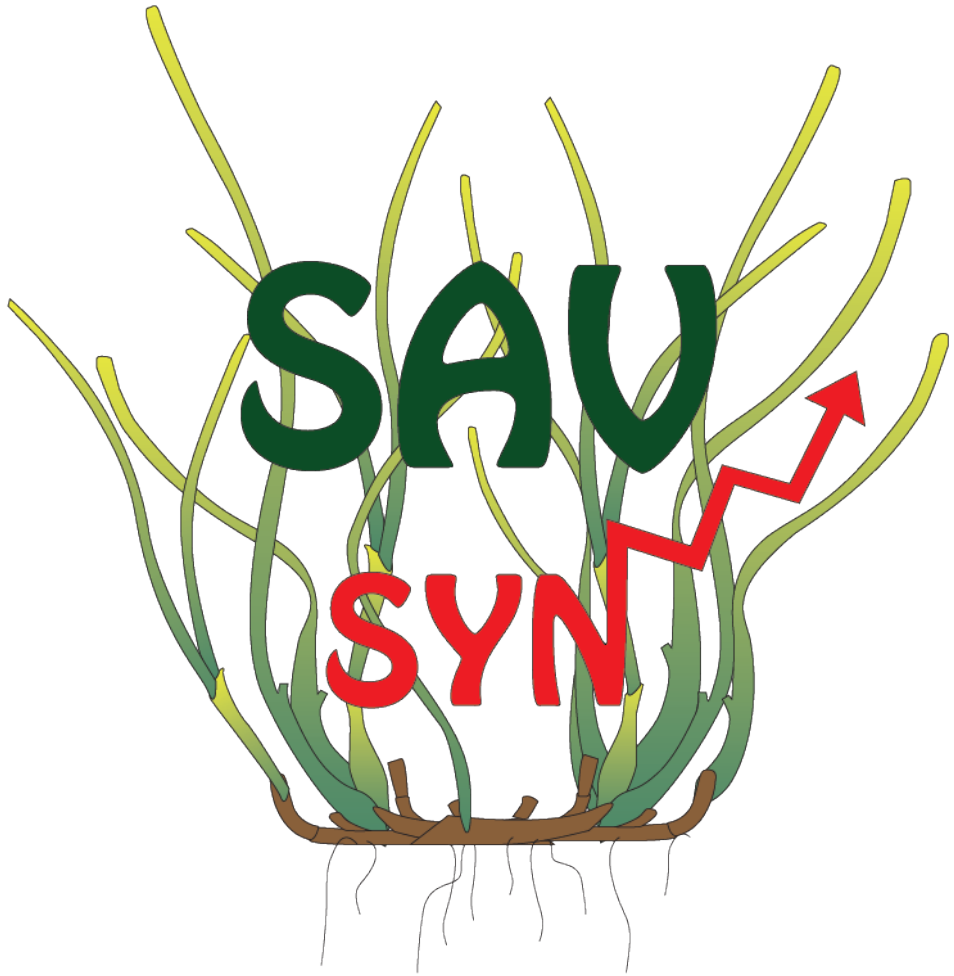
SAV Synthesis process and results

Bill Dennison

University of Maryland
CENTER FOR ENVIRONMENTAL SCIENCE
INTEGRATION AND APPLICATION NETWORK

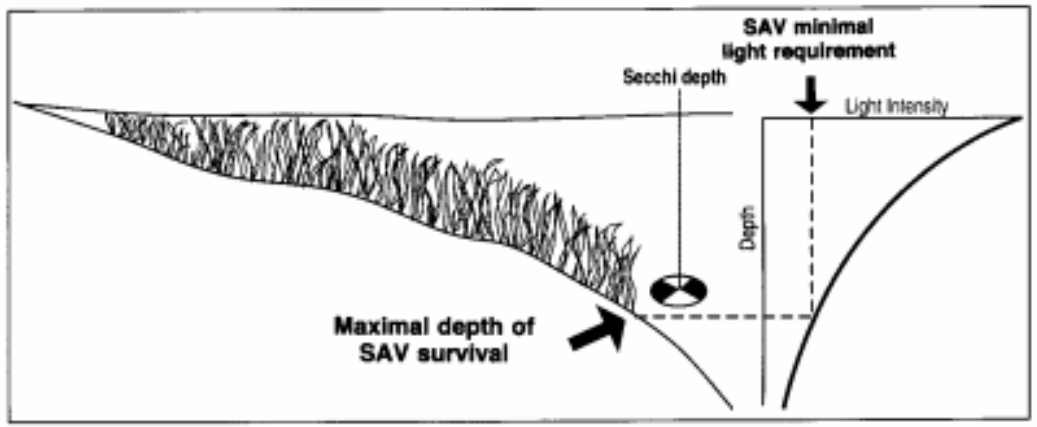


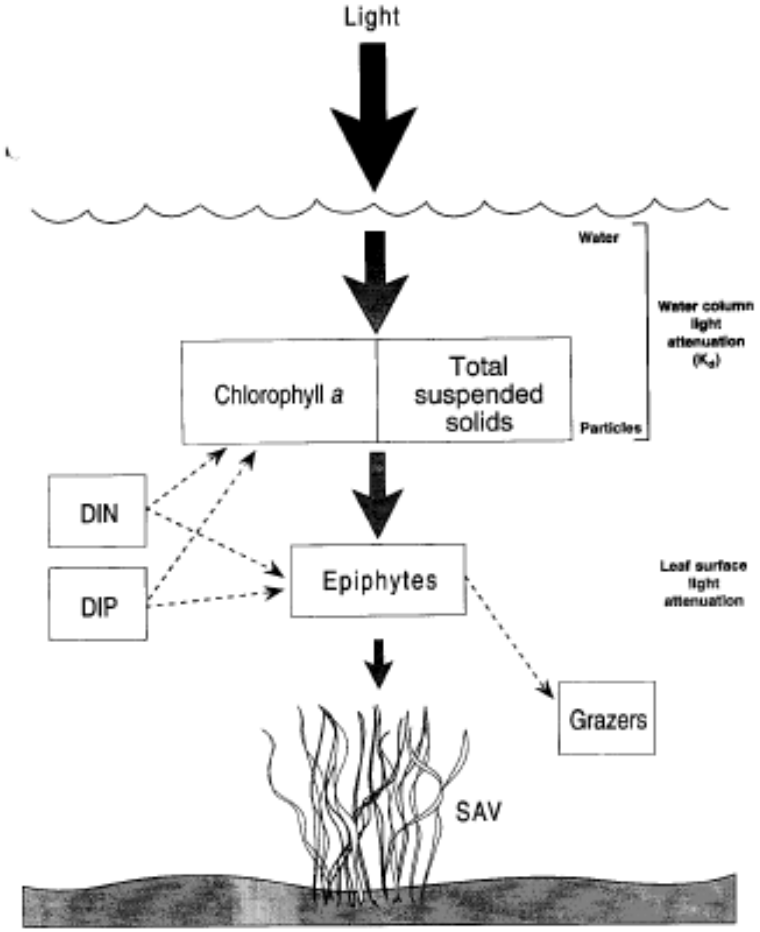
Initial SAV synthesis (1993)

Assessing Water Quality with Submersed Aquatic Vegetation

Habitat requirements as barometers of Chesapeake Bay health

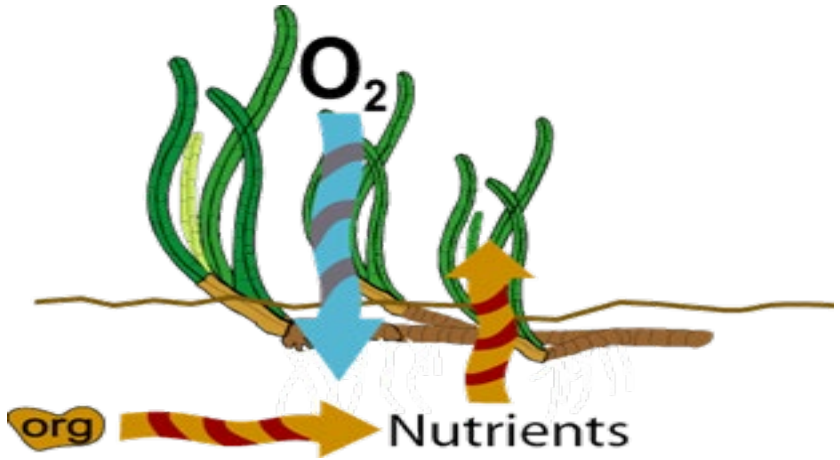
William C. Dennison, Robert J. Orth,[1] Kenneth A. Moore, J. Court Stevenson, Virginia Carter, Stan Kollar, Peter W. Bergstrom, and Richard A. Batiuk





Seagrasses = canary in mine shaft for global coastal impacts

Plant	Min. light requirement (% of surface)
Seagrasses	**10-30%**
Phytoplankton	0.5-1.0
Green algae	0.05-1.0
Brown algae	0.7-1.5
Red algae	0.0005

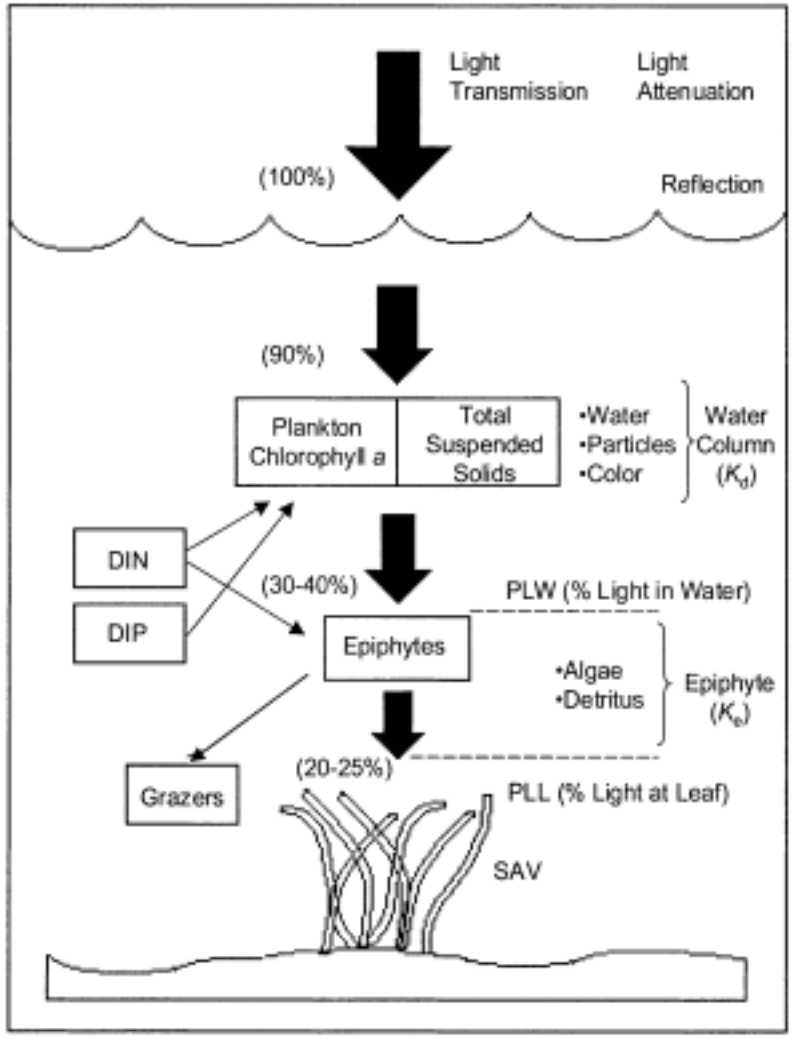


Second SAV synthesis (2004)

Estuaries Vol. 27, No. 3, p. 363–377 June 2004

Habitat Requirements for Submerged Aquatic Vegetation in Chesapeake Bay: Water Quality, Light Regime, and Physical-Chemical Factors

W. Michael Kemp[1,*], Richard Batiuk[2], Richard Bartleson[1], Peter Bergstrom[3], Virginia Carter[4], Charles L. Gallegos[5], William Hunley[6], Lee Karrh[7], Evamaria W. Koch[1], Jurate M. Landwehr[4], Kenneth A. Moore[8], Laura Murray[1], Michael Naylor[7], Nancy B. Rybicki[4], J. Court Stevenson[1], and David J. Wilcox[8]

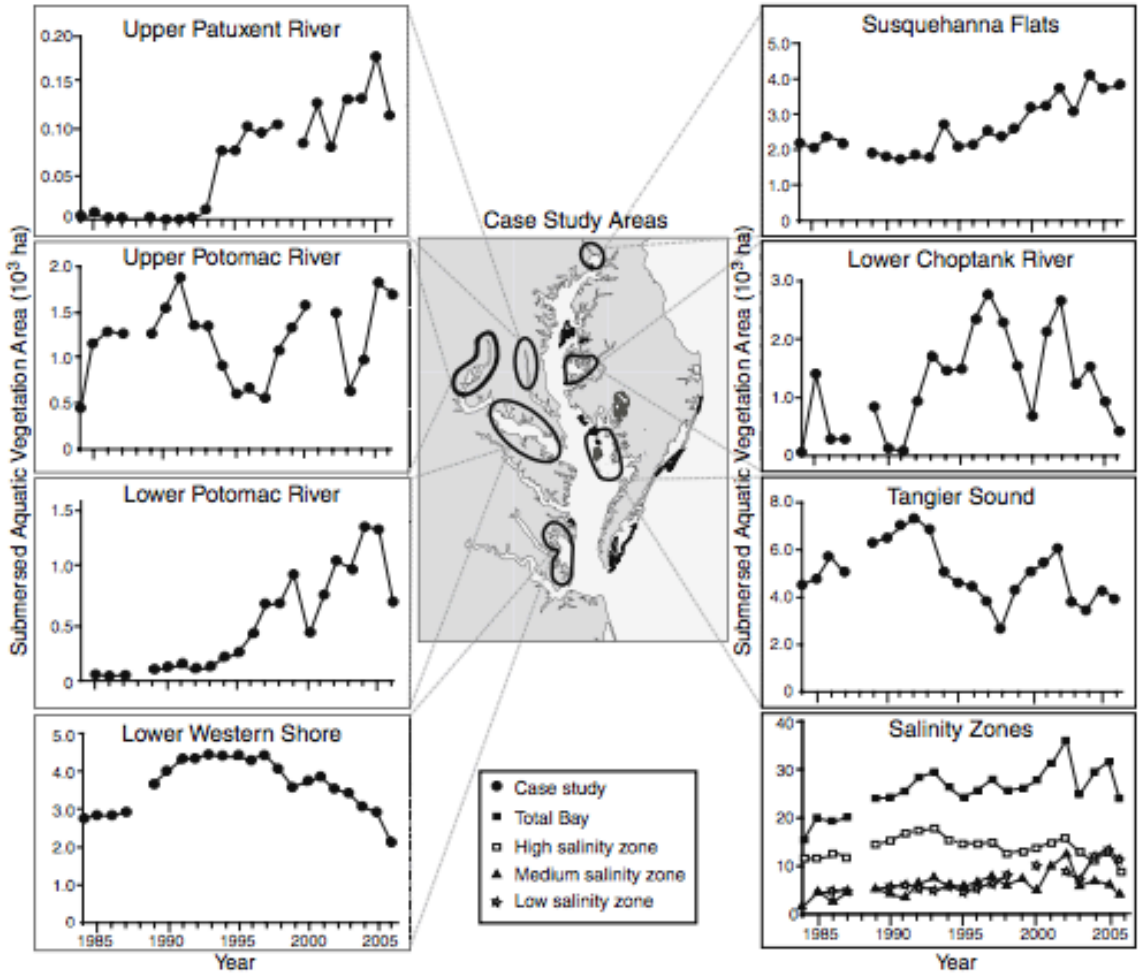


Third SAV synthesis (2010)

Estuaries and Coasts (2010) 33:1144–1163
DOI 10.1007/s12237-010-9311-4

Long-Term Trends in Submersed Aquatic Vegetation (SAV) in Chesapeake Bay, USA, Related to Water Quality

Robert J. Orth · Michael R. Williams · Scott R. Marion · David J. Wilcox · Tim J. B. Carruthers · Kenneth A. Moore · W. Michael Kemp · William C. Dennison · Nancy Rybicki · Peter Bergstrom · Richard A. Batiuk



Rich's wish list

Management Relevant Outcomes from the Chesapeake Bay SAV Trends Analysis and Synthesis

Updated May 8, 2017

In the forthcoming development of the Phase III Watershed Implementation Plans, we have a truly unprecedented opportunity to help hundreds of local partners lay out their commitments to do their fair share of the larger Chesapeake Bay restoration. Those local partners need to understand what that fair share is and how will it benefit their local streams, rivers, and tidal habitats. We must put the results of these SAV trend analyses into as local of a context as possible. Therefore, ~~these~~ for segment profiles.

- Temporal scope
  - Early 1970s through 2016
  - If data from the 1930s-1960s can help put the trends into perspective, we should bring that data into the trend analyses

- Spatial scope
  - ~~Bayside~~
  - Three region salinity based zones
  - **92 Chesapeake Bay Program segments**
  - Additional CBP segments' sub-segments for purposes of SAV/water clarity water quality standard attainment assessment: Susquehanna Flats (CB1TF), Gunpowder River, Patuxent River, Potomac River, James River, Elk River, Sassafras River, Tangier Sound, ~~Manokin~~ River, and Big ~~Annemessex~~ River[1]

- Data to be included in the trends analyses
  - ~~Bayside~~ SAV aerial survey data: 1984-2016
  - ~~Bayside~~ and Regional SAV aerial survey data: 1971-1983
  - Maryland SAV Ground Survey data: 1971-1997
  - VIMS ground survey data collective from various sources over the years
  - Chesapeake Bay ~~Maintem~~ and Tidal Tributary Water Quality Monitoring Program data
  - USGS Ground Survey data in the Potomac River
  - Chesapeake Bay Shallow Water Monitoring Program data

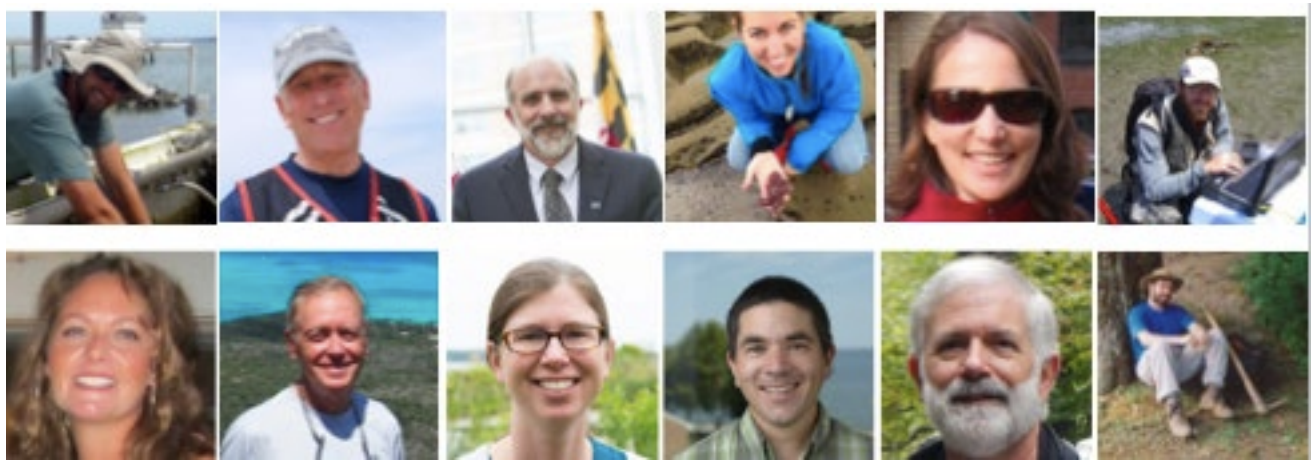
- Trends to be analyzed
  - Acreage
  - Bed density
  - Species coverage through time
  - Explanatory variables (temperature, salinity, water clarity, N concentrations, P concentrations, TSS, chlorophyll *a*, others)
  - Shoreline condition (hardened, natural, living shoreline)
  - Surrounding land cover/land uses
  - Long term precipitation records

[1] U.S. EPA. 2004. Technical Support Document for Identification of Chesapeake Bay Designated Uses and Attainability—2004 Addendum

- Regional, salinity regime, and river basin-specific descriptions of trends and their explanatory variables

- Segment-specific SAV trend profiles including the following to the extent the available data and professional judgment will allow:
  - Graphical illustration and accompanying narrative description of the long term acreage trends compared with the CBP segment specific SAV restoration acreages adopted by each state into the state's water quality standards regulations
  - Narrative description/graphical illustration of trends in SAV bed density and species diversity over time and implications for eventual achievement of the segment's acreage restoration target
  - Narrative description/graphical illustration of trends in water quality within the segment
  - If the segment has a state established sub-segment/sub-segments, develop narrative and graphical illustrations of the above three sub-bullets
  - Is there a definable trend or sequence of trends in SAV acreage, bed density and species diversity over 1970s through 2015 timeframe?
  - How do these observed trends compare with the desired level of SAV bed density associated with persistence over time even in the face of poor water quality years?
  - How do these observed trends in species diversity over compare with the species restoration goals/targets published in the first SAV technical synthesis?
  - Can these observed trends be explained over time by one or more of the analyzed explanatory variables?
  - Has the segment hit a 'glass ceiling' and does not seem able to expand its SAV bed coverage due to explained or unexplained factors?
  - What further changes in the explanatory variable(s) are necessary to support continued expansion of the SAV beds and increases in their density towards established goals and targets?
  - What specific management actions including but beyond 'further reductions in loads of nitrogen, phosphorus and sediment' need to be taken in order to increase the probability for eventual achievement of that segment's assigned SAV restoration acreage goal?
  - Is the segment on a trajectory to achieve its SAV restoration acreage goal within the next 5 years? 10 years?
  - Is the segment on a trajectory to never achieve its SAV restoration acreage goal? If so, what factor or factors are behind this conclusion? Should the state seriously consider modifying its water quality standards as a result of this finding?

The SAV team response:



The distilled version of Rich's wish list:

1. What are the long term SAV trends in Chesapeake Bay?

2. How are the trends related to human activities?

Criteria for selecting participants

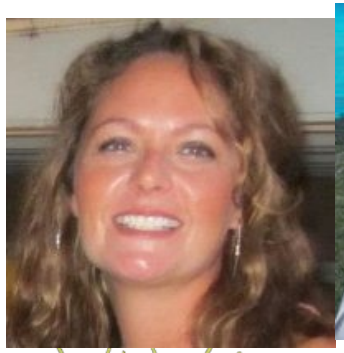
- Excellent scientists
- Focus on analysis and interpretation
- Commitment to Chesapeake Bay
- Willingness to work collaboratively towards a common cause

SAV Synthesis team members











SAV workshop goals

Productive

Workshop summary produced, bookmarks event, document progress

Interactive

Activities & breakouts lead to input & exchange

Condensed

Workshops limited to necessary conta hours

Participatory

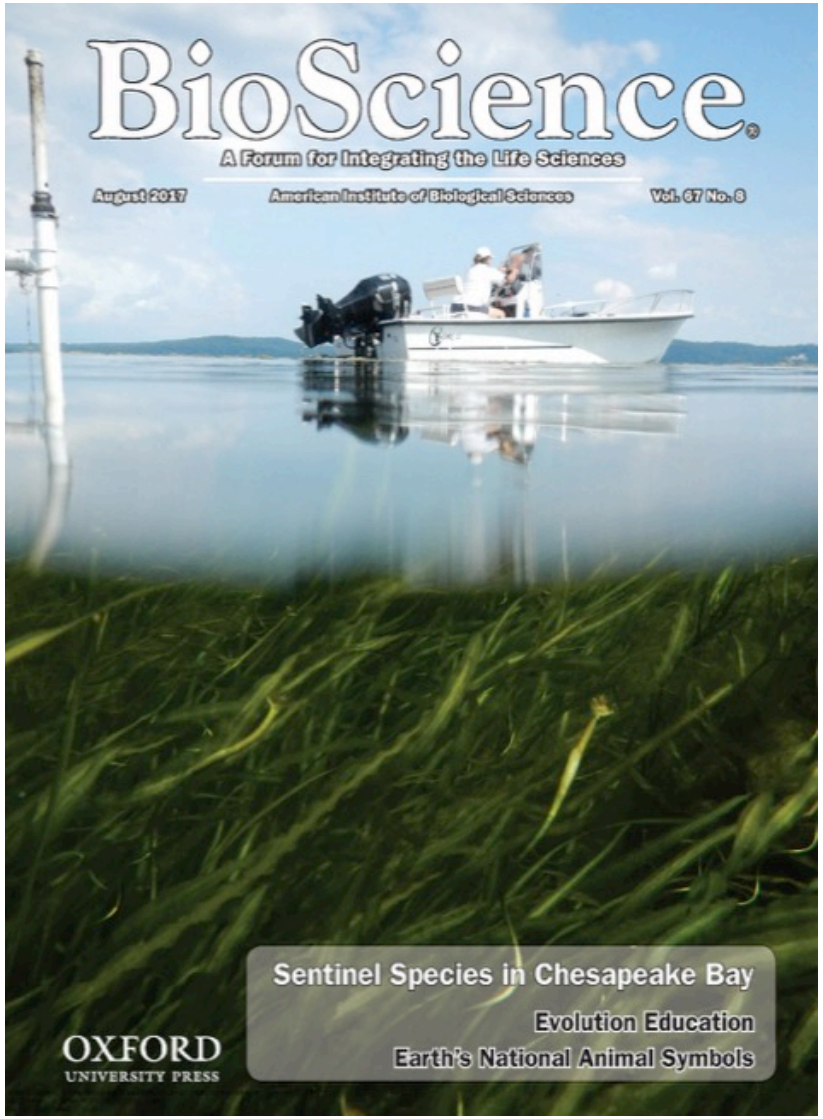
Multiple opportunities for input

SAV Fun

Initial qualitative paper: Bioscience

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

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



Case study: Eelgrass decline due to climate change

Global Change Biology

Global Change Biology (2017) **23**, 3474–3483, doi: 10.1111/gcb.13623

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

JONATHAN S. LEFCHECK[1], DAVID J. WILCOX[1], REBECCA R. MURPHY[2], SCOTT R. MARION[3] and ROBERT J. ORTH[1]

[1]*Virginia Institute of Marine Science, The College of William & Mary, Gloucester Point, VA 23062, USA,* [2]*University of Maryland Center for Environmental Science, Chesapeake Bay Program, Annapolis, MD 21403, USA,* [3]*Oregon Department of Fish & Wildlife, Marine Resources Program, Newport, OR 97365, USA*

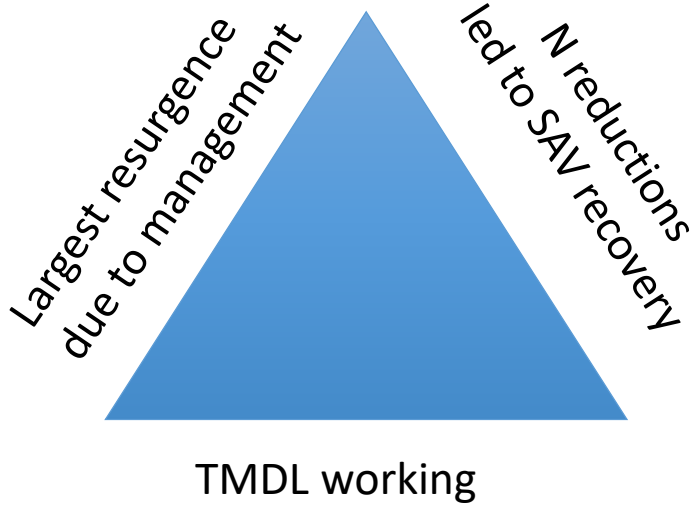
Abstract

Proc. Natl. Acad. Sci.

Nutrient reductions lead to unprecedented recovery of a temperate coastal ecosystem

Jonathan S. Lefcheck[1,2*], Robert J. Orth[2], William C. Dennison[3], David J. Wilcox[2], Rebecca R. Murphy[4], Jennifer Keisman[5], Cassie Gurbisz[6,7], Michael Hannam[8,9], J. Brooke Landry[10], Kenneth A. Moore[2], Christopher J. Patrick[11], Jeremy Testa[12], Donald E. Weller[8], Richard A. Batuik[13]

Media push: National Press Club visit



Large media coverage

Energy and Environment

The Chesapeake's 'secret garden' is thriving again, but Trump could end that

By Darryl Fears March 5 Email the author

Eelgrass in the Chesapeake Bay in summer 2017. (Photo by Jon Lefcheck)

The Post's View • Opinion

Why the Chesapeake Bay is the best in the world

THE CONVERSATION

Academic rigor, journalistic flair

Search analy

Arts + Culture Economy + Business Education Environment + Energy Ethics + Religion Health + Medicine Politics + Society Science + Technology

Cutting pollution in the Chesapeake Bay has helped underwater grasses rebound

March 5, 2018 3.15pm EST

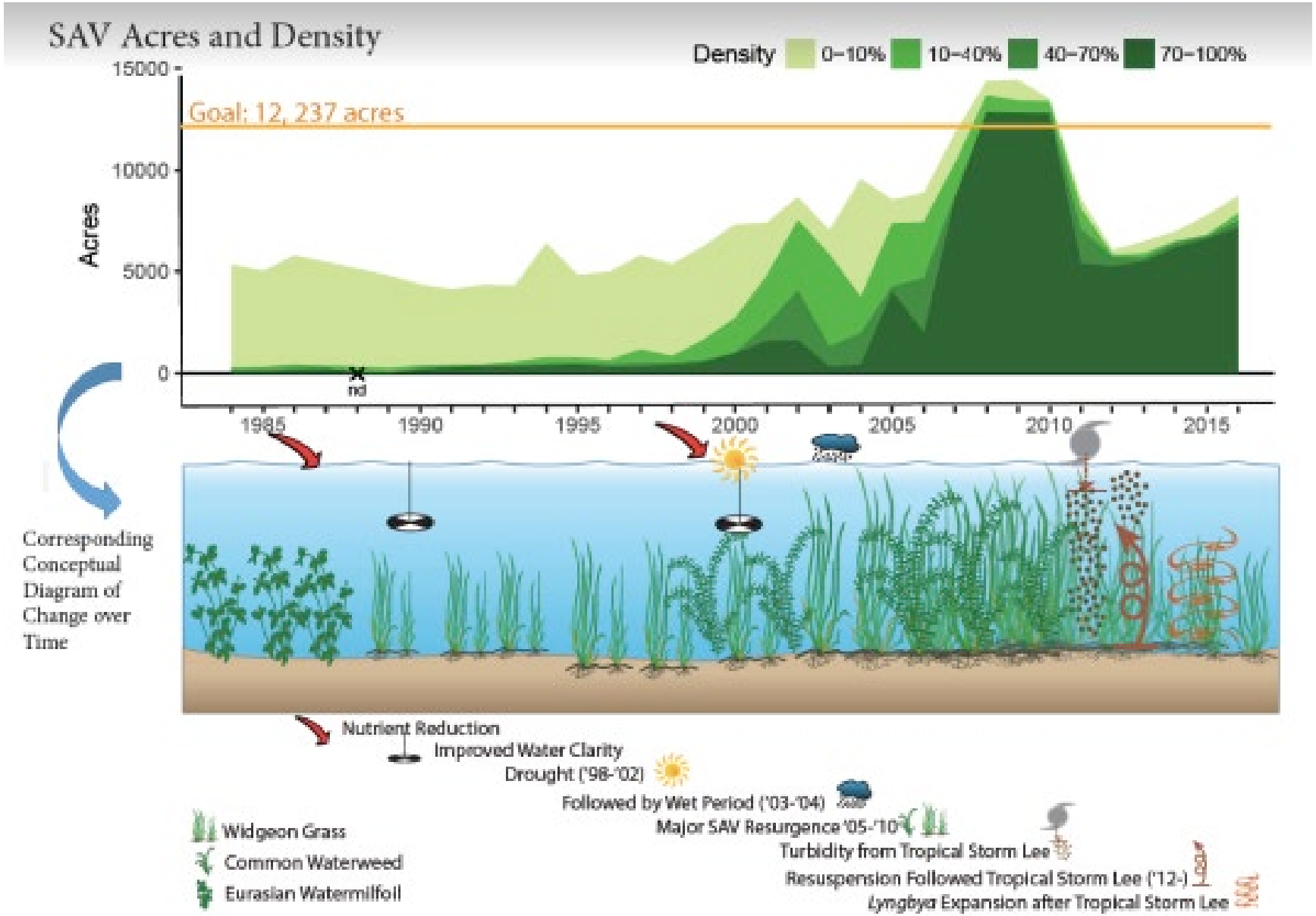
Washington Post editorial supporting Chesapeake Bay Program

56 M people exposed to story via traditional and social media

Fact sheets targeted for resource managers

- Specific data & recommendations for each region
- Time course & conceptual diagrams for each region
- Take home points; short summaries linked to data
- Overall stoplight color scheme used

Susquehanna Flats example

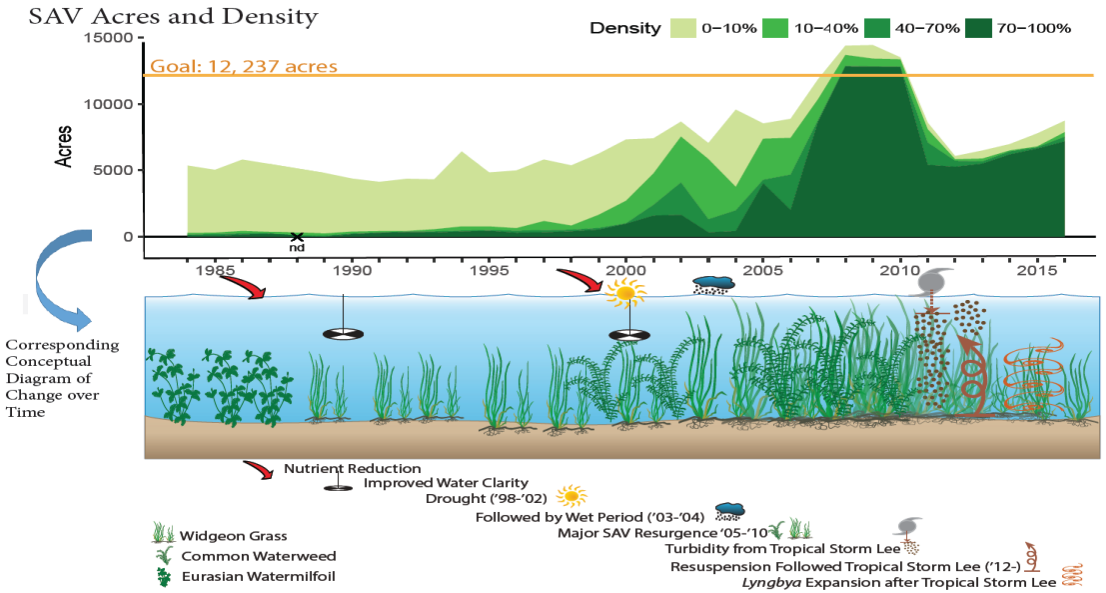


SAV Segment: Susquehanna Flats (CB1TF2 and NORTF)

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 milfoil 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

Attainable: Goal has/had been reached

Attainable: Goal can be reached

Potentially Attainable: with water quality improvement

Potentially Attainable: with significant water quality improvements

Unlikely Attainable

Take Home Points SAV Segment Susquehanna Flats (CB1TF2 and NORTF)

Goal is attainable

The goal of 12,237 acres was achieved from 2008-2010, following a decade of increasing of improving water quality, reduction in total nitrogen, and expanding SAV. In September 2011, Tropical Storm Lee led to the second highest flow amount recorded from the Susquehanna River at the Conowingo Dam, resulting in high turbidity in the upper bay, and causing a decline of SAV primarily at the deeper sections of the SAV beds.

Historic coverage

Changing Patterns

This region historically supported a dense, diverse SAV assemblage which provided habitat for a myriad of migratory waterfowl. The Susquehanna Flats was the premier wintering waterfowl habitat of the mid-Atlantic coast. The appearance of milfoil in the late 1950s dramatically altered the presence of native species. The disappearance of milfoil beginning in the late 1960s allowed some native species to return but in June, 1972, the passage of Agnes negatively altered the recovery pattern for the native SAV species. Over the next two decades, some recovery of native species occurred on the flanks of the Susquehanna Flats, but little recovery on the main flats. Over the last two decades, the Flats have become colonized by a dense and diverse SAV community of up to 15 species, possibly rivaling the density and diversity noted in the early 1900s.

Key Events

Extreme runoff event susceptibility but SAV is resilient

Tropical Storm Agnes was the most extreme runoff event in the Bay's history and resulted in the loss of any remaining SAV at the head of the Bay. Following the resurgence of SAV in the region through 2011, Tropical Storm Lee in Sept., 2011 (http://ian.umces.edu/ecocheck/summer-review/chesapeake-bay/2011/indicators/influencing_factors/), led to a dramatic decline of SAV. A secondary issue regarding these two storms was the timing of each storm. Agnes occurred in late June when SAV may not have reached peak abundance and the meadow itself was not very dense. Lee occurred in September when the meadow was at its maximum development and had reached a size not seen since the early 1900s.

Vulnerability/Resilience

Diversity and Resilience, Resuspension

Tropical Storm Lee caused a decline in SAV because of prolonged turbidity from the resuspension of fine-grained sediments. However, unlike after Agnes, the large dense beds that had developed over the last two decades protected the interior of the meadow from the river-borne turbidity. SAV losses were primarily in the deeper, south and east ends of the Flats. These beds proved to be resilient, with the center core area persisting, facilitating a steady recovery of SAV in the years following Lee.

Lyngbya Expansion

Expansion of the invasive blue-green cyanobacteria *Lyngbya* shades SAV from light. It thrives in warm, clear water. *Lyngbya* can also fix nitrogen and produce toxins. It forms dense floating mats, and loosely attaches to SAV. In other regions of the world, *Lyngbya* has been known to decrease SAV density. *Lyngbya* can be very ephemeral, disappearing quickly due to viral lysis.

Management implications

The two major issues that will influence the continued abundance and diversity of SAV in this region will be additional sediments that will be released from behind the Susquehanna Dam currently at full capacity of sediments, and nitrogen loads coming into the river. While we have shown the resiliency of this vast expanse of SAV following Tropical Storm Lee, the persistent release of sediments has the potential of altering the dynamics of SAV, either by the shoaling of the Flats, decreasing water clarity, or the smothering of SAV by the sediments.

References

Bailey et. al.1978; Dennison et. al. 1993; Orth et. al 2010, 2017; Kemp et. al 2005; Gurbisz et. al 2016, 2017.
http://www.vims.edu/bio/sav/SegmentAreaChart.htm (abundance data)
http://www.vims.edu/bio/sav/maps.html (species and distribution information)
www.vecos.org (water quality in the Virginia waters)

Two key questions answered:

1. What are the long term SAV trends in Chesapeake Bay?

   Nutrient reductions have led to SAV recovery since the 1980s

2. How are the trends related to human activities?

   Nutrient pollution reduces SAV; species enrichment enhances SAV

Additional papers; SAV mapping, SAV synthesis

Robert J. Orth[1], William C. Dennison[2], Cassie Gurbisz[3], Michael Hannam[4], Jeni Keisman[5], J. Brooke Landry[6], Jonathan S. Lefcheck[7], Kenneth A. Moore[1], Rebecca R. Murphy[8], Christopher J. Patrick[9], Jeremy Testa[10], Donald E. Weller[12], David J. Wilcox[1], Richard A. Batiuk[13]

Long-term annual aerial surveys of submersed aquatic vegetation (SAV) support science, management, and restoration

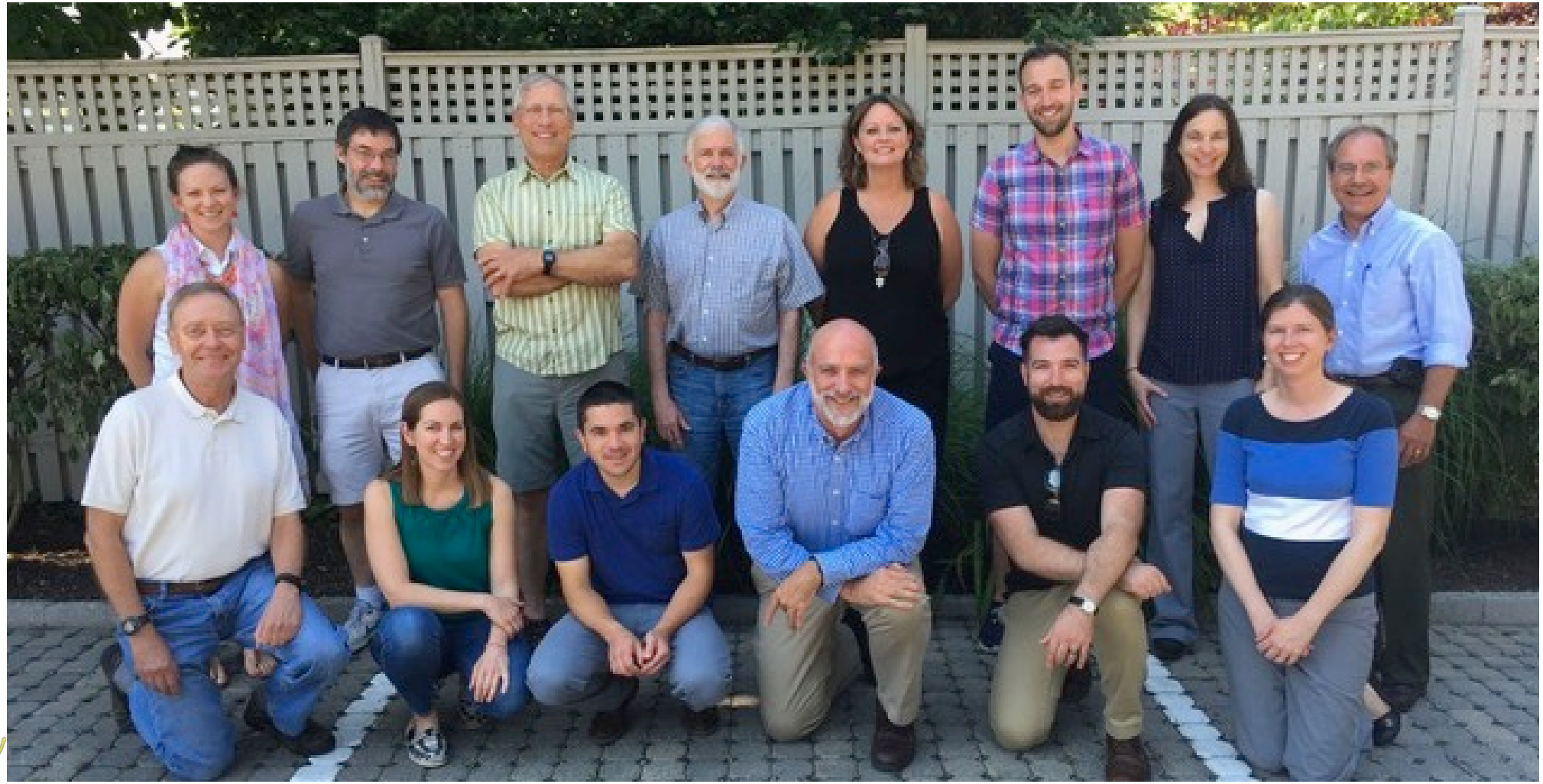
Title: Data synthesis for environmental management: A case study of Chesapeake Bay

Authors: William C. Dennison, Robert J. Orth, David J. Wilcox, Melissa F. Merritt, J. Brooke Landry, Jonathan S. Lefcheck, Jennifer Keisman, Richard A. Batiuk

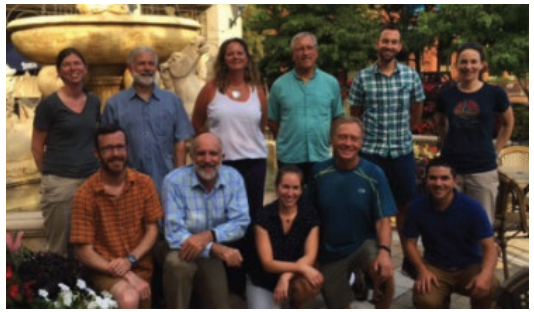
Journal: Environmental Management

1. Experienced leadership

2. Limited size



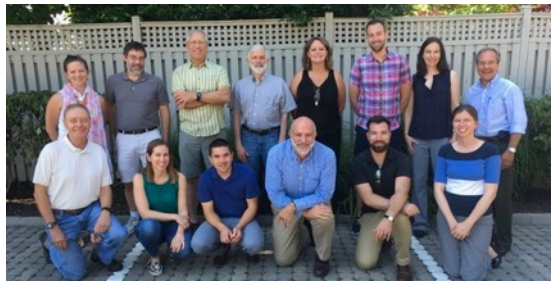
3. Multiple immersive workshops



July 2016

Sept 2016

Jan 2017

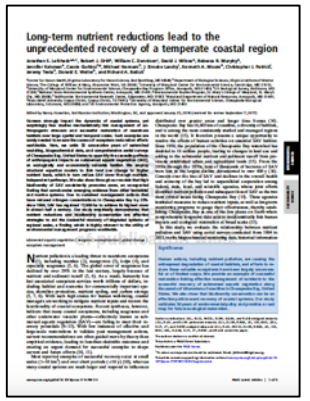


Oct 2017

Feb 2017

Aug 2017

Apr 2018



4. Regular communication

Bill Dennison		Fwd: Bay Journal article on our PNAS paper - Robert J Orth CC: Jonathan Lefcheck , Bill Dennison (dennison@umc	Apr 3
Bill Dennison		Fwd: Bay Journal article on our PNAS paper - Robert J Orth CC: Jonathan Lefcheck , Bill Dennison (dennison@umc	Apr 3
Robert J Orth	Inbox	**RE: [EXTERNAL] Segment conference call Wed.** - Robert J **Orth**; Bill Dennison (dennison@umces.edu); I	**Apr 3**
Brooke Landry -DNR-	Inbox	Re: [EXTERNAL] Segment conference call Wed. - Robert J Orth wrote: >>> >>>> Is supposed to be an upda	Apr 3
Keisman, Jennifer	Inbox	**Re: [EXTERNAL] Segment conference call Wed.** - Robert J **Orth** wrote: >> >>> Is supposed to be an upd	**Apr 3**
Brooke Landry -DNR-	Inbox	**Re: [EXTERNAL] Segment conference call Wed.** - Robert J **Orth** wrote: > >> Is supposed to be an update	**Apr 3**
Keisman, Jennifer	Inbox	**Re: [EXTERNAL] Segment conference call Wed.** - Robert J **Orth** wrote: > Is supposed to be an update on	**Apr 3**
Robert J Orth	Inbox	**RE: Responses! th**	
Melissa Merritt	Inbox	**RE: Responses! th**	
Robert J Orth	Inbox	**RE: Responses! th**	
Jonathan Lefcheck	Inbox	**RE: Responses! th**	
David J Wilcox	Inbox	**RE: Responses! th**	
David J Wilcox	Inbox	**RE: Responses! th**	
Melissa Merritt	Inbox	conf line for tomorro	
Melissa Merritt	Inbox	**RE: conf line for to**	

Robert J Orth	Inbox	**conf line for tomorrow** - Melissa: Can you set up a conf line for all of us to call in to review the segment wo	**Apr 3**
Robert J Orth	Inbox	**RE: [EXTERNAL] Segment conference call Wed.** - Robert J **Orth** Cc: Bill Dennison (dennison@umces.ed	**Apr 3**
Robert J Orth	Inbox	**RE: Double-checking which SAV goal we are using for the segment summaries** - Robert J **Orth** Cc: Da	**Apr 3**
David J Wilcox	Inbox	**RE: Double-checking which SAV goal we are using for the segment summaries** - Robert J **Orth** Cc: Da	**Apr 3**
Batiuk, Rich	Inbox	**RE: Double-checking which SAV goal we are using for the segment summaries** - Robert J **Orth** Cc: Da	**Apr 3**
David J Wilcox	Inbox	**RE: Double-checking which SAV goal we are using for the segment summaries** - Robert J **Orth** Cc: Da	**Apr 3**
Keisman, Jennifer	Inbox	**Re: [EXTERNAL] Segment conference call Wed.** - @usgs.gov 443-498-5565 On Mon, Apr 2, 2018 at 9:41	**Apr 3**
Brooke Landry -DNR-	Inbox	**Re: Double-checking which SAV goal we are using for the segment summaries** - Robert J **Orth** wrote:	**Apr 3**
Robert J Orth	Inbox	RE: Double-checking which SAV goal we are using for the segment summaries - Robert J Orth; Jonathan Le	Apr 3
Robert J Orth	Inbox	**RE: Responses! the segment work - full speed ahead** - Robert J **Orth**; Melissa Merritt Cc: Brooke Landry	**Apr 3**
Jonathan Lefcheck	Inbox	RE: Responses! the segment work - full speed ahead - Robert J Orth; Melissa Merritt Cc: Brooke Landry; Bill	Apr 3
David J Wilcox	Inbox	**RE: Responses! the segment work - full speed ahead** - Robert J **Orth** ; Melissa Merritt Cc: Brooke Landry	**Apr 3**
Jonathan Lefcheck	Inbox	**RE: Responses! the segment work - full speed ahead** - Robert J **Orth**; Melissa Merritt Cc: Brooke Landry	**Apr 3**
David J Wilcox	Inbox	**RE: Responses! the segment work - full speed ahead** - Robert J **Orth** ; Melissa Merritt Cc: Brooke Landry	**Apr 3**
Jonathan Lefcheck	Inbox	**RE: Responses! the segment work - full speed ahead** - Robert J **Orth**; Melissa Merritt Cc: Brooke Landry	**Apr 3**
David J Wilcox	Inbox	**RE: Responses! the segment work - full speed ahead** - Robert J **Orth** Sent: Tuesday, April 03, 2018 8:57	**Apr 3**

5. Flexibility

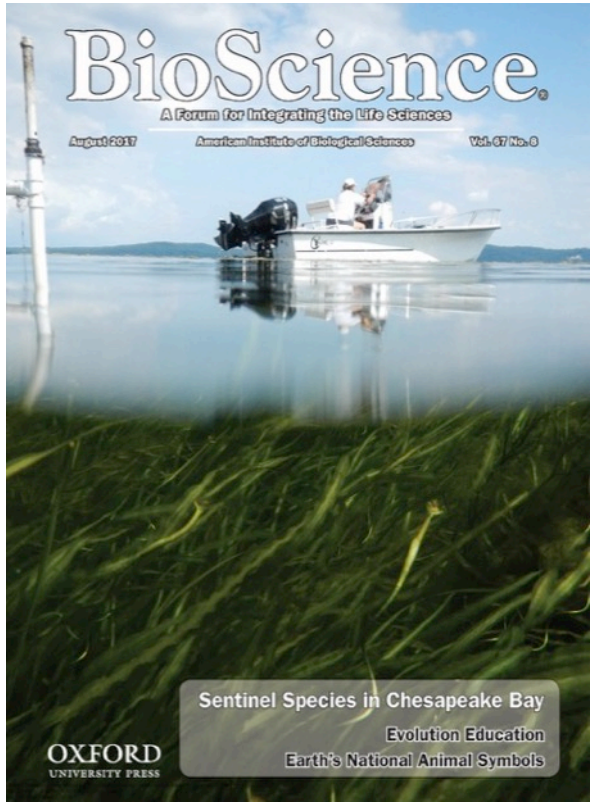
SAV Status and Trends
Agenda Feb. 1 and 2, 2018
IAN Conference Room, Annapolis, MD

Thursday	9:00-9:30	Review PNAS Media Strategy
	9:30-10:30	Review, revise, and finalize segments recently completed
	10:30-11:00	COFFEE BREAK
	11:00-12:30	Identify next set of segments for analysis and begin process of developing the SAV storyline for them
	12:30-1:30	LUNCH
	1:30-3:00	Continue analysis
	3:00-3:30	COFFEE BREAK
	3:30-5:30	Continue analysis

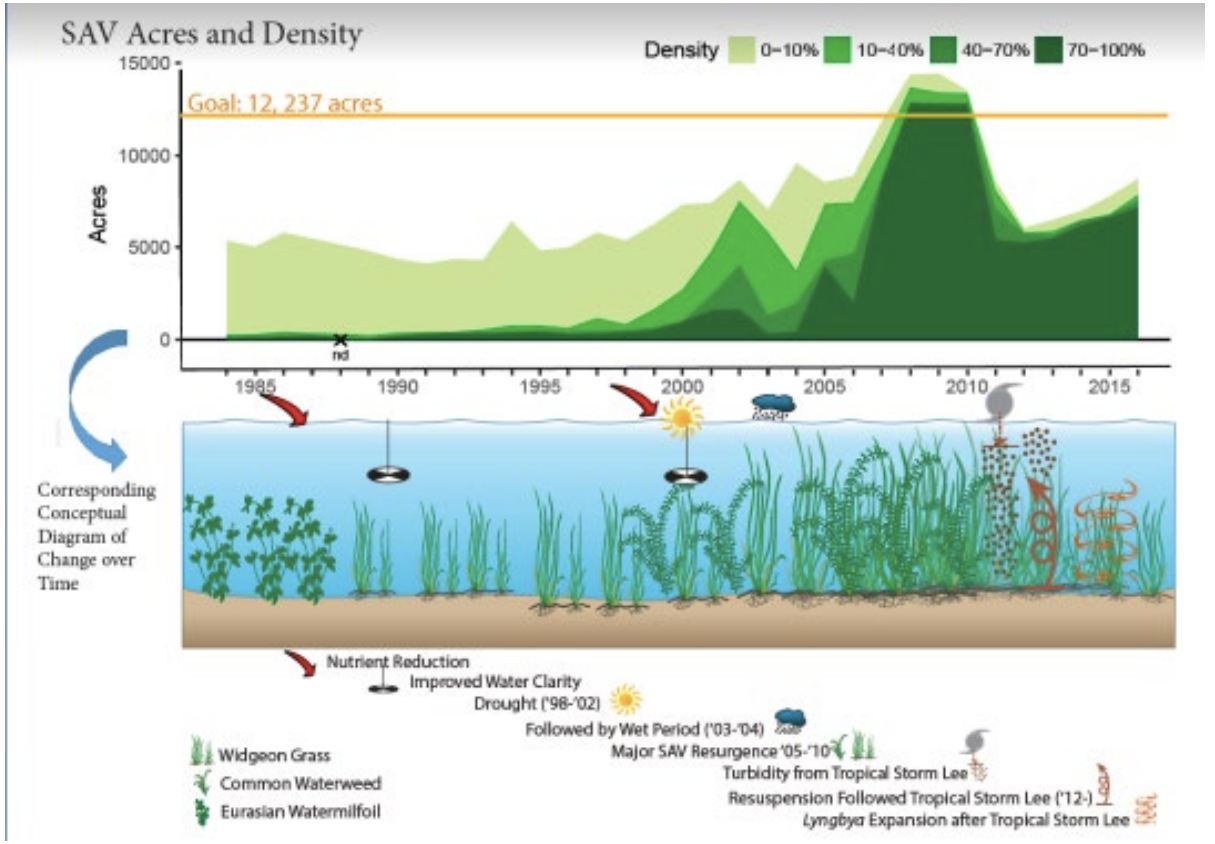
Friday	8:30-10:30	Summary first day – Continue segment analysis
	10:30-11:00	COFFEE BREAK
	11:00-12:00	Continue segment analysis
	12:00-1:00	LUNCH
	1:00-2:30	Review Progress and set date for next segment meeting

6. Product focus

Peer review papers



Segment analysis



7. Conducive location

Walk-able restaurants, coffee shops, bars & hotels

8. Clear goals and objectives

1. What are the long term SAV trends in Chesapeake Bay?

2. How are the trends related to human activities?

9. Fun

The Chesapeake Sentinels

27 Jan 2017

William C. Dennison

Submerged aquatic vegetation are an important mainstay

They provide homes to many of the little critters

So if we lost the sentinels, the critters would get the jitters.

Defending against erosion and protecting the coastline

These aquatic grasses are not at all benign

They suck up nutrients, and cause sediments to drop out

Cleaning the water in the Bay beyond any doubt.

Indicators for water quality, acting as a coastal canary

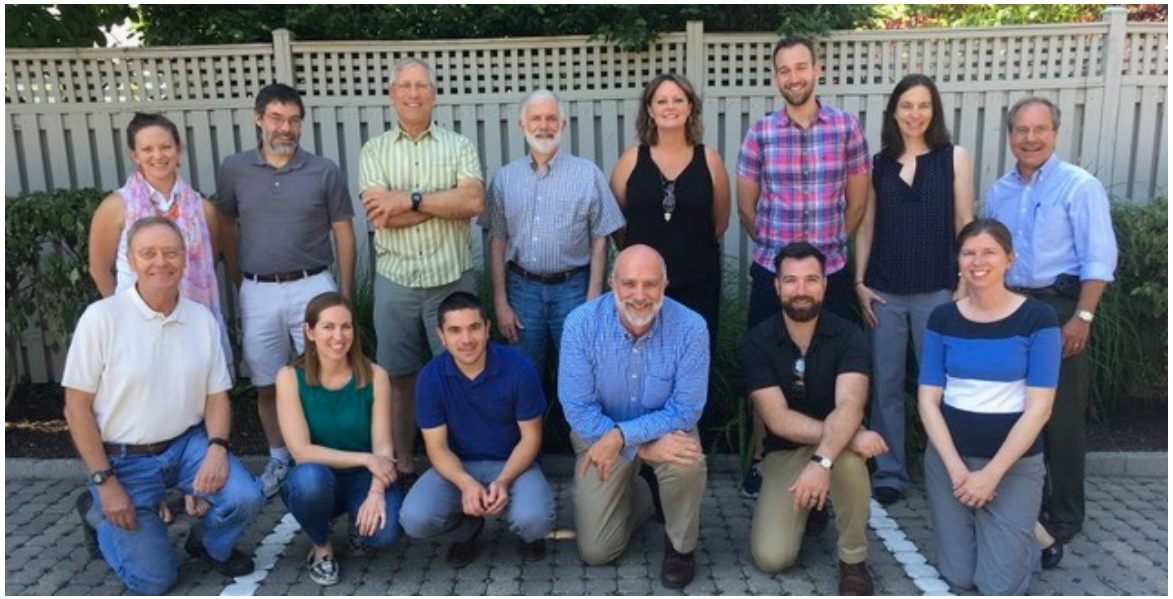
Declining when water gets too warm or too cloudy

They are sensitive to subtle changes in nature

So we can recognize signs of imminent danger.

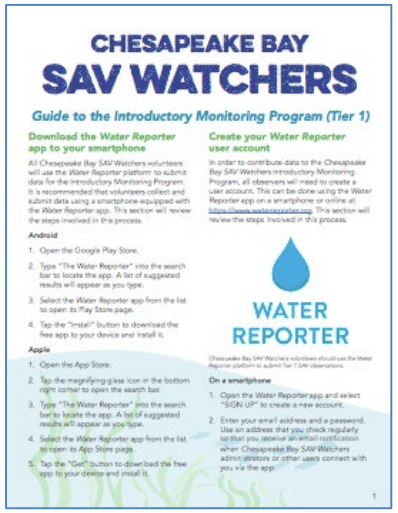
Future: Include graduate students/staffers; utilize CBP staff and young faculty

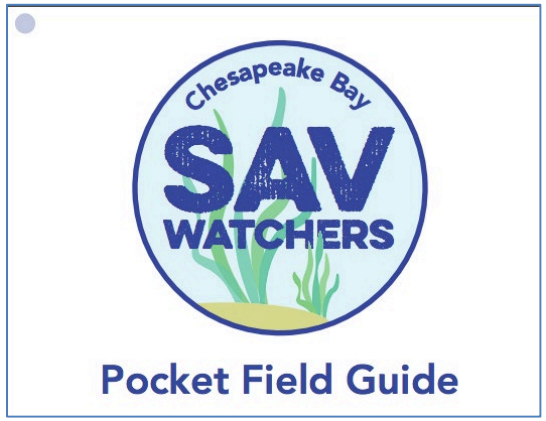
Legacy impacts; Awards, jobs, conference

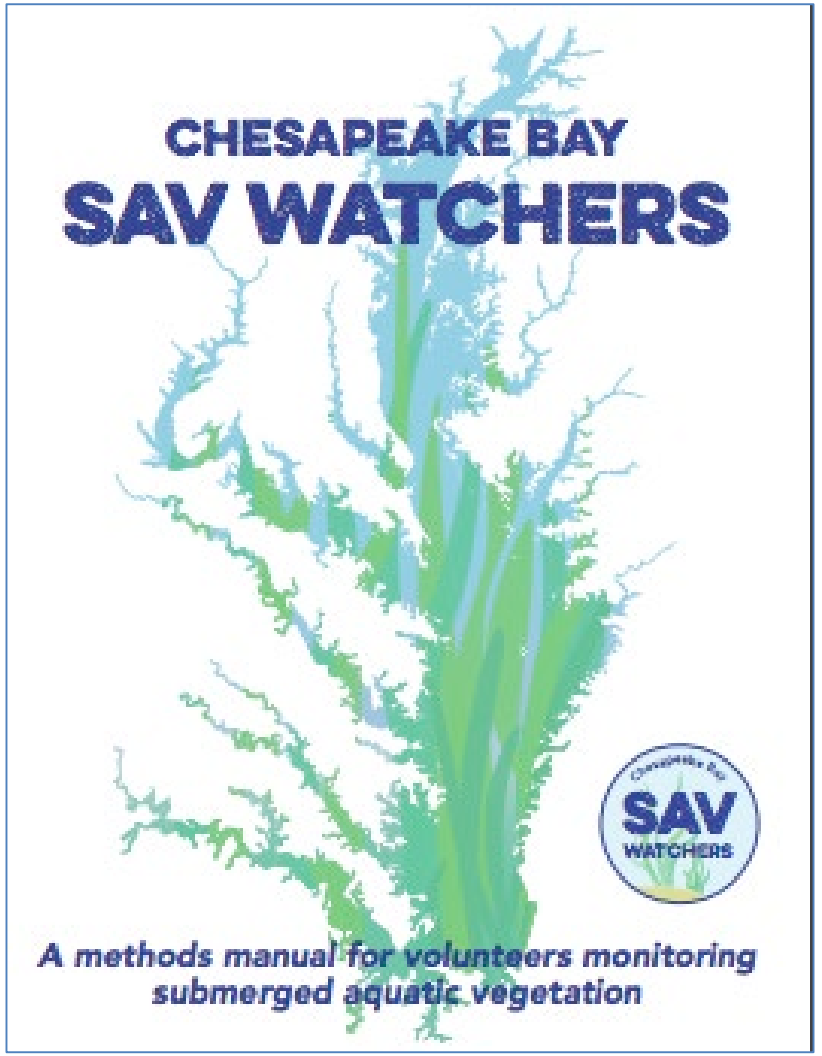


Lefcheck: SERC; Research Scientist
Gurbisz: St. Mary's; College Asst. Professor
Patrick: VIMS; Asst. Professor
Testa: UMCES; Assoc. Professor

Legacy impacts: SAV Watchers







SAV SYN

Legacy impacts: Awesome video