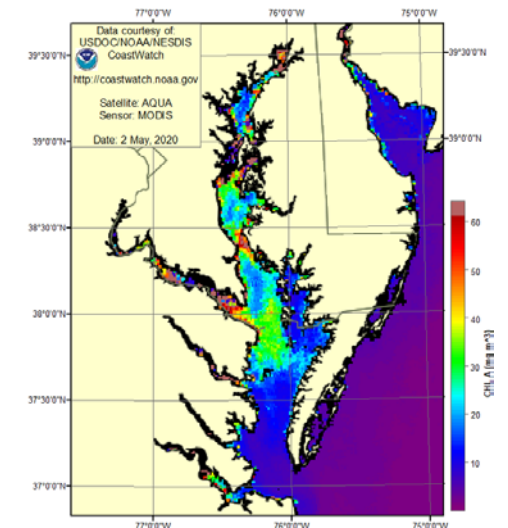
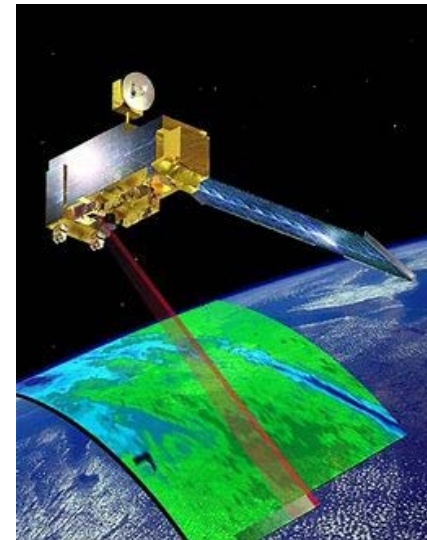
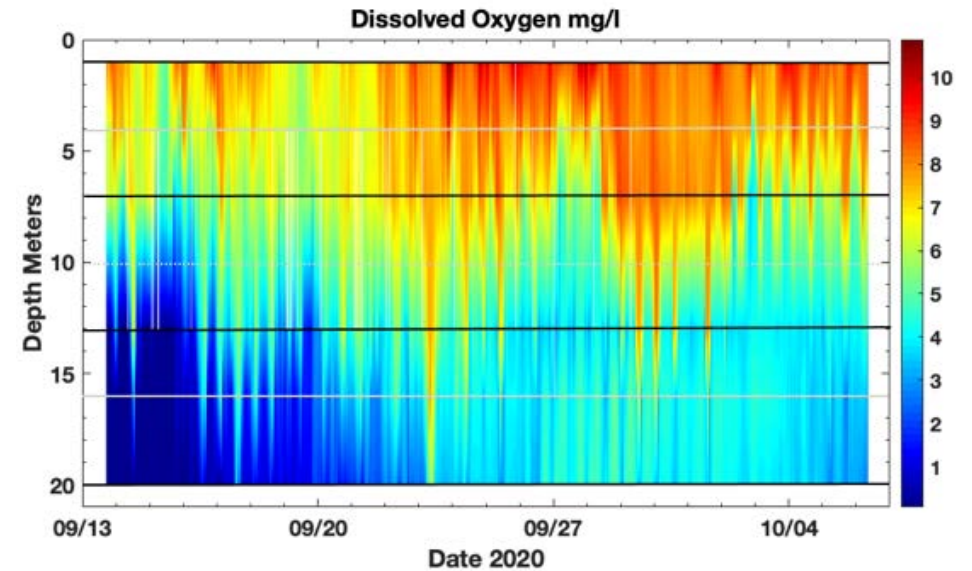


2021 STAC proposal outline:  
Establishing sustainable, cost  
effective monitoring and  
assessment recommendations to  
fully address Chesapeake Bay  
TMDL water quality standards  
assessment

Peter Tango  
USGS@CBPO  
CAP WG  
11/17/2020



*Through the 2014 Chesapeake Bay Watershed Agreement, the Chesapeake Bay Program has committed to...*



**Goal:** *Water Quality*

**Outcome:**

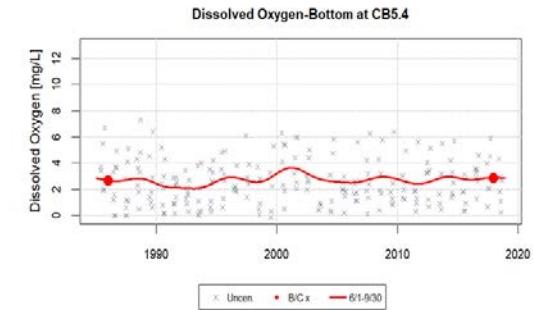
*Continually improve the capacity to monitor and assess the effects of management actions* being undertaken to implement the Bay TMDL and improve water quality. Use the monitoring results to report annually to the public on progress made in attaining established Bay water-quality standards and trends in reducing nutrients and sediment in the watershed.



## Successes and Challenges



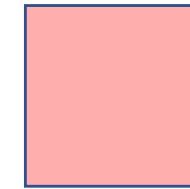
- **New analysis tools**
  - e.g. GAMs, bay models, pilot work with AI/Machine Learning algorithms
- **Enhanced communications**
  - Bay Barometer, blogs, social media, partner meetings, Data Dashboard
- **Implemented CBP's Strategic Science and Research Framework**
  - Identify/fill gaps)
- **Advanced scientific syntheses completed**
  - publications and reports on Bay and watershed science)
- **Supported an MOU using Citizen Science-based data**
  - Chesapeake Data Explorer >300,000 data points





# Successes and Challenges

- **Unassessed criteria for 17 years** remain a hurdle for delisting decisions of State-adopted water quality standards with our existing framework
- **Financial stresses** on Bay cruises, SAV aerial survey, NTN
- **Contraction** of traditional long-term monitoring programming
- **Slow** pace for expanded assessment of water-quality standards
- **Limited** non-traditional data use in assessments
- **Limited** use of new interpretation and interpolation options

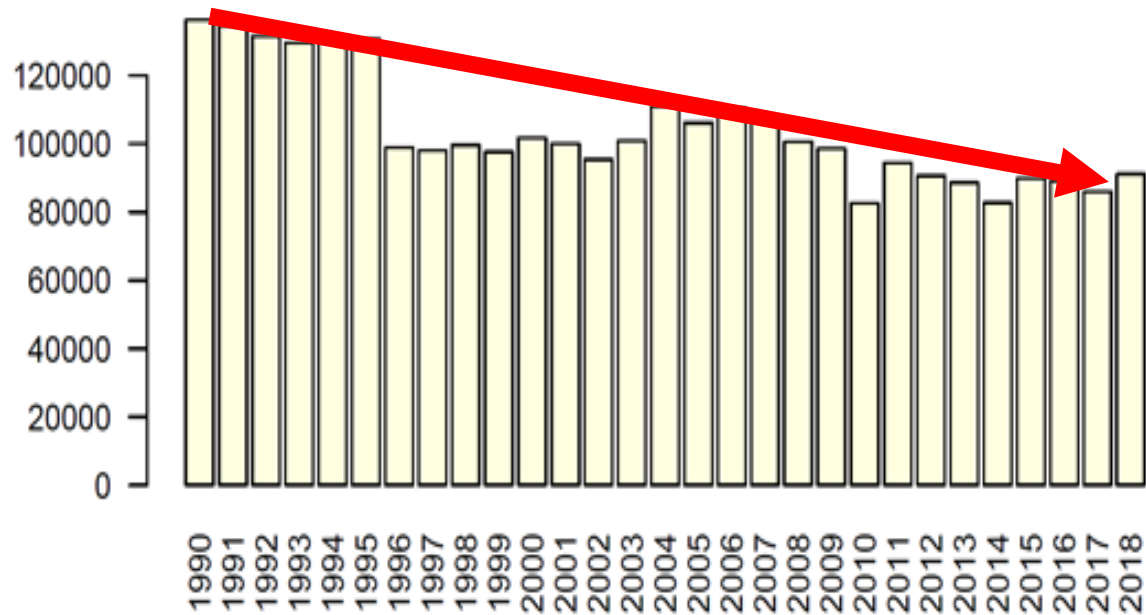


= Inability to report on standard attainment

Designated Use	Dissolved oxygen Criteria Concentration/Duration	Temporal Application
Migratory fish spawning and nursery use	7-day mean $\geq$ 6 mg/L tidal habitats with 0-0.5ppt salinity	February 1 – May 31
	Instantaneous min $\geq$ 5 mg/L	
	Open water fish & shellfish designated use criteria apply	June 1 – January 31
Shallow water Bay grass use	Open water fish & shellfish designated use criteria apply	Year-round
Open water fish and shellfish use	30-day mean $\geq$ 5.5 mg/L Salinity: (0-0.5ppt)	Year-round
	$\geq$ 5 mg/L Salinity: >0.5ppt	
	7-day mean $\geq$ 4 mg/L	
	Instantaneous min $\geq$ 3.2 mg/L	
Deep-water seasonal fish and shellfish use	30 day mean > 3mg/L	June 1 – September 30
	1-day mean >2.3 mg/L	
	Instantaneous min $\geq$ 1.7 mg/L	
	Open water Fish and shellfish designated use criteria apply	October 1-May 31
Deep channel seasonal refuge use	Instantaneous min > 1 mg/L	June 1 – September 30
use	Open water F & S applies	October 1 – May 31

# What is our Expected and Actual Progress?

Count of Tidal Water-quality Samples



## Monitoring Capacity: Good/**Fair**/Poor

- Capacity is highly stressed and declining
- Data collections remain “marginal” for the Bay criteria assessment, “adequate” for the watershed loads estimates

# Proposed STAC Workshop Structure

## **Opening Workshop event**

- 6 (or more) options to address our monitoring and assessment challenges, enhance capacity in monitoring and assessment
- Address each option or theme –
  - pros, cons,

## **Second workshop event**

- Review examples of how it works or doesn't work and produce a recommendation for what is needed to adopt and implement in a timely manner (not 17 years) actions to meet assessment needs of our water quality standards.
- Establish steps to adoption and implementation of capacity building targets for improved assessment of TMDL criteria in the water quality standards by 2025

# Issue: With no new funding, we have ripe opportunities to expand use of our toolbox to estimate conditions over much of the Bay and its tributaries

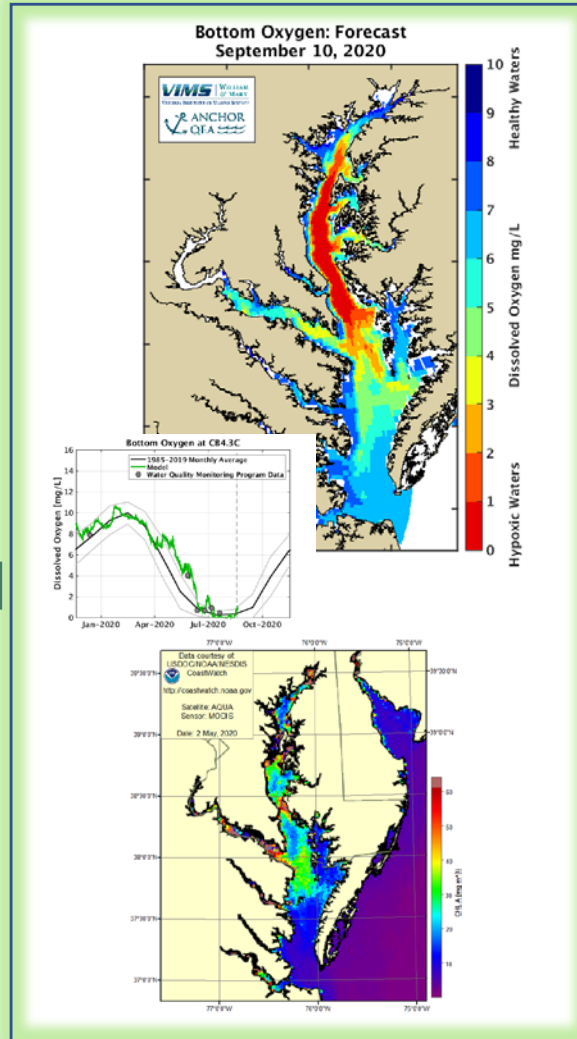
**Chesapeake Monitoring Cooperative**  
A partnership that aims to provide technical, logistical, and outreach support for the integration of volunteer-based and nontraditional water quality and benthic macroinvertebrate monitoring data into the Chesapeake Bay Program (CBP) partnership.

Cooperative Agreement: Alliance for Chesapeake Bay, VIMS, and others.

Participating Institutions: VA, MD, DC, DE.

CMC development team partners & service providers.

Update integrated monitoring approach



Update analytical and assessment approaches

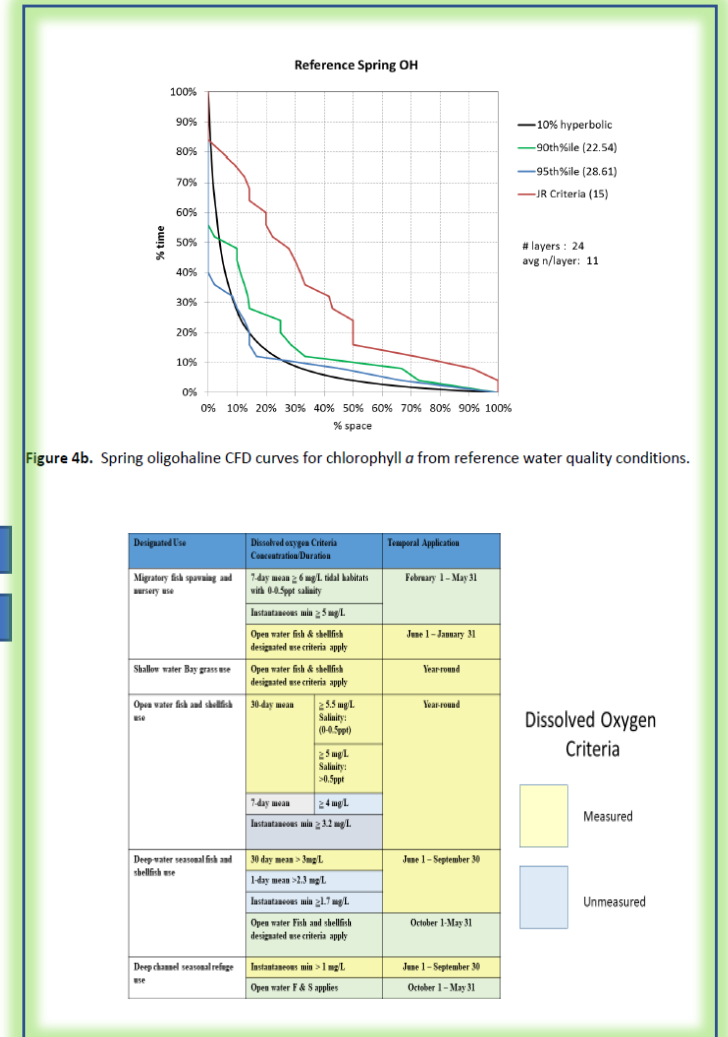


Figure 4b. Spring oligohaline CFD curves for chlorophyll a from reference water quality conditions.

Improved capacity Fill Habitat Assessment Gaps

# SAV: Satellite assessment of SAV in high resolution in estuaries over large areas is already being done, AI/ML interpretation make high thru-put assessment feasible

Estuaries and Coasts  
DOI 10.1007/s12237-013-9764-3

## Evaluating Light Availability, Seagrass Biomass, and Productivity Using Hyperspectral Airborne Remote Sensing in Saint Joseph's Bay, Florida

Victoria J. Hill · Richard C. Zimmerman ·  
W. Paul Bissett · Heidi Dierssen · David D. R. Kohler

Received: 29 October 2012 / Revised: 23 December 2013 / Accepted: 26 December 2013  
© Coastal and Estuarine Research Federation 2014

**Abstract** Seagrasses provide a number of critical ecosystem services including habitat for numerous marine invertebrates...

Journal of Great Lakes Research 39 (2013) 70–89



Journal of Great Lakes Research



journal homepage: www.elsevier.com/locate/jglr

## Mapping and monitoring the extent of submerged aquatic vegetation in the Laurentian Great Lakes with multi-scale satellite remote sensing

Robert A. Schuchman<sup>a</sup>, Michael J. Sayers<sup>b</sup>, Colin N. Brooks<sup>c</sup>

<sup>a</sup>Michigan Tech Research Institute (MTI), Michigan Technological University, 1400 Townsend Drive, 1400 Townsend Drive, 1400 Townsend Drive, 1400 Townsend Drive, 1400 Townsend Drive

### ARTICLE INFO

Article history:  
Received 21 January 2012  
Accepted 1 April 2013  
Available online 13 August 2013

Communicated by George Lefflerbach

Index words:  
Cladophora  
SAV  
Remote sensing  
Satellite algorithm development

### ABSTRACT

A satellite-based algorithm intended to map submerged aquatic vegetation (SAV), which was mostly the nuisance algae *Cladophora*, for the Laurentian Great Lakes has been developed and successfully demonstrated test areas in Lakes Michigan and Ontario. The new Submerged Aquatic Vegetation Mapping Algorithm (SAVMA) first utilizes deep water (opaque) radiance values to correct shallow water values (translucent) so that depth invariant reflectance values for all three visible Landsat bands of the lake bottom can be derived. Combinations of two bands are then used to generate a depth invariant bottom type index. The index then maps the lake bottom into three types: sand, dense SAV, and sparse SAV by thresholding depth invariant reflectance values. The SAVMA also generates a biomass estimator by assigning an arbitrary weight obtained by field sampling to both the dense and sparse SAV areas identified by the index. The algorithm performance was successfully evaluated on Lake Michigan at the Sleeping Bear Dunes National Lakeshore (SBDNL) using *Cladophora* locations provided by diver surveys as well as from an independent National Park Service monitoring. The SAVMA correctly mapped *Cladophora* to an approximate accuracy of 80% where the misclassification was a result of mixed pixels due to the resolution of the Landsat data and local atmospheric corrections. The algorithm was also successfully evaluated in Lake Ontario near Pickett Island. The SAVMA was then used to generate both short and long term time-series analyses of *Cladophora* extent at SBDNL.

© 2013 Published by Elsevier B.V. on behalf of International Association for Great Lakes Research.

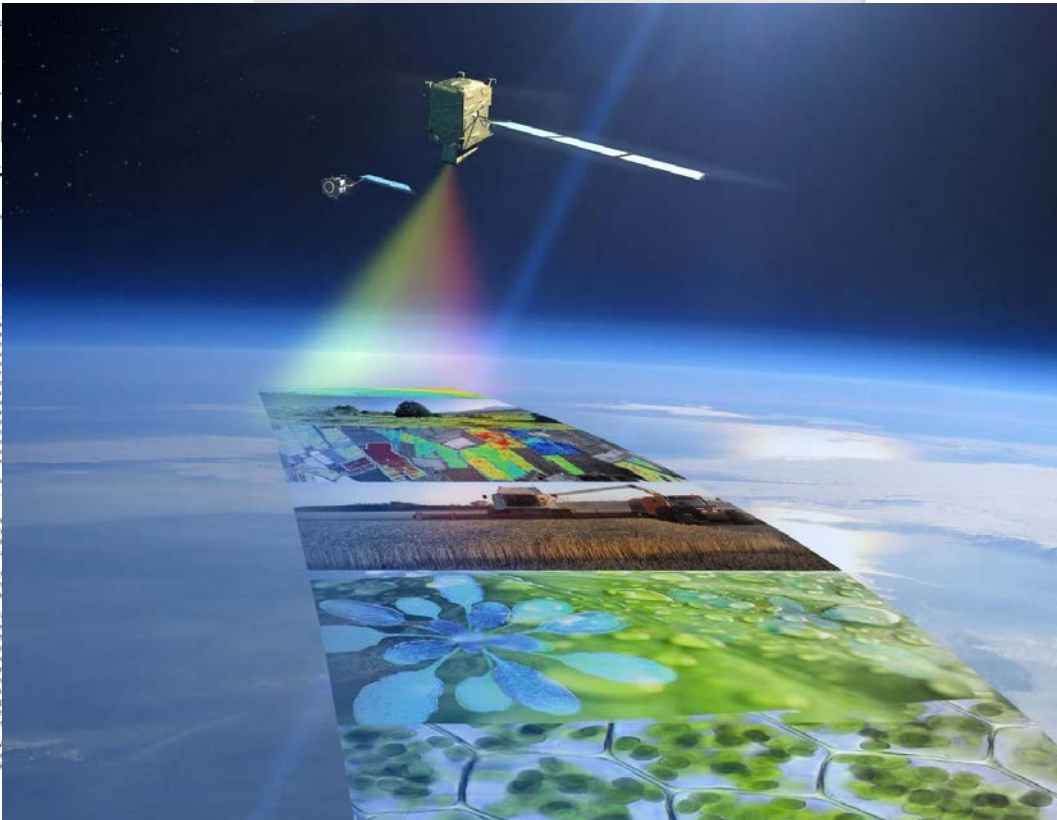
### Introduction

Satellite imagery offers the potential to map submerged aquatic vegetation (SAV) in the near shore waters of the Great Lakes. Recent increases in the clarity of Great Lakes waters have led to a dramatic increase in Great Lakes benthic algal biomass. The objective of this paper is to present an algorithm that utilizes electro-optical satellite data to map SAV extent and provide a qualitative biomass estimate. The algorithm is validated using Landsat data collected in the Lake Michigan near shore area at the Sleeping Bear Dunes National Lakeshore (SBDNL) and off Pickett Island in Lake Ontario. *Cladophora* is the dominant SAV present in both these areas.

*Cladophora*, shown in Fig. 1, is a native, filamentous, green alga that grows attached to solid substrate in all of the Laurentian Great Lakes (Jackson et al., 1990), where phosphorus levels are comparatively high (Jauer et al., 1982; Greb et al., 2004; Higgins et al., 2006a; Wilson et al., 2006). *Cladophora* is the major component of submerged aquatic vegetation (SAV) on rocky substrate and other submerged hard surfaces in the lower Laurentian Great Lakes, with minor contributions from diatoms and a few other filamentous algae that seldom develop into significant standing stocks (Mullin et al., 2008). Soft substrate habitats also support SAV with charophytes such as *Chara* that is locally abundant (Stewart and Loner, 2008).

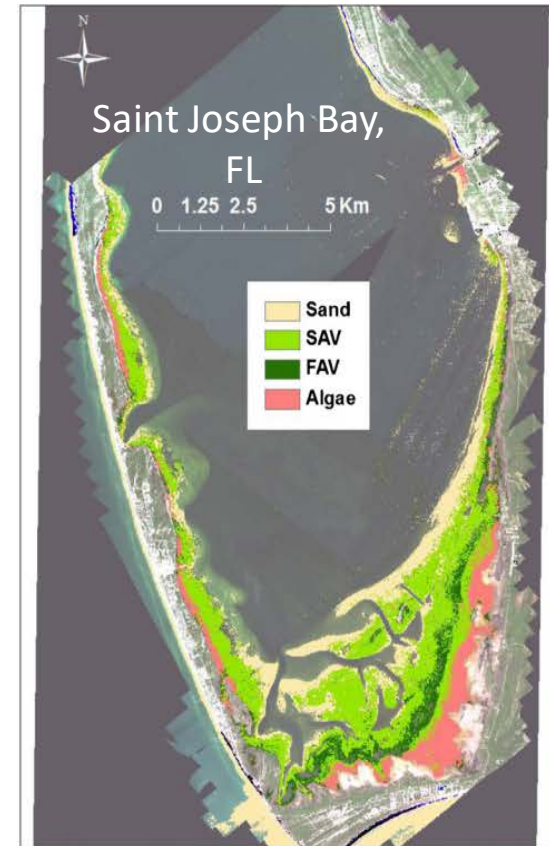
Nuisance growth of *Cladophora* and other SAV in the near waters of Lakes Erie, Michigan and Ontario has attracted the attention of those involved in waterfront recreation, utility operations and quality management. Public awareness of the problem has heightened by reports in the popular press of beach fouling (F and incidents of avian botulism that are linked to nuisance *Cladophora* (New York Sea Grant and Pennsylvania Sea Grant, 2008). Historically, nuisance *Cladophora* and other SAV growth in Great Lakes have been documented as early as the mid-1920s (Talt and Kishler, 1973), with increased research interest in mid-1970s and 1980s. It was expected that phosphorus management strategies would be able to reduce and control nuisance growth conditions. By most accounts the management and reduction of phosphorus resulted in significantly less *Cladophora* biomass as seen "hot spots" in the Great Lakes (Castle and Auer, 1982; Fausch-Kammaris, 1987).

There has been renewed interest in *Cladophora* and other SAV since growth over the past decade as the green alga has been observed growing in significantly deeper water (>25 m) than previously reported (Kumaris, 1987).



water on the deep edge of SAV zones but were not classified and algal origin was responsible for the remaining absorption

Fig. 5 Mapped distributions of red algae, submerged aquatic vegetation (SAV), floating aquatic vegetation (FAV), and sand benthic types identified and overlaid on the high resolution SAMSON pseudo-true color image of the Saint Joseph's Bay

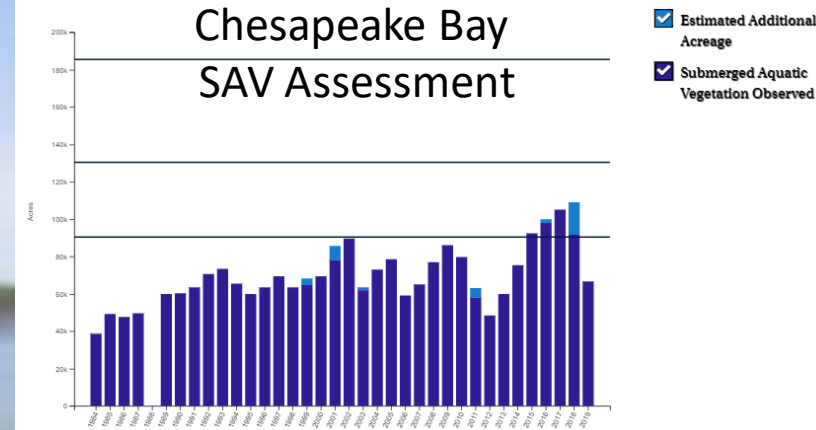


Hill et al. 2014

\* Corresponding author. Tel.: +1 734 913 3886.  
E-mail address: schuchman@mti.mtu.edu (R.A. Schuchman), rpschuchman@mti.mtu.edu (R.A. Schuchman), csayers@mti.mtu.edu (M.J. Sayers), colin.brooks@mti.mtu.edu (C.N. Brooks).  
† Tel.: +1 734 913 3882.  
‡ Tel.: +1 734 913 6838.



## Chesapeake Bay SAV Assessment



### Recent success:

- \* VIMS – recent gap filling data Needs with satellite imagery For the SAV annual survey

- \* Zimmerman Lab at ODU

- \* Workshop focused on the protocol steps needed from planning data collection through phases of interpretation

- \* **FREE DATA\*** (\$300K worth of FREE)

# Exploring Satellite Image Integration for the Chesapeake Bay SAV Monitoring Program

~a Responsive STAC Workshop~

Co-Chairs 2019-2020:  
Brooke Landry and Peter Tango

**Dissolved Oxygen: 2018 Chesapeake Bay Program Partnership**  
**Memorandum of Understanding:**  
*Using Citizen and Non-traditional Partner monitoring data to assess progress toward restoration.*



OCTOBER 12, 2018

**MEMORANDUM OF UNDERSTANDING**  
AMONG

The State of Delaware, the District of Columbia, the State of Maryland, the State of New York, the Commonwealth of Pennsylvania, the Commonwealth of Virginia, the State of West Virginia, the Interstate Commission on the Potomac River Basin, the Susquehanna River Basin Commission, the Metropolitan Washington Council of Governments, the United States Environmental Protection Agency, the Chesapeake Bay Commission, and the Chesapeake Monitoring Cooperative.

REGARDING

Using Citizen and Non-traditional Partner Monitoring Data to Assess Water Quality and Living Resource Status and Our Progress Toward Restoration of a Healthy Chesapeake Bay and Watershed

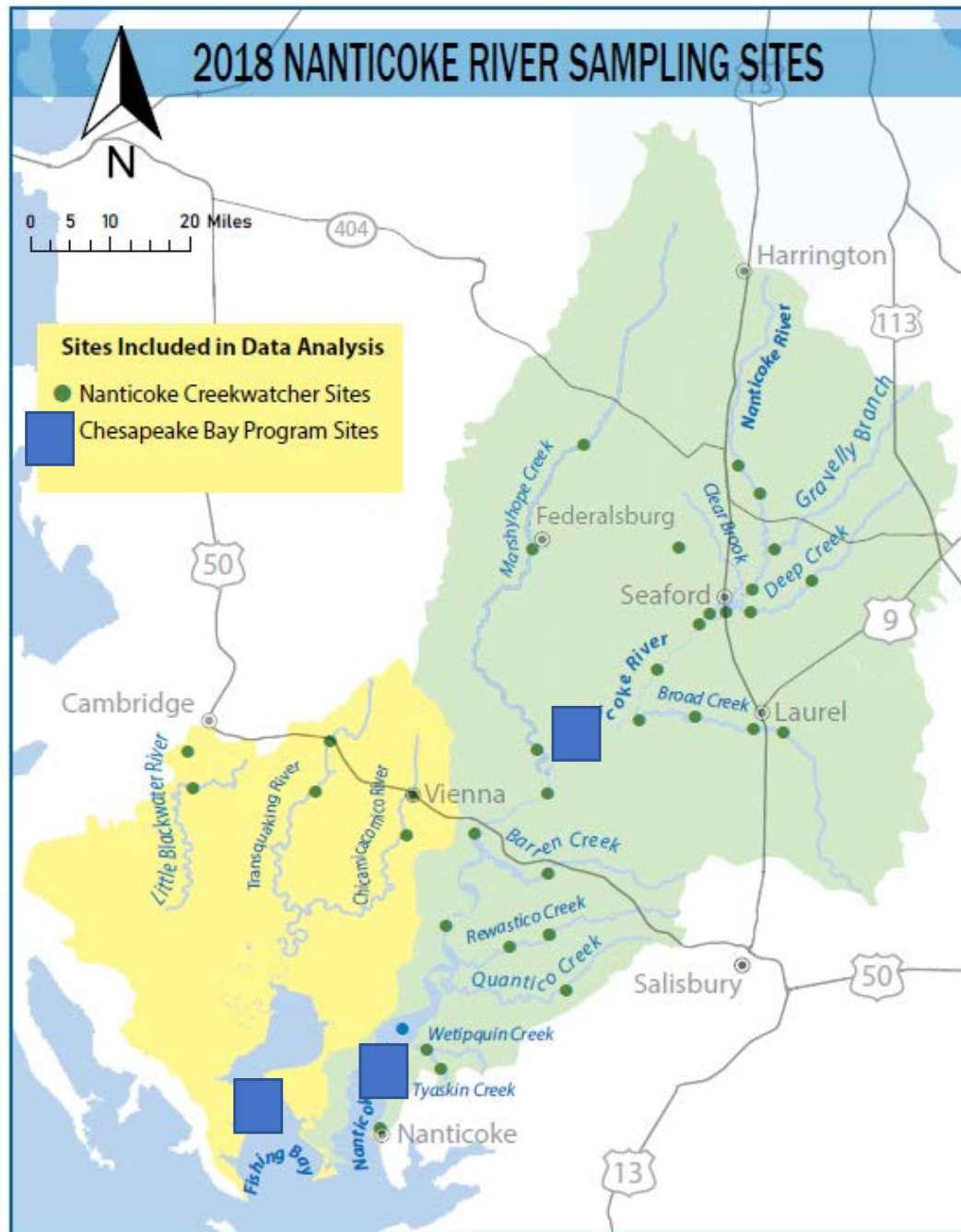
WHEREAS, the health of the Chesapeake Bay and its watershed depends on individual and community-based stewardship by the more than 18 million people who call this watershed home;

WHEREAS, the Clean Water Act states that all existing and readily available information must be evaluated for assessment of our nations waterways and the Chesapeake Bay Program is a leader in leveraging resources through a partnership approach;

NOW, THEREFORE, we, the undersigned representatives of the District, state, interstate, and federal entities with responsibility for monitoring the waters and resources of the Chesapeake Bay and its watershed agree that we will:

- Work cooperatively with the CMC and the Chesapeake Bay Program partnership to support and sustain a network of citizen science and non-traditional monitoring partners.
- Endorse an open-access clearinghouse of quality-assured environmental data generated by citizen

**\$470K per year**  
**Investment in**  
**Data collection**  
**by**  
**Cit Scientists and**  
**nontraditional**  
**partners**



Let's invest and analyze smarter!

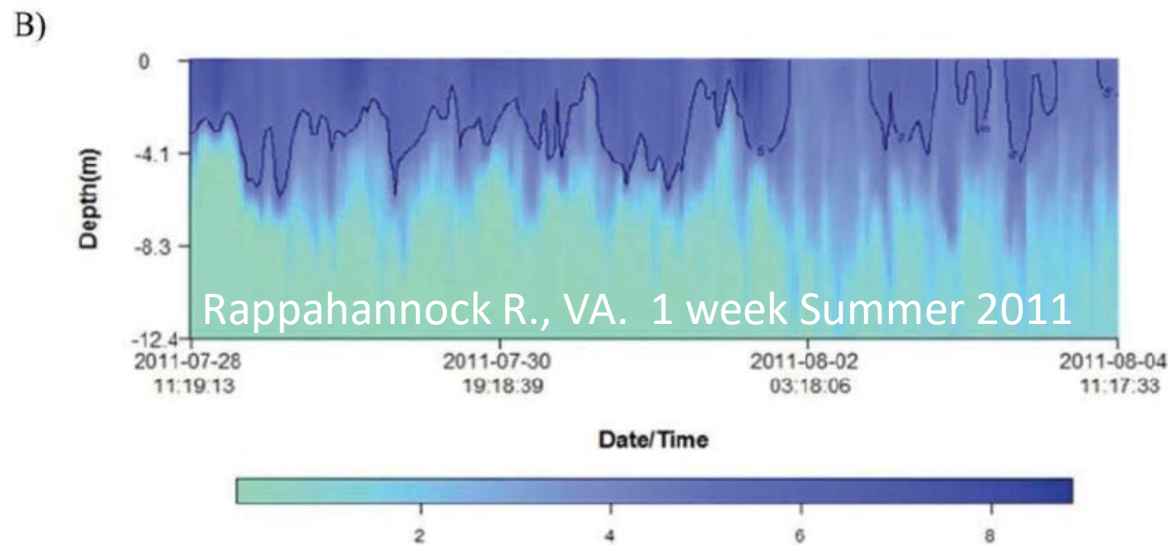
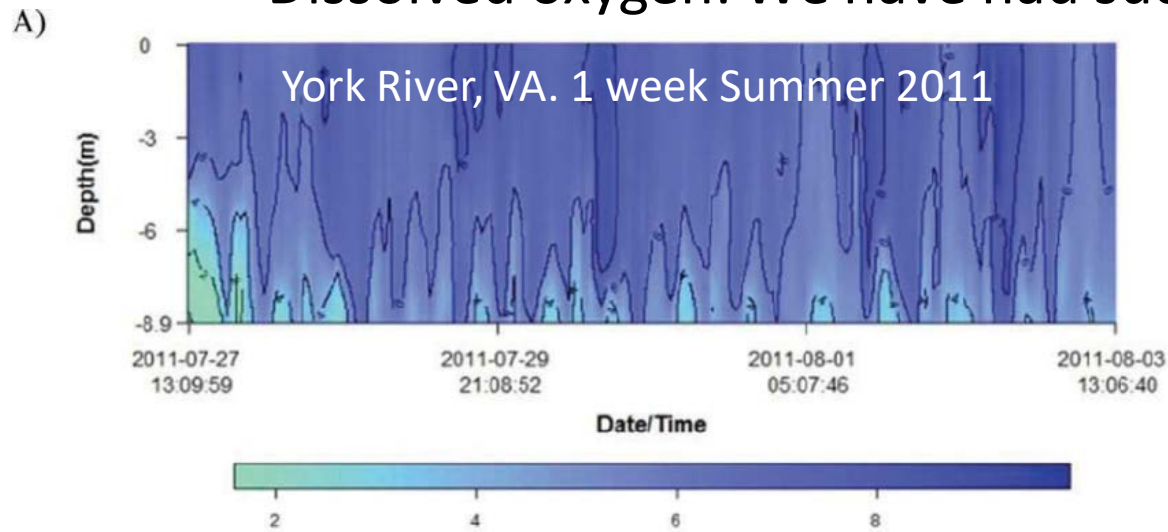
Nanticoke Creekwaters are  
Approved for Tier 3 D.O. monitoring  
(Water quality standards approved)

Do we continue to compute standards  
Attainment based on 3 sites visited  
1x per month ■ That is 12 data points for  
the summer,

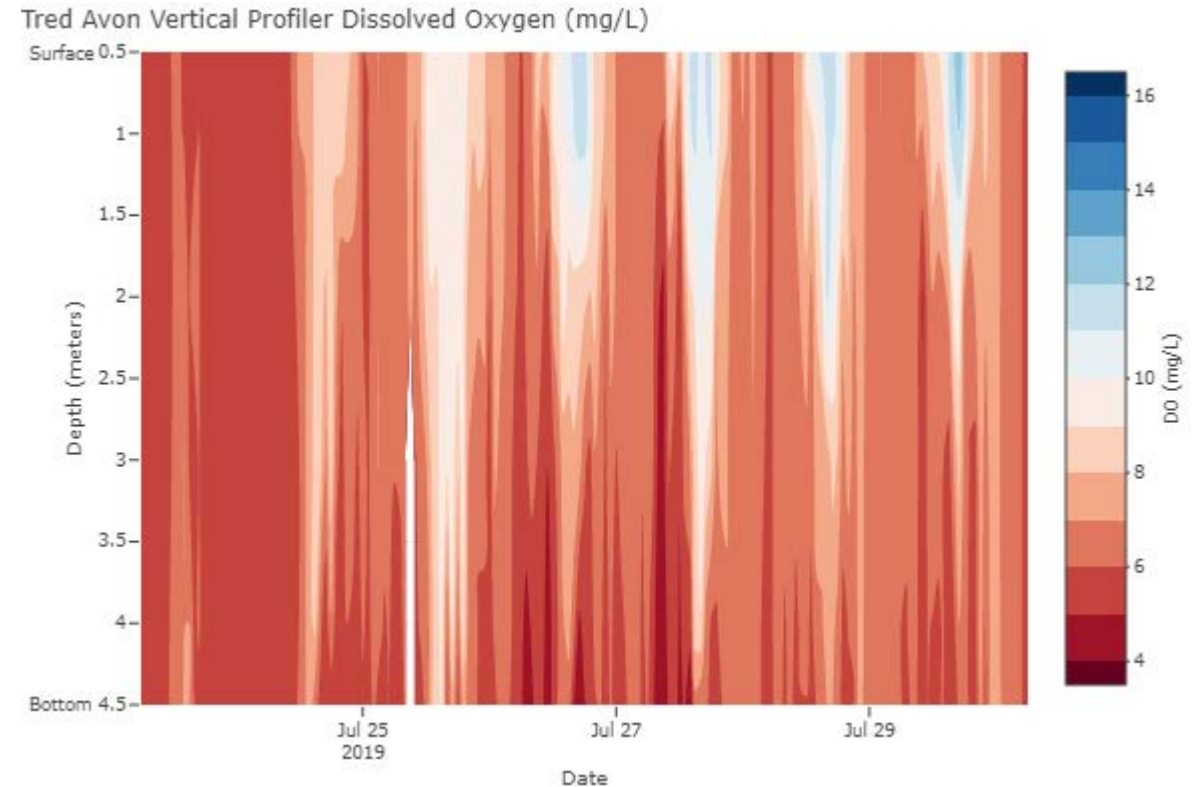
Or

Do we include 30 sites ● collected  
weekly to evaluate D.O. standards? That is  
Over 120 data points for one season?  
That is a 10x increase in information over  
our existing monitoring program by incorporating  
their data, and that is just one tributary system.

# Dissolved oxygen: We have had success with profilers in shallow river habitats



Water Quality Profiler data  
(Tuckey and Fabrizio 2016)

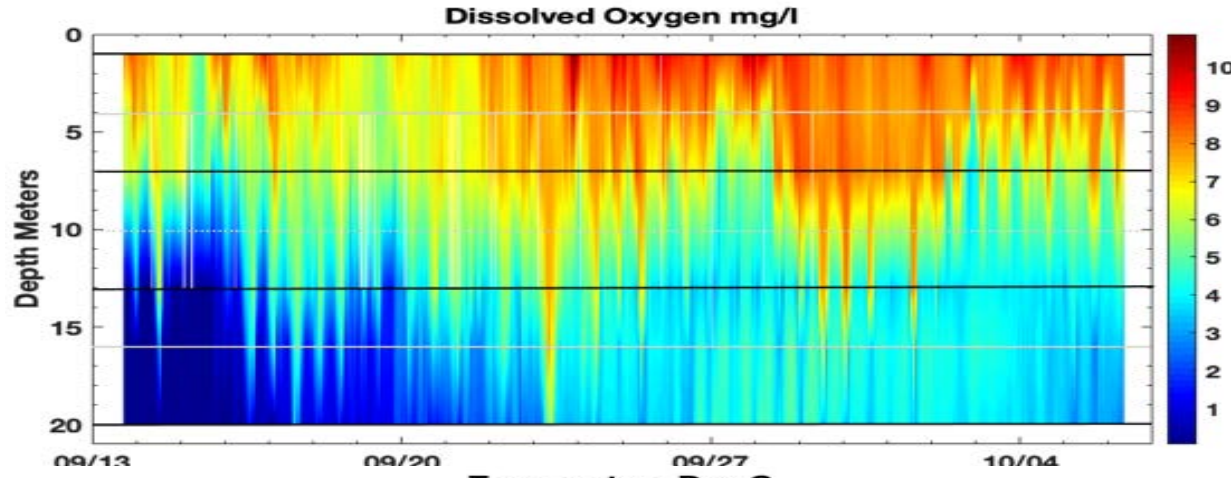
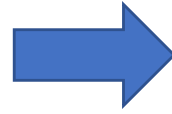


MD DNR Water Quality Profiler - hourly  
About 1 week, 4.5meter depth, Tred Avon River  
July 26- July 30, 2019

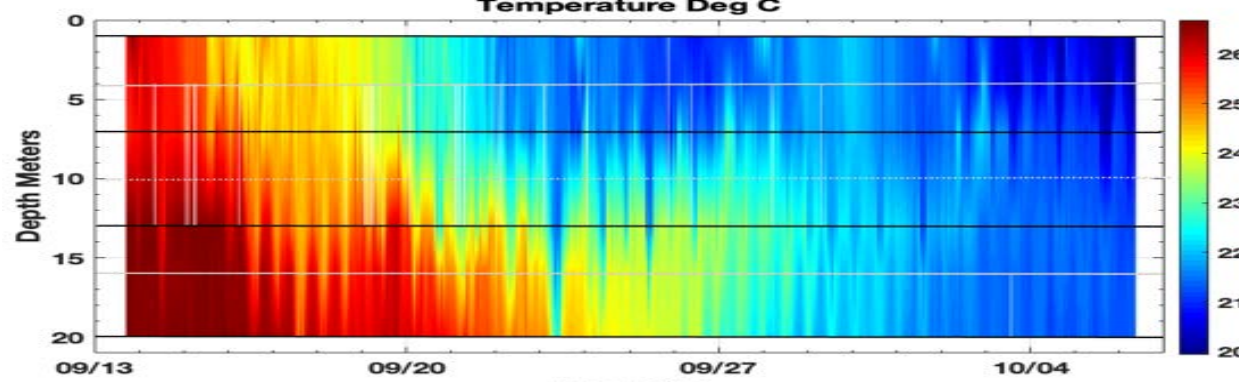
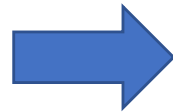
M. Trice  
MD DNR

# Dissolved oxygen: We have had success with profilers in the open bay habitats

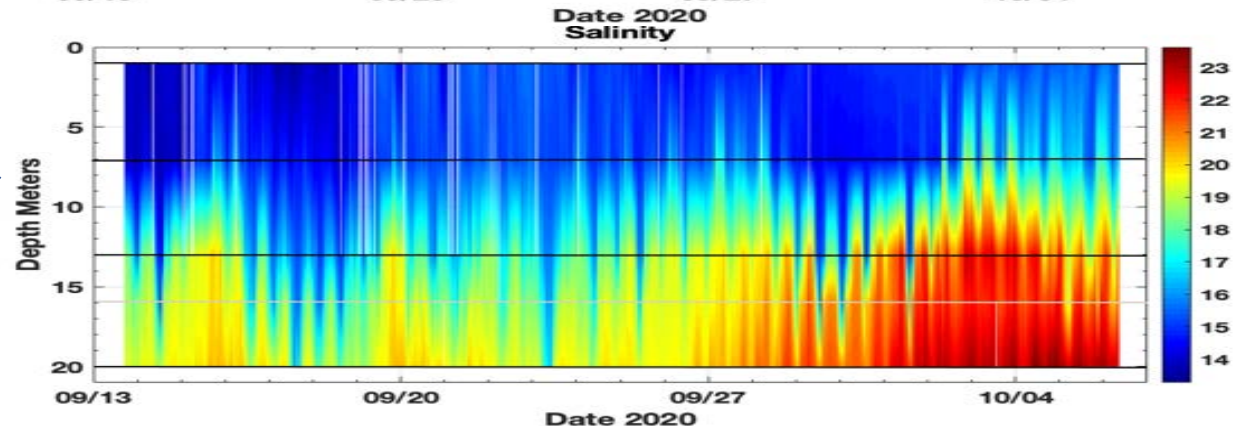
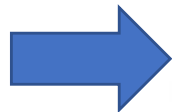
- Dissolved oxygen – water at this station becomes oxygenated



- Temperature stratification is lost and becomes isothermal



- Salinity stratification declines before oxygen rich high salinity water moves into the bottom waters



~ \$50K Instrument with high data return on investment

September 2020

D. Wilson 2020. CBT GIT-funded pilot project data

Continuous vertical profiler collecting data at 10 minute intervals provides assessment support for all criteria applicable in all designated uses.

- Instantaneous minimum
- 1 day mean
- 7 day mean
- 30 day mean
- Seasonal mean

\*No other form of monitoring is achieving this level of information support throughout the water column.

# Chlorophyll: Florida is EPA approved for assessing coastal chlorophyll *a* water quality standards with satellite image interpretation since 2012

Microsoft Office Home | Mail - Peter Tango - Outlook | New tab | NASA - NASA Satellites Eye Coas: x

Not secure | https://www.nasa.gov/vision/earth/lookingatearth/coastal\_waters.html

## News & Features

- News Topics
- News Releases
- Media Resources
- Speeches
- Budgets & Plans
- Reports

## Feature

Text Size + -

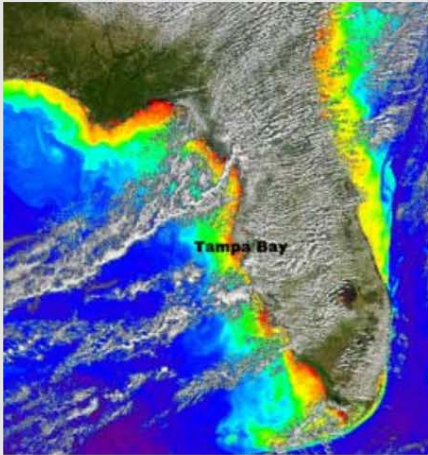
### NASA Satellites Eye Coastal Water Quality 08.29.07

Armed with data from two NASA satellites, researchers have invented a way to map the fleeting changes in coastal water quality from space - something that has long evaded researchers and coastal managers relying only on ground-based measurements.

*Image right: High concentrations of microscopic plants called phytoplankton (red regions) along the Florida coast and in Tampa Bay are an indicator of ocean health and change as seen in this SeaWiFS image from October 2004. Researchers have successfully used data from similar images to monitor almost daily changes in coastal water quality. + High resolution Credit: SeaWiFS Project*

Using data from instruments aboard NASA satellites, Zhiqiang Chen and colleagues at the University of South Florida in St. Petersburg, found that they can monitor water quality almost daily, rather than monthly. Such information has direct application for resource managers devising restoration plans for coastal water ecosystems and federal and state regulators in charge of defining water quality standards.

The team's findings will aid in the effort to tease out factors that drive changes in coastal water quality. For example, sediments entering the water as a result of coastal development or pollution can cause changes in water turbidity – a measure of the amount of particles suspended in the water. Sediments suspended from the bottom by strong winds or tides may also cause such changes. Knowing where the sediments come from is critical to managers because turbidity cuts off light to the bottom, thwarting the natural growth of plants.



Connecting...

Type here to search

9:38 AM  
8/18/2020

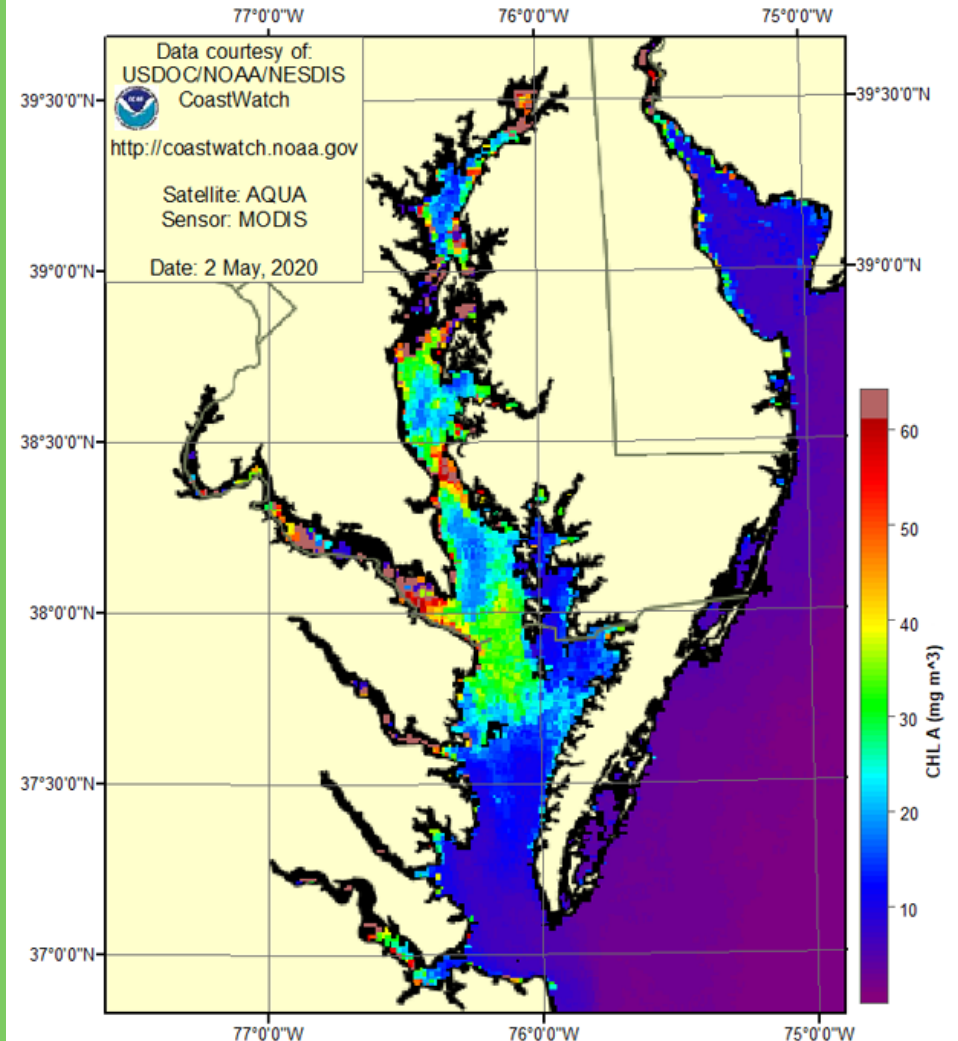
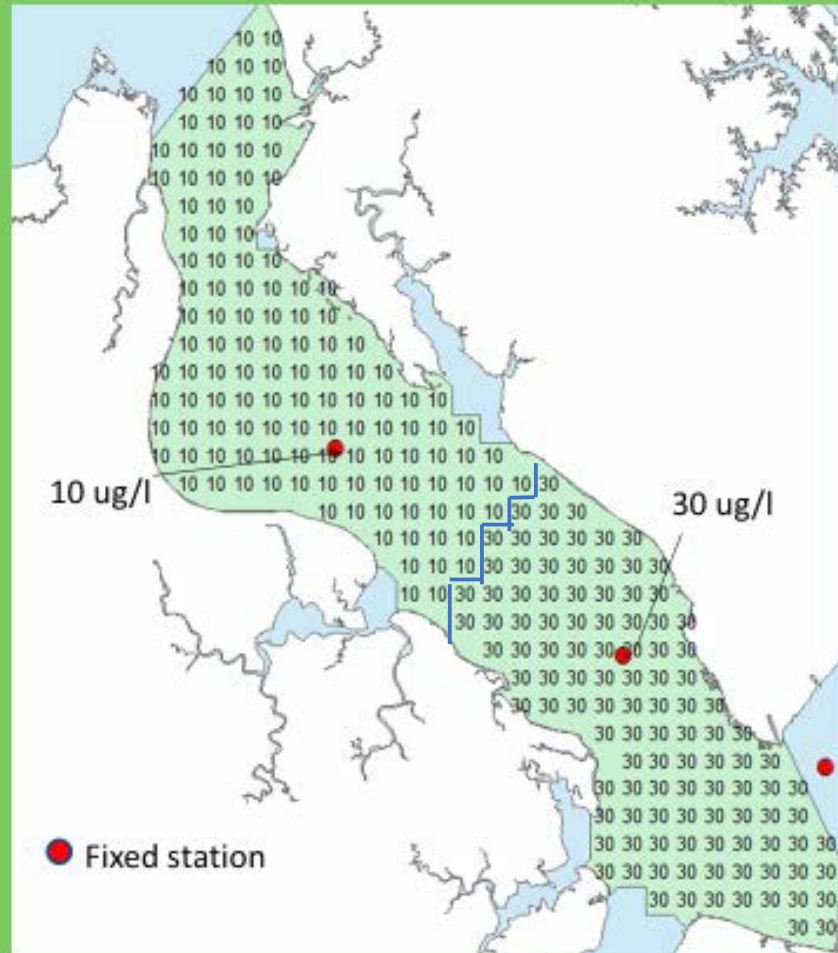
Chlorophyll *a*: And there are opportunities here in the bay to get single day, baywide assessments with alternate assessment protocol strategies, e.g. Hi-res satellite imagery

1 Bay segment, 2 fixed stations, limited variability expressed

vs. Full bay and tribs, continuous gradient CHLA

The Interpolator fills "in" and "out" so that we can calculate the aerial extent of exceedence.

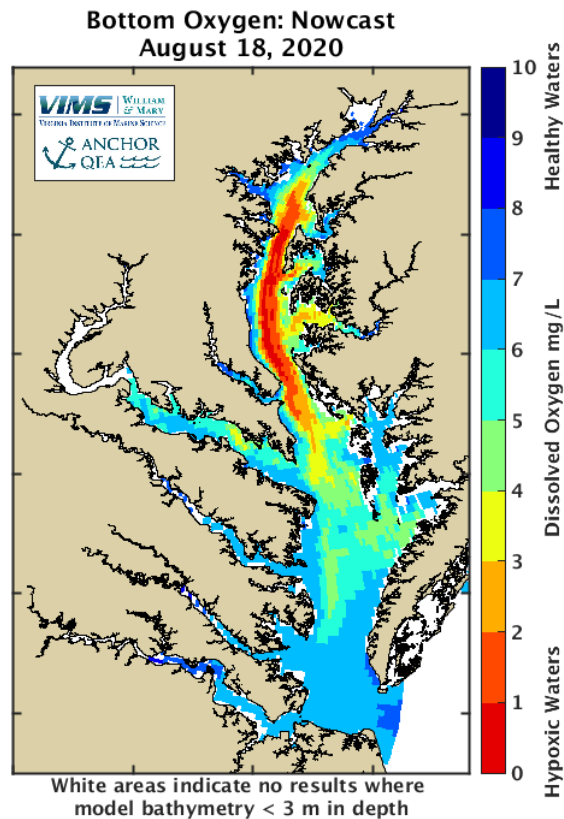
Note: It does not create or rely on any statistical model of spatial variation (e.g., a variogram).



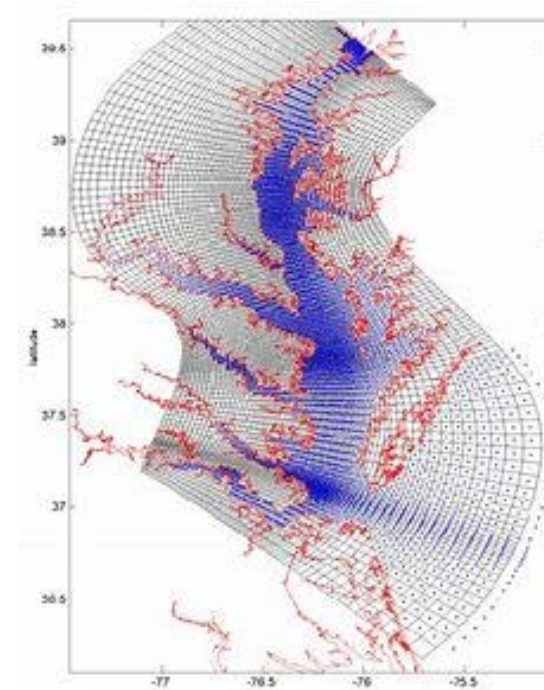


Data Interpolation – We are not nimble for data integration. 1980s methods in our 2020s world. We can do much better.

- Is ChesROMS our next generation interpolator?



- Are we ready to create the 4-D interpolator?



- *Post-doc feasible project with AI/ML and enhanced monitoring*

# \*\*\*Reminder\*\*\*

*Through the 2014 Chesapeake Bay Watershed Agreement, the Chesapeake Bay Program has committed to...*



**Goal:** *Water Quality*

**Outcome:**

*Continually improve the capacity to monitor and assess the effects of management actions* being undertaken to implement the Bay TMDL and improve water quality. Use the monitoring results to report annually to the public on progress made in attaining established Bay water-quality standards and trends in reducing nutrients and sediment in the watershed.

# Draft workshop themes on how we improve capacity

- **Theme 1. NO NEW DATA**
- Sustain existing long-term water quality monitoring program as it is.
  - **Option 1. Use existing data with new rules of interpretation.**
    - Pro and Con – if 1-2 samples can represent an estimate of the 30-day mean, why don't we use 1 sample as an estimate of the instantaneous minimum, 1-day mean, and 7-day mean criterion assessments?
  - **Option 2. Update the standards for dissolved oxygen to be reported based on the Multimetric Water Quality Standards Indicator results**
    - Pro and Con – EPA relies on the Indicator results for tracking and reporting progress on meeting water quality standards. Revise the standards to make the indicator the basis for the standard assessment
  - **Option 3. Fully implement Conditional Probability approach (“Umbrella Criterion Assessment”).**
    - Pro and Con – the methods have been documented in 1996, 2004 and 2017. Establish future cycles as using these methods to report achievement of all DO standards.

# Workshop Themes on improving capacity

- **Theme 2. INTEGRATE NEW DATA and NEW TOOLS**

- **Option 1. Apply existing analyses to data with improved resolution in space and time**

- Pro and Con – incorporate Tier 3 Cit Sci and Nontraditional Partner Data, Incorporate vertical profiler data, Incorporate Satellite data into existing assessments.

- **Option 2. Apply new data interpretation approaches**

- Pro and Con. Florida is using satellite image assessment of CHLA proxy measures with uncertainty evaluated in order assessment standards. We use proxies in the watershed for phosphorus load estimation from suspended sediment data. AI/Machine learning algorithms are capable of fine scale assessment of submerged aquatic vegetation. NASA generated baywide estimates of turbidity in shallow water. Why aren't we using these methods to help us assess the Bay?

- **Option 3. Develop next generation interpolation with low and high frequency monitoring feeds**

- Pro and Con – Inverse distance weighting has no connection to underlying influences on constituent distributions. Is 4-D interpolation through machine learning algorithm development now feasible? Why not use ChesROMS?

---

# Comments and Suggestions Welcome!

---

- Structure of Workshop?
- Draft Themes and Options are open for editing, additions/deletions
- Workshop Team volunteers





