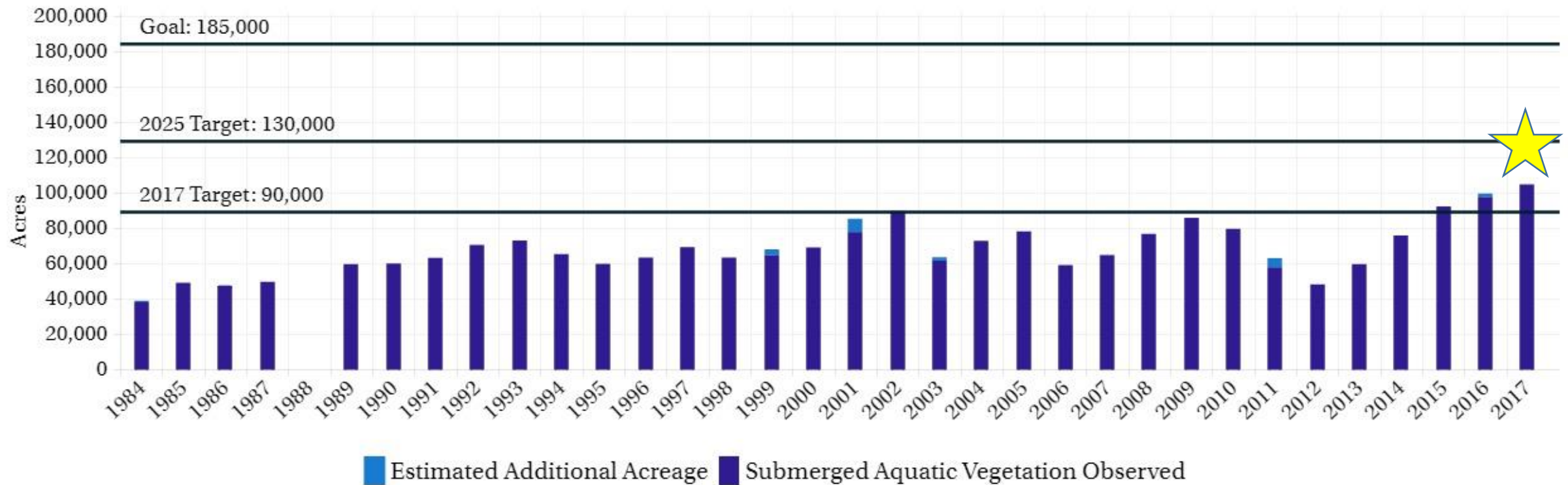


Good News!!!



104,843 Acres of SAV in the Bay in 2017!!

Submerged Aquatic Vegetation (SAV) Abundance (1984-2017)



Good News!!!

An underwater photograph showing a dense field of seagrass. The blades are long and thin, with some showing signs of damage or decay. The water is slightly murky, and there are some small bubbles or particles visible. The seagrass is growing in a sandy or silty substrate.

International Seagrass Biology Workshop 14 Maryland, 2020 'Signs of Success'

SAV Financing Strategy



#10 in our 2-Year Work plan: Work with the Chesapeake Bay Program's Budget and Finance Workgroup (BFWG) to create a financing strategy/system for all aspects of the SAV Management Strategy and 2-Year Work plan. Having a financial strategy/system in place will increase likelihood of reaching our ultimate SAV acreage goal through the protection and restoration of SAV in the Chesapeake Bay.

a. Report and Guidance document will be written by BFWG for implementation of SAV Outcome Finance Strategy

The BFWG is working to support the CBP partners by facilitating the workgroups in development of specific finance strategy/systems for the Management Strategies, outcomes, and biennial work plan action items.

Status Update: We had our third dialogue session with the BFWG (lead by Julie Winters and Dan Nees) and several banker/financial types in March.

Three avenues for funding were discussed: 1. Full cost pricing, 2. Mitigation banking (proactive restoration), and 3. creation of a third party recovery fund or endowment.

Take home: The financial sector wants to know exactly how much SAV is worth based on its ecosystem services (~\$220 million in 2016, Elliott Campbell). Need to relate nutrient sequestration capacity of SAV to TMDLs.

SAV Synthesis and Segment Analysis

Lead by JJ Orth and Bill Dennison



We assembled a diverse and talented scientific team



The Bay is changing, but SAV is an indicator and defender of water quality...a sentinel!



Overview Articles

Submersed Aquatic Vegetation in Chesapeake Bay: Sentinel Species in a Changing World

ROBERT J. ORTH, WILLIAM C. DENNISON, JONATHAN S. LEFCHECK, CASSIE GURBISZ, MICHAEL H. JENNIFER KEISMAN, J. BROOKE LANDRY, KENNETH A. MOORE, REBECCA R. MURPHY, CHRISTOPHER J. PATRICK, JEREMY TESTA, DONALD E. WELLER, AND DAVID J. WILCOX

Chesapeake Bay has undergone profound changes since European settlement. Increases in human and livestock populations, and in land use, increases in nutrient loadings, shoreline armoring, and depletion of fish stocks have altered the important habitats. Submersed aquatic vegetation (SAV) is a critical foundational habitat and provides numerous benefits and services to society. Bay SAV species are also indicators of environmental change because of their sensitivity to water quality and shoreline development. SAV has been deeply integrated into regional regulations and annual assessments of management outcomes. Restoration efforts, literature, and popular media coverage. Here, we review SAV in Chesapeake Bay from many historical and emerging challenges. Chesapeake Bay is indicated by and contingent on the success of SAV. Its persistence will require continued action, coupled with a healthy and sustainable ecosystem.

Keywords: SAV management, land use, climate change, water quality

Chesapeake Bay: 400 years of change

Chesapeake Bay is one of the largest and most important estuaries in the world. American history and much of the history of the Western world have been shaped by Chesapeake Bay. American growth and development have likewise transformed the Bay dramatically. Modern Europeans first settled the shores of Chesapeake Bay in 1607 in what is now Jamestown, Virginia. At their arrival, they encountered a well-established and highly organized population of around 14,000 indigenous people, the Algonquian-speaking Powhatan Indians. Now, over 400 years since European settlement, a population of more than 18 million people dominates the Chesapeake Bay watershed (CBP 2016), so it is not surprising that the Bay of today is very different from the Bay of 1607.

The name Chesapeake comes from the Algonquian word *Chic-se-potuck*, meaning "land along the big river." This big river had such a great wealth of natural resources that Captain John Smith, renowned early explorer, made special note of their abundance. Oysters, blue crabs, striped bass, and waterfowl were so plentiful that they supported much of the early population growth of this region. Crucial to the abundance of these species were important foundational habitats that provided food, refuge, and

nurseries, including submersed aquatic vegetation (SAV). Submersed aquatic vegetation was abundant in the Bay and its rivers at the time of the first European settlers (Hilgartner 2000, Lotze et al. 2006). These also protected shorelines from erosion, stabilized sediments, captured suspended solids, and large amounts of carbon and nitrogen (Rouse et al. 2012, Lefcheck et al. 2017). These ecosystem services increased in value as the human population on the Bay's shorelines and throughout its watershed (Lotze et al. 2005) and in the face of global threats to change (Najjar et al. 2010).

Humans have altered the landscape in many ways that have harmed the same resources that we rely on and rely on. Shorelines have been armored, they have been made eutrophic by nutrient pollution, and farm animals, and fisheries have been (Lotze et al. 2006, Beck et al. 2011, Gitman et al. 2012) of these factors have contributed to a decline in the services they provide. With a steadily increasing and new challenges continuing to arise, introduction of nonnative species, aquaculture change (figure 1), the management of Chesapeake Bay remains a prominent challenge in the twenty-first century.

BioScience 67: 698–712. © The Author(s) 2017. Published by Oxford University Press on behalf of the American Institute of Biological Sciences. All rights reserved. For Permissions, please email: journals.permissions@oup.com. doi:10.1093/biosci/bix015

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698 BioScience • August 2017

High heat and low light is bad for Zm, and it's going to lose us a lot of \$\$

Long-term nutrient reductions lead to the unprecedented recovery of a temperate coastal region

Jonathan S. Lefcheck^{1,2,3}, Robert J. Orth¹, William C. Dennison¹, David J. Wilcox⁴, Rebecca R. Murphy⁵, Jennifer Keisman⁶, Cassie Gurbisz^{1,4}, Michael Hanneman¹, J. Brooke Landry¹, Kenneth A. Moore⁷, Christopher J. Patrick¹, Jeremy Testa¹, Donald E. Weller⁸, and Richard A. Battali¹

¹Center for Ocean Health, Bigelow Laboratory for Ocean Science, East Boothbay, ME 04545; ²Department of Biological Sciences, Virginia Institute of Marine Science, The College of William & Mary, Gloucester Point, VA 23062; ³University of Maryland Center for Environmental and Estuarine Science, Cambridge, MD 21613; ⁴University of Maryland Center for Environmental and Estuarine Science, Chesapeake Bay Program Office, Annapolis, MD 21403; ⁵US Geological Survey, Baltimore, MD 21226; ⁶National Oceanic and Atmospheric Administration, Silver Spring, MD 20910; ⁷University of Maryland System, 30 Maryland College of Maryland, 30 Maryland College of Maryland, P.O. Box 38, Poolesville, MD 20854; ⁸US Environmental Protection Agency, Annapolis, MD 21403

Received 10 November 2016; revised 10 February 2017; accepted 10 February 2017

Human actions strongly impact the dynamics of coastal systems, yet surprisingly few studies mechanistically link management of anthropogenic stressors and successful restoration of nearshore habitats over large spatial and temporal scales. Such examples are rarely needed to ensure the success of ecosystem restoration efforts worldwide. Here, we unite 30 consecutive years of watershed modeling, biogeochemical data, and comprehensive aerial surveys of Chesapeake Bay, United States, to quantify the cascading effects of anthropogenic impacts on submersed aquatic vegetation (SAV), an ecologically and economically valuable habitat. We employ structural equation models to link land use change to higher nutrient loads, which in turn reduce SAV cover through multiple independent pathways. We also show through our models that high biodiversity of SAV consistently promotes cover, an unexpected finding that corroborates emerging evidence from other terrestrial and marine systems. Due to sustained management actions that have reduced nitrogen concentrations in Chesapeake Bay by 25% since 1984, SAV has regained 17,000 ha to achieve its highest cover in almost half a century. Our study empirically demonstrates that nutrient reductions and biodiversity conservation are effective strategies to aid the successful recovery of degraded systems at regional scales, a finding which is highly relevant to the utility of environmental management programs worldwide.

Subject terms: submersed aquatic vegetation, | seagrass | autotrophs | global change | ecosystem management

Significance

Human actions, including nutrient pollution, are causing the widespread degradation of coastal habitats, and efforts to restore these valuable ecosystems have been largely unsuccessful or of limited scale. We provide an example of successful restoration linking effective management of nutrients to the successful recovery of submersed aquatic vegetation along thousands of kilometers of coastline in Chesapeake Bay, United States. We also show that biodiversity conservation can be an effective path toward recovery of coastal systems. Our study validates 30 years of environmental policy and provides a road map for future ecological restoration.

Author contributions: J.S.L., R.J.O., W.C.D., D.J.W., R.R.M., and J.B.L. designed research; J.S.L., R.J.O., W.C.D., D.J.W., R.R.M., and J.B.L. performed research; J.S.L., R.J.O., W.C.D., D.J.W., R.R.M., and J.B.L. analyzed data and wrote the paper. All authors contributed to the writing of the paper.

The authors declare no conflict of interest.

This article is a U.S. Government work and, as such, is in the public domain in the United States of America.

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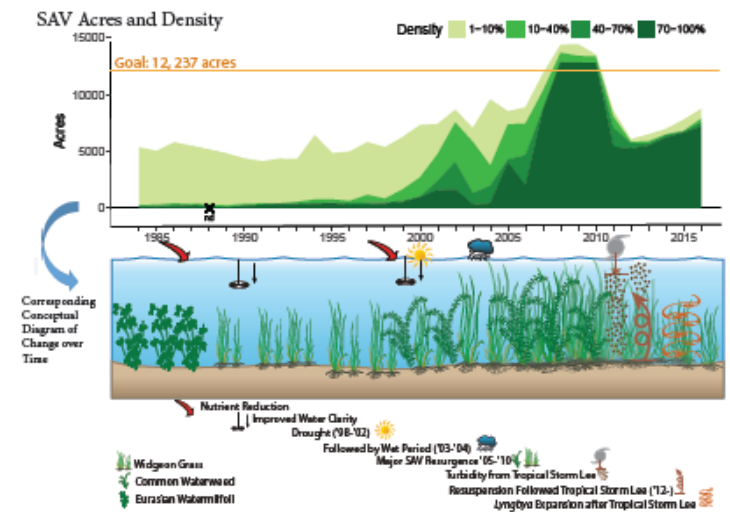
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SAV Segment: Susquehanna Flats (CB1 TF2 and NORTF)

Current expansive freshwater SAV beds in the Upper Chesapeake Bay near Havre de Grace.

Executive Summary

Historic SAV beds that supported migrating waterfowl populations were decimated by 1972 through dominance of millfed that outcompeted native species and Tropical Storm Agnes that resulted in large amounts of sediments and nutrients that smothered existing SAV. Following two decades of minimal to no recovery, SAV beds on the Susquehanna Flats began recovering due to reductions in total nitrogen and improving water clarity, achieving the restoration goals in this segment by 2008 and attained it through 2010. Tropical Storm Lee and the accompanying residual turbidity reduced the coverage below the restoration goal, but steady recovery has been facilitated by the dense, resilient SAV beds that persisted after Tropical Storm Lee.



Take Home Points

1. Goal attainable
2. Historic coverage: Changing patterns
3. Key events: Tropical Storm Agnes, Resurgence 2005-2010, Tropical Storm Lee
4. Vulnerability/Resilience: Diversity and Resilience, Resuspension, Lyngbya
5. Management implications: Conowingo Dam, water clarity, nitrogen loads



Global Change Biology (2017), doi:10.1111/gcb.13629

Multiple stressors threaten the imperiled coastal foundation species eelgrass (*Zostera marina*) in Chesapeake Bay, USA

JONATHAN S. LEFCHECK^{1,2,3}, DAVID J. WILCOX⁴, REBECCA R. MURPHY⁵, SCOTT E. MARION⁶, and ROBERT J. ORTH¹
¹Virginia Institute of Marine Science, The College of William & Mary, Gloucester Point, VA 23062, USA; ²University of Maryland Center for Environmental and Estuarine Science, Chesapeake Bay Program, Annapolis, MD 21403, USA; ³Oregon Dept. of Wildlife, Marine Resources Program, Newport, OR 97135, USA

Abstract

Interactions among global change stressors and their effects at large scales are often proposed, but are rarely tested. This situation is primarily due to lack of comprehensive, sufficiently long-term, and spatially explicit data. Seagrasses, which provide nursery habitat, improve water quality, and constitute a globally important sink, are among the most vulnerable habitats on the planet. Here, we unite 31 years of high-resolution toting and water quality data to elucidate the patterns and drivers of eelgrass (*Zostera marina*) abundance in Chesapeake Bay, USA, one of the largest and most valuable estuaries in the world, with an unparalleled regulatory effort. We show that eelgrass area has declined 29% in total since 1981, with wide-ranging ecological and economic consequences. We go on to identify an interaction between decreasing water warming temperatures as the primary drivers of this trend. Declining clarity has gradually reduced the past two decades, primarily in deeper beds where light is already limiting. In shallow beds, however, visibility exacerbates the physiological stress of acute warming, leading to more instances of dieback. While degraded water quality has long been known to influence underwater grasses, we provide a clear and rapidly emerging interaction with climate change. We highlight the urgent need a broader perspective into local water quality management, in the Chesapeake Bay and in the many other estuaries facing similar stresses.

Keywords: climate change, eutrophication, global warming, nutrients, remote sensing, seagrass

Received 24 October 2016 and accepted 19 December 2016

Introduction

Identifying the drivers of environmental change and predicting their consequences is the preeminent scientific challenge of the Anthropocene (Hajdu et al. 2000). Marine systems in particular are experiencing rapid and often irreversible alterations as a consequence of human activities (Lotze et al. 2006), and almost half of these changes can be attributed to multiple drivers (Lotze et al. 2006, Halpern et al. 2008). Despite the increasing recognition that global and local stressors often act jointly, rigorous empirical examples of this phenomenon are lacking at the large scales relevant to both the observed change and human well-being. This absence is particularly striking for temperate coastal ecosystems, which, historically, support much of the world's human population. Instead, most of our understanding of coastal change comes from small-scale experiments and observations (Crain et al. 2008, 2009). Correspondence: Jonathan S. Lefcheck, tel. +1 804 644 7150, fax +1 804 644 7097, e-mail: jle@chesapeakebay.edu

or from tropical systems such as coral reefs (e.g., 2008; D'Elia et al. 2012). This knowledge impedes our ability to predict a variety of global change on key population particularly given the fact that stressors, and management actions, often occur at much larger scales. Seagrasses in particular are extremely global change, with losses exceeding 25% in just the last century (Orth et al. 2011, 2012). Because of its global distribution, major anthropogenic influences, and its forming monospecific stands in shallow coastal systems (*Zostera marina*) is actively vulnerable to numerous stressors (Waycott et al. 2009). Consequently, it has experienced declines worldwide, including in northern Europe (1990; Frederiksen et al. 2004), the Atlantic (Boon & Short, 2009; Cappelletti et al. 2011), and the western coast of the USA, San Francisco Bay (Short & Wyllie-Echeverria, 2008). However, though, has eelgrass experienced declines



2018 GIT Funded Projects

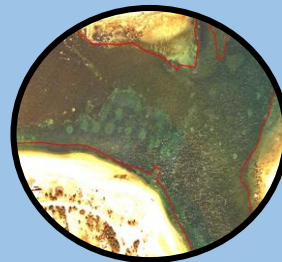
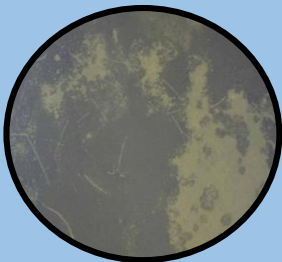
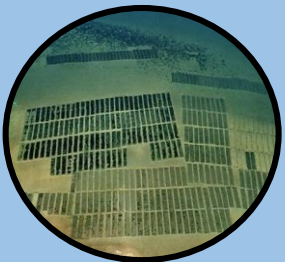
1. Development of Citizen Scientist SAV Monitoring Protocol/Manual and Training/Certification Program

GIT Lead: Brooke Landry, Contracted to UMCES, IAN



2. Review of Statutes and Regulations that Protect SAV in the Bay

GIT Lead: Becky Golden, Contracted to the Chesapeake Legal Alliance



Review of Statutes and Regulations that Protect SAV in the Chesapeake Bay



GIT Lead: Becky Golden, Contracted to the Chesapeake Legal Alliance

- **Funding requirement:** \$25,000 for one year
- Objectives
 - Review statutes & regulations currently in place to protect existing SAV
 - Determine if these regulations are adequate to protect existing & expanding SAV
 - Recommend language to the CBP for new statutes and regulations and/or recommend language for changes to current regulations
- Deliverables:
 - Mid-point progress report and electronic copy of database on or before August 17th
 - Draft report w/ summary and recommendations, including draft legislative language on or before January 15th, 2019
 - Presentation of findings and recommendations at Spring SAV Workgroup



SAV Survey Design: Dave Wilcox



SAV Survey Design: Dave Wilcox



March 2017. SAV Aerial & Ground Survey Design Workshop

Objectives: to reach agreement on...

- The collective management, regulatory and research needs for and uses of data and information generated by the SAV aerial and ground surveys
- A set of aerial and ground survey design options which maximize addressing the Partnership's collective data and information needs
- A more diverse funding partners' portfolio to recommend to the Partnership.

SAV Survey Design: Dave Wilcox



March 2017. SAV Aerial & Ground Survey Design Workshop

Design Options:

1. Existing survey design with no modifications
2. Existing survey design but upgrading to a semi-automated imagery processing routine
3. Collecting baywide annual imagery but only processing regions of the Bay annually with the entire Bay being mapped every three to four years
4. Collecting baywide imagery but only processing a statistically random subset

SAV Survey Design: Dave Wilcox



Statistical Subsampling Effort

- Dong Liang, UMCES CBL

- Evaluate statistical sub-sampling strategies to further improve the cost efficiency of the aerial survey design.
- Use the long term SAV database as ground truth to estimate the accuracies of the design options.
- Identify the most efficient sub-sampling procedure that maintains the core functions of the SAV data.

SAV Survey Design: Dave Wilcox



Statistical Subsampling Effort

- Dong Liang, UMCES CBL

- Sampling around 1,000 cells (10 m² in size) within a segment can estimate total cover within 1.5% - 2.5%.
- Sampling around 2,000 cells (10 m² in size) within a segment can estimate segment-specific SAV presence and absence with an accuracy of 85% - 92%.
- Cautions
 - Cost estimates undetermined
 - Accuracies are likely optimistic given implementation constraints
 - Large errors can occur with expansion of SAV into new areas

SAV Survey Design: Dave Wilcox



Researching and Implementing Remote Sensing Methods to Automate and Facilitate the Chesapeake Bay Annual SAV Monitoring Project

VIMS will employ a post doctoral associate to:

- Identify and implement automated aerial triangulation and orthorectification methods.
- Evaluate available benthic remote sensing tools and methods for classifying SAV in a turbid estuary using annual multispectral imagery and available ancillary data. Develop automated classification methods to facilitate and improve the annual Chesapeake Bay SAV monitoring project.

SAV Workgroup Research Prioritization



SAV Workgroup Research Prioritization



#14 in our 2-Year Work plan: Prioritize research topics based on current gaps in knowledge regarding SAV restoration, recovery, and resilience. Use recent synthesis efforts and information (ie. TS III and SAV Syn) to guide discussion and prioritization.

a. Facilitate inter-agency working session to prioritize research topics

SAV Workgroup Research Prioritization



#14 in our 2-Year Work plan: Prioritize research topics based on current gaps in knowledge regarding SAV restoration, recovery, and resilience. Use recent synthesis efforts and information (ie. TS III and SAV Syn) to guide discussion and prioritization.

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But first, we need a list of
things *to prioritize....*

SAV Workgroup Research Prioritization



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But first, we need a list of things *to prioritize....*

NOTE: GIT
Funding proposals
are due soon, so
project ideas are
welcome!



Gaps identified in the most recent MStrat

- *Watershed Impacts on SAV.* Determine the extent to which processes and impacts on adjacent watersheds influence SAV survival and growth. Assess impact of watershed improvements on SAV.
- *Succession.* Determine whether success rate increases if a primary colonizing SAV species is planted first, followed by a climax species (e.g., *Ruppia* followed by *Zostera*).
- *Species diversity.* Determine the conditions under which planting multiple species in the same location are likely to increase the chances of population survival.
- *Reconciliation ecology.* Identify and select species with characteristics that maximize ecological function.
- *Genetic Diversity.* Determine the condition under which planting multiple genotype and locally adapted genotypes are likely to increase chances of population survival.



Gaps identified in the most recent MStrat

- *Propagule choice.* For species that grow well from two or more types of propagules, such as seeds and whole shoots, determine which propagule choice is the most cost-effective under different conditions, comparing total planting cost to the survival rate.
- *Propagule transport modeling.* Determine connectivity among source beds that act as source of seed material over varying spatial scales.
- *Size.* Define the ideal size of restoration plots to maximize success (further understanding the role of small sub-pops).
- *Density and Pattern.* Determine at what density and spatial arrangement SAV should be planted to maximize growth and survival.
- *Exclosures.* Determine whether the physical protection of plantings (and naturally recovering populations) results in significantly improved survivorship and the spread of individuals in a population.



Gaps identified in Tech Syn III

SAV and feedback processes: Implications for restoration and resilience

- SAV habitat requirements were largely derived using data collected near existing beds. However, already established beds can, in theory, withstand worse conditions than a recovering bed because of self-stabilizing feedbacks. Therefore, recovering SAV beds may require more stringent habitat requirements than those established for existing SAV beds. Further analysis is needed to explore this possibility. **Research project: Determine habitat requirements for recovering SAV beds rather than existing beds.**

The role of genetics and connectivity in the restoration of SAV beds

- Regarding genetics, there are still important gaps in our knowledge: most studies have focused on marine species, and moreover most of those have focused on just a few species (particularly *Z. marina*). **Research Project: Genetic and connectivity studies on fresh and brackish water species.**

Effects of land use and shoreline armoring on SAV

- Further research is needed to understand the impacts of different living shorelines on SAV compared to riprap, bulkhead, and natural shoreline. **Research Project: comparison study similar to natural vs. riprapped study by Landry and Golden 2017** changes in SAV communities.



Gaps identified in Tech Syn III

21st century climate change and SAV in the Chesapeake Bay

- If the current trajectory of climate change continues, warming may eliminate eelgrass populations and favor heat-tolerant species such as widgeon grass. A variety of subtropical plants and animals are likely to become more common in the region. **Research Project: transplant experiment using the sub-tropical species, shoal grass (*Halodule wrightii*)**
- Sea level rise will reshape our shorelines. Where they are permitted to migrate landward, suitable SAV habitat may persist. However, where shorelines are hardened, suitable SAV habitat is likely to be lost. **Research Project: We have requested that STAR work on an SAV habitat forecasting map which will combine SLR projections with current shoreline hardening and nearshore land use maps to determine how much soft bottom habitat will be available for SAV in the future. If they don't pursue this topic, we should...**
- Climate change predictions regarding SAV are limited by a poor understanding of the indirect effects of climate change on organisms associated with SAV die-offs (fouling organisms, grazers, microbes). These indirect effects may trigger abrupt, unforeseen changes in SAV communities. **Research Project: Several projects here.**

SAV Sentinel Sites



SAV Sentinel Sites



#6c in our 2-Year Work plan: Monitor SAV throughout the Bay.

c. Establish SAV Sentinel sites throughout the Bay for annual monitoring by CBP partners and volunteers. Sentinel sites may include current long-term monitoring sites. Sites will be established at next SAV Workgroup meeting.

Location

-

Partners

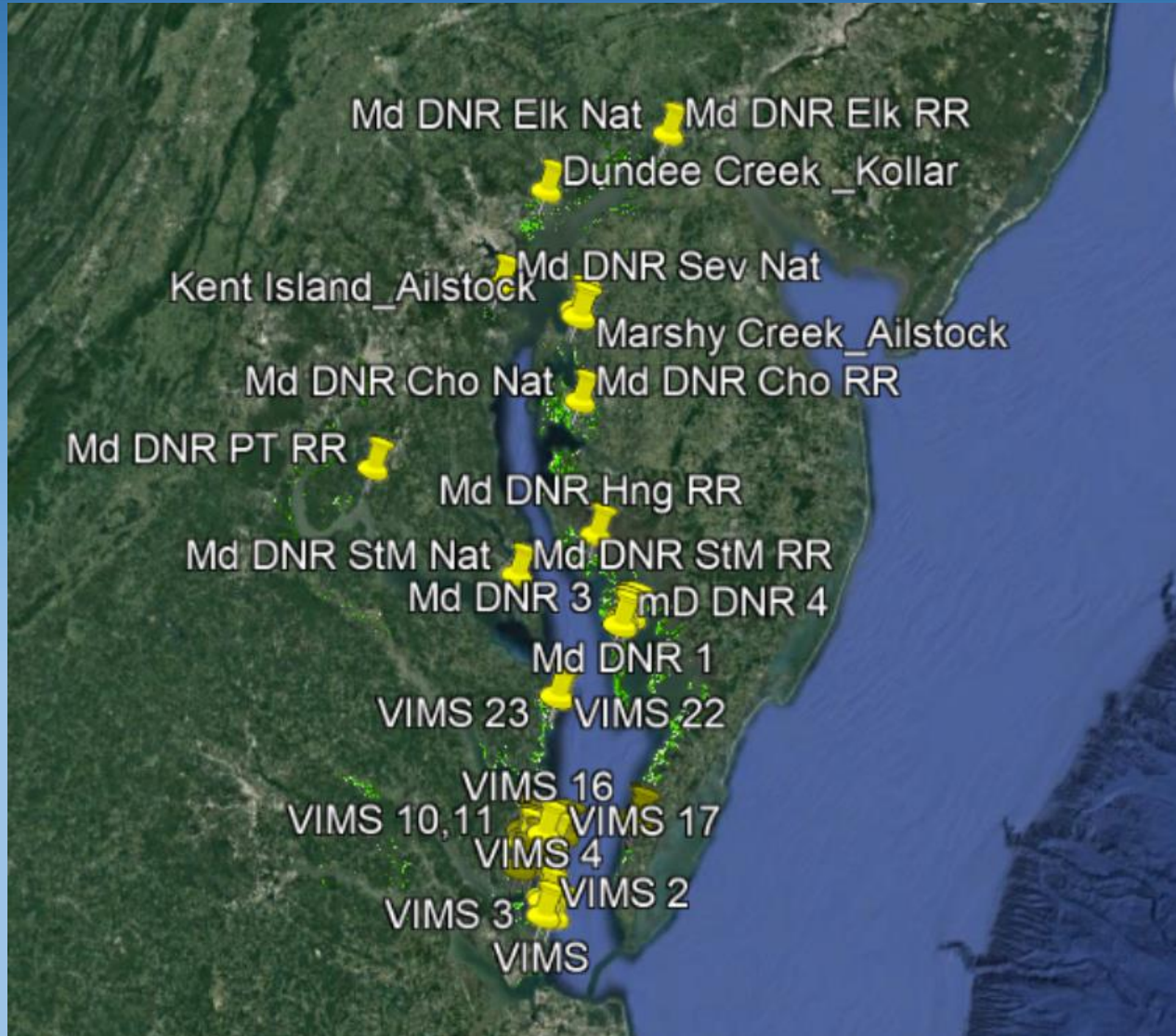
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Protocol



SAV Sentinel Site - Locations

VIMS has about 23 long-term sites clustered in Mobjack Bay and vicinity, some on Eastern shore



DNR has about 10 sites throughout Maryland (4 on Smith Island)

Others recommended:
Susquehanna Flats
Kent Island
Dundee Creek

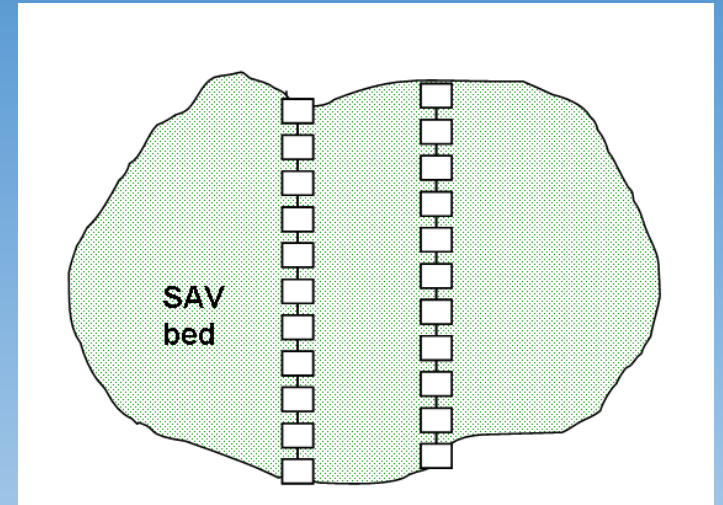
Where else???



SAV Sentinel Site - Protocol

VIMS – SAV % cover (total and by species) every 10 meters for the length of the bed in a 1m² quadrat.

DNR - SAV % cover (total and by species) in a 0.25m² quadrat every X meters depending on length of bed. Also record shoreline type, canopy height, depth, and epiphyte presence at each quad. Paired transects.





SAV Sentinel Site – Adopt a Sentinel

We need partners and volunteers to commit to annual monitoring of the sentinel sites decided upon.....

VIMS ☒

DNR ☒

