Criteria Assessment Protocol Workgroup

April 12, 2023

Peter Tango – Chair

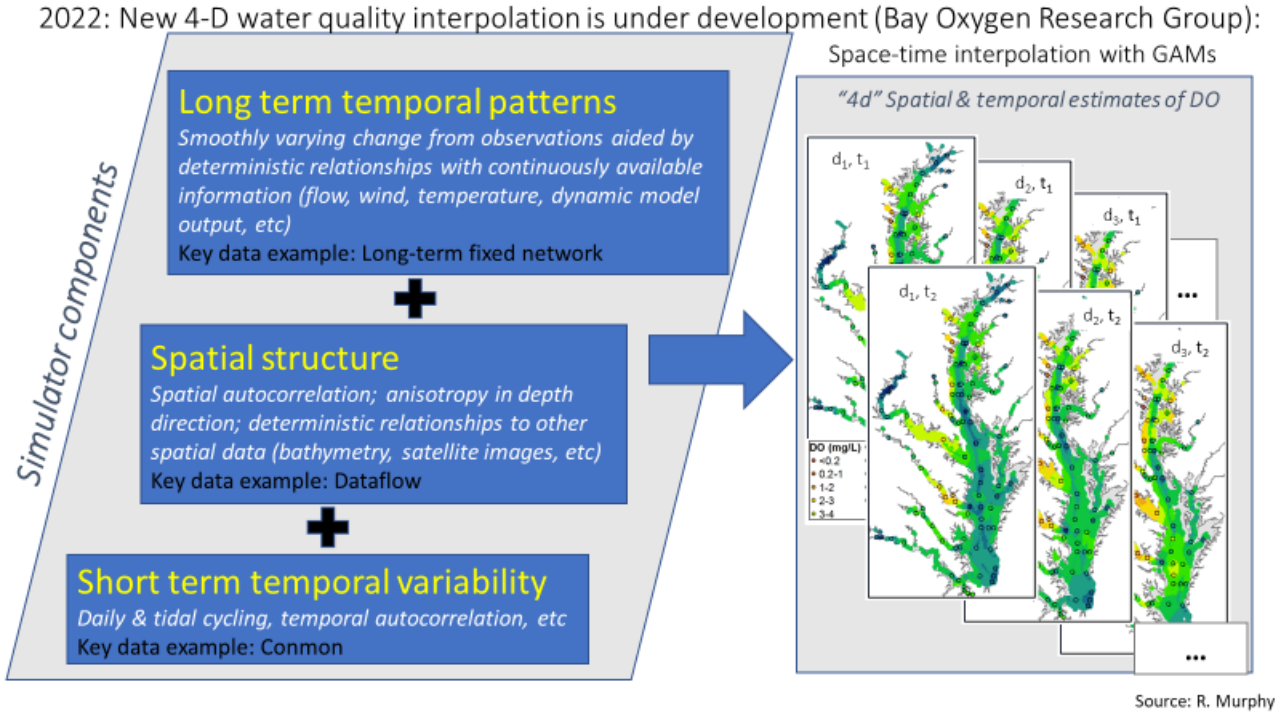
USGS@CBPO

Bay Oxygen Research Group (BORG) – 4 D Interpolator Development updates

- Co-coordinators/Co-Chairs
  - Rebecca Murphy & Peter Tango

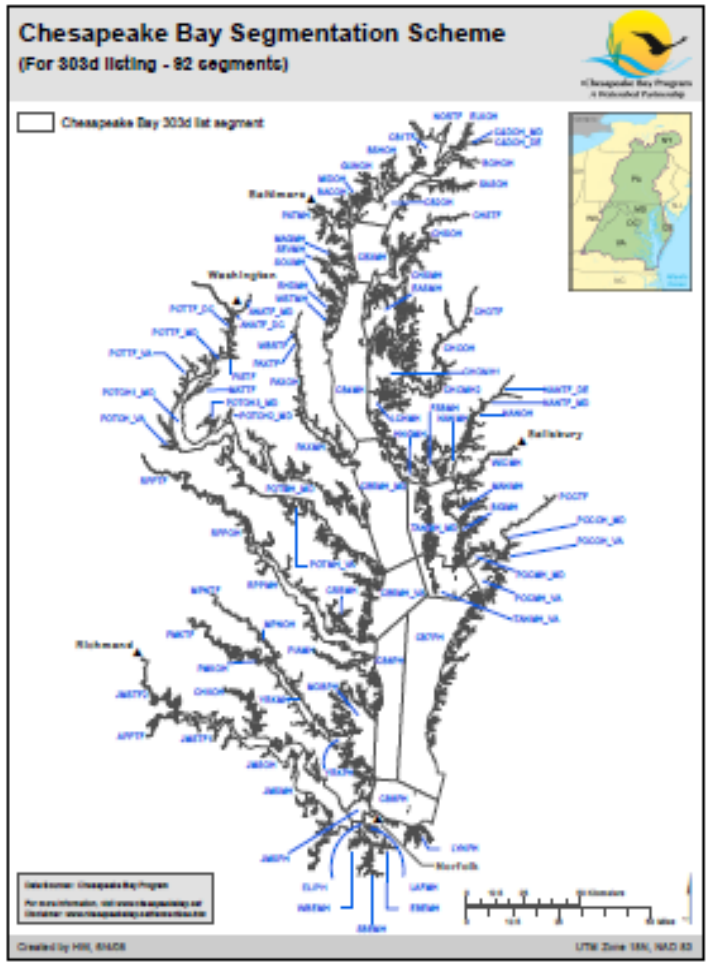
BORG Profile pics

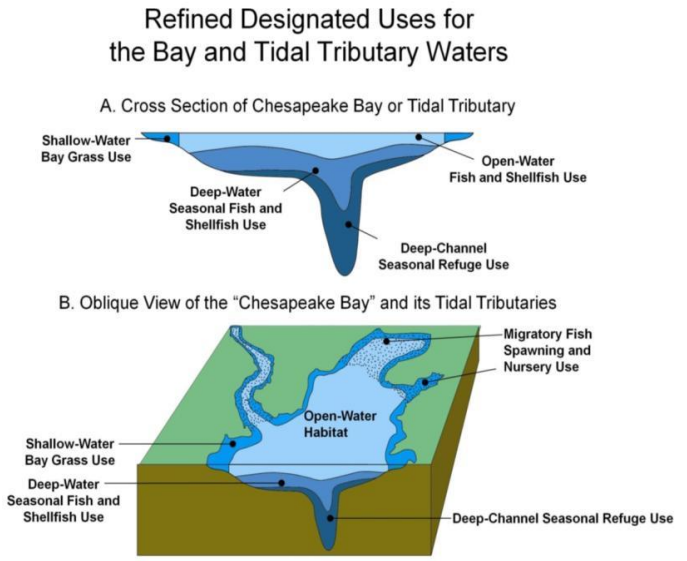
- STAR Staffer
  - August Goldsfischer



Source: R. Murphy

REMINDER: Clean Water Act Water Quality Standards Monitoring and Assessment Issue: A segment must meet **all criteria** in **all applicable designated uses** for a decision on listing category in State water quality standards





No assessment available for approximately 61% (512 of 838) Individual decisions needed to make a full assessment of the bay criteria (PT)

0

The number of segments we have full monitoring data accounting for to support all criteria assessments needed to make a delisting decision

Challenges

- Unassessed criteria remain a hurdle for delisting decisions of State-adopted water quality standards with our existing framework
- Contraction of traditional long-term monitoring programming
- 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 ≥ 6 mg/L tidal habitats with 0-0.5ppt salinity		February 1 – May 31
	Instantaneous min ≥ 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	≥ 5.5 mg/L Salinity: (0-0.5ppt)	Year-round
		≥ 5 mg/L Salinity: >0.5ppt	
	7-day mean	≥ 4 mg/L	
	Instantaneous min ≥ 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 ≥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
	Open water F & S applies		October 1 – May 31

Historical interest in 4-dimensional (4D) water quality interpolation: 2008 STAC Workshop

Assessing the feasibility of developing a four-dimensional (4-D) interpolator for use in impaired waters listing assessment December 2008 STAC Publication 08-008

Recommendations from the STAC Expert Panel

- Frank Curriero (Johns Hopkins University)
- Eileen Hofmann (Old Dominion University)
- Ragu Murtugudde (University of Maryland)
- Jian Shen (Virginia Institute of Marine Science)
- J. Andrew Royle (U.S. Geological Survey)

2008 Findings

- The panel recommended a study to evaluate the different approaches available for developing a 4-D interpolator
- Data analysis studies should be initiated to develop the statistical basis for a 4-D interpolator.

2022: New 4-D water quality interpolation is under development (Bay Oxygen Research Group):

Space-time interpolation with GAMs

Simulator components

Long term temporal patterns

Smoothly varying change from observations aided by deterministic relationships with continuously available information (flow, wind, temperature, dynamic model output, etc)

Key data example: Long-term fixed network

+

Spatial structure

Spatial autocorrelation; anisotropy in depth direction; deterministic relationships to other spatial data (bathymetry, satellite images, etc)

Key data example: Dataflow

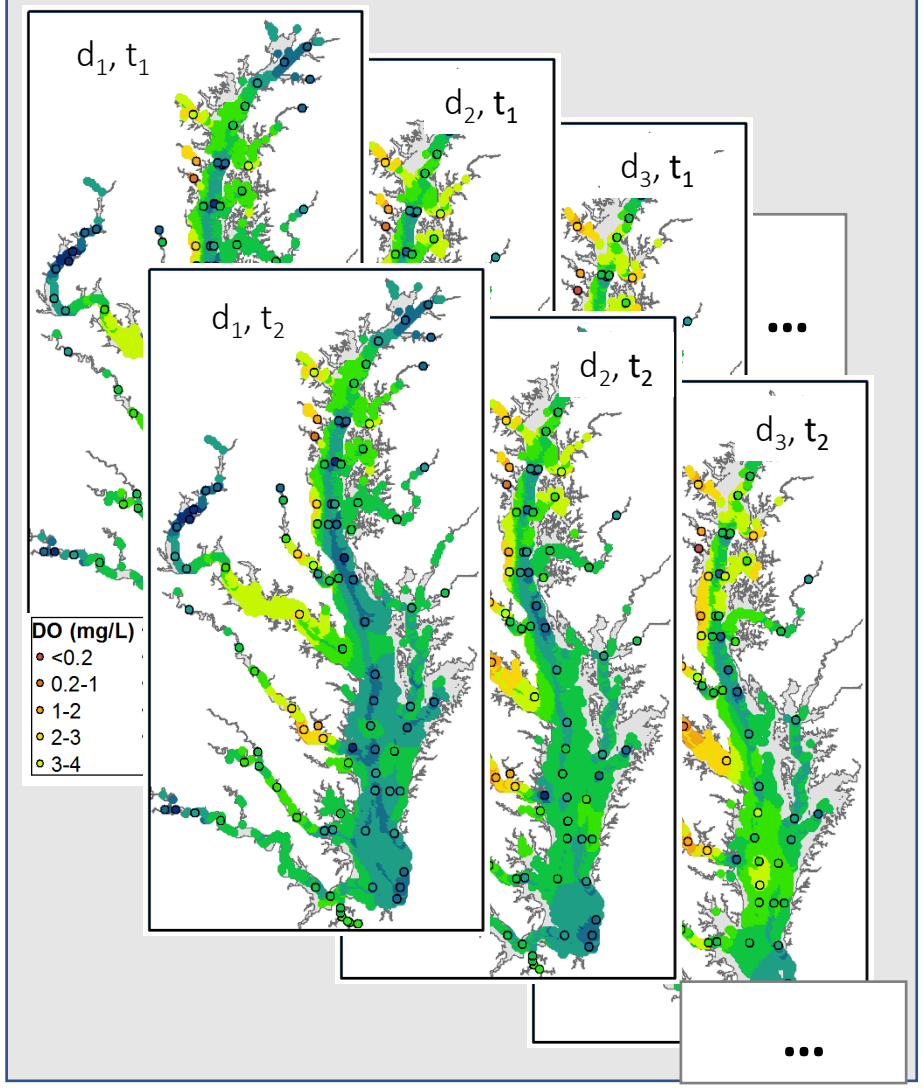
+

Short term temporal variability

Daily & tidal cycling, temporal autocorrelation, etc

Key data example: Conmon

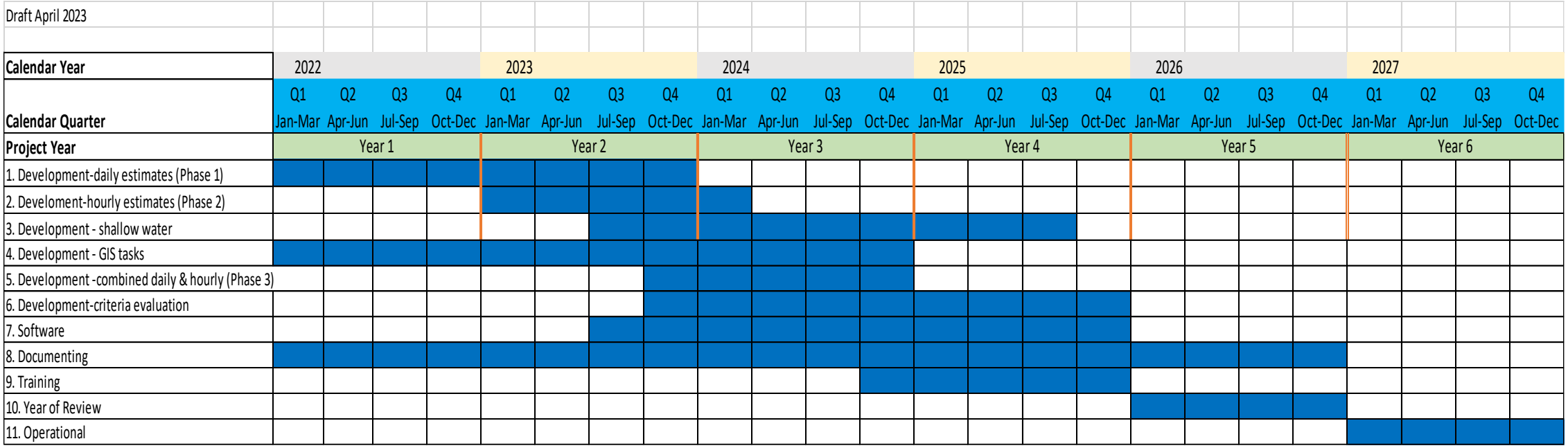
"4d" Spatial & temporal estimates of DO



Source: R. Murphy

4D Interpolator Tool: Work timeline

- We are still very much in the early development and testing phases.

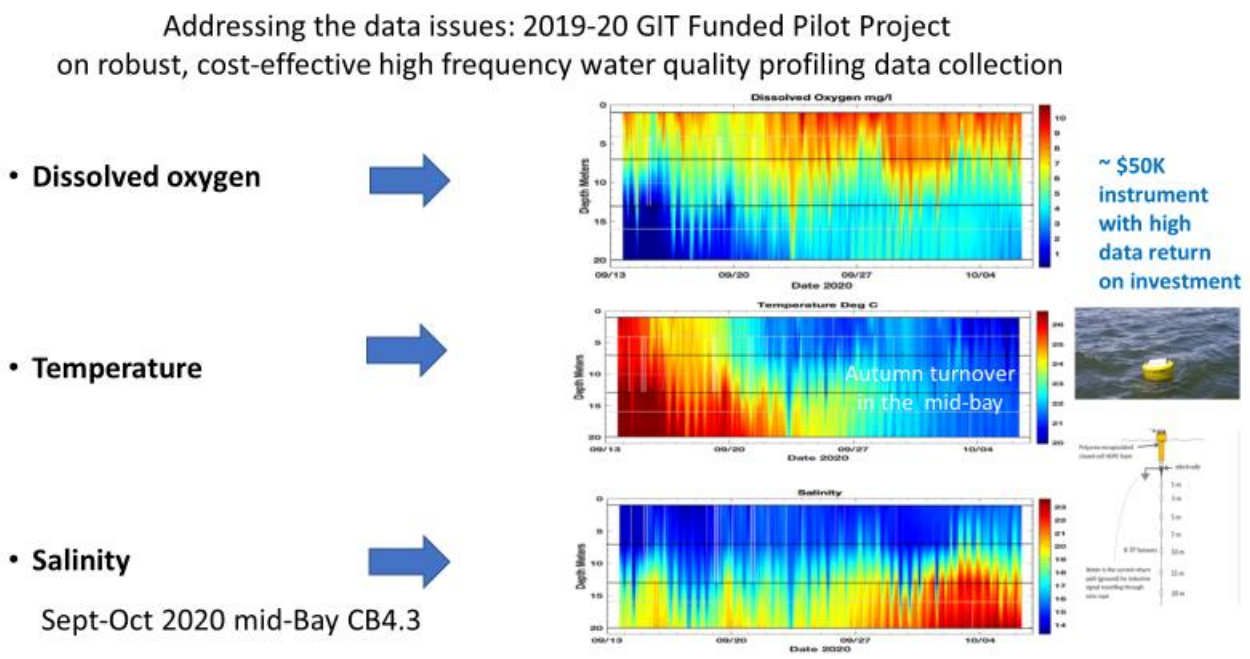


2022-early 2023 4D progress

- Angie Wei, GIS, helped set up a coordinate system underpinning the tool
- Success on having a working prototype using GAMs for a large chunk of the mainstem bay. (Elgin Perry and Rebecca Murphy)
  - Work ahead looking at performance
- Successful test of a prototype for applying the mainstem interpolation approach to the Patuxent River. (Rebecca Murphy)
- Tests underway for knitting together tributaries with mainstem as one method for structuring the interpolator (Elgin Perry, Rebecca Murphy)
- Tetra Tech support in place to help on assembling data, creating the software of a working tool, documentation, etc.

Hypoxia Collaborative 2023

- Leadership Team
  - Bruce Vogt
  - Jay Lazar
  - Kevin Schabow
  - Peter Tango
  - Justin Shapiro
  - Breck Sullivan
  - August Goldfischer



D. Wilson 2020. 2019-2020 Chesapeake Bay Trust GIT-funded pilot project results

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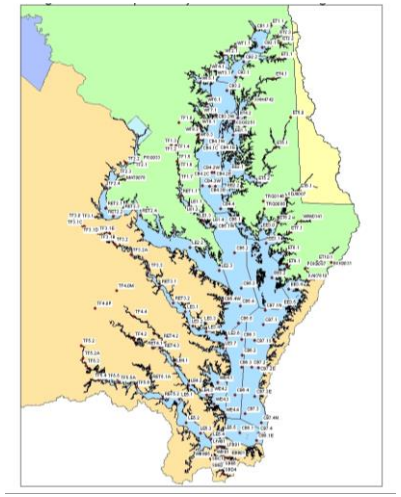
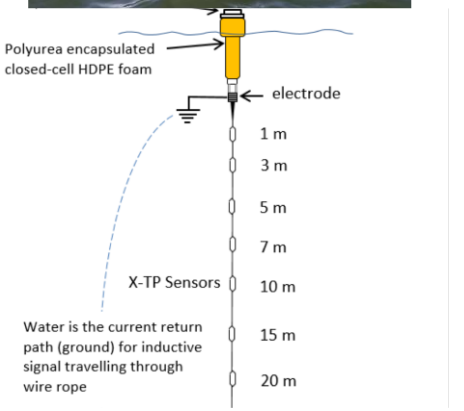
2008 Findings

- A consensus opinion from the expert panel was that **the sampling frequency and spatial resolution of the existing Chesapeake Bay datasets are insufficient for successful extrapolation to four dimensions**.

Fast forward 2019-2023

- However, there is an on-going effort among Chesapeake Bay partners to acquire funding to deploy continuous monitoring buoys, which are equipped with vertical profilers in deep water areas of the Chesapeake Bay and tidal tributaries.
  - GIT funded Pilot project 2019-2020
  - NOAA investments in initial arrays
  - PSC Monitoring Review: recommendations for 10 array+ network
    - 2023+ 5yr annual funding to support EPA-NOAA approx. $1M





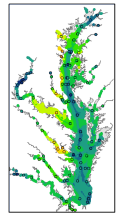
"*If these (i.e., expanded data collection with high temporal density water column measures) efforts succeed, then the shortcomings of existing datasets will be greatly alleviated.*"

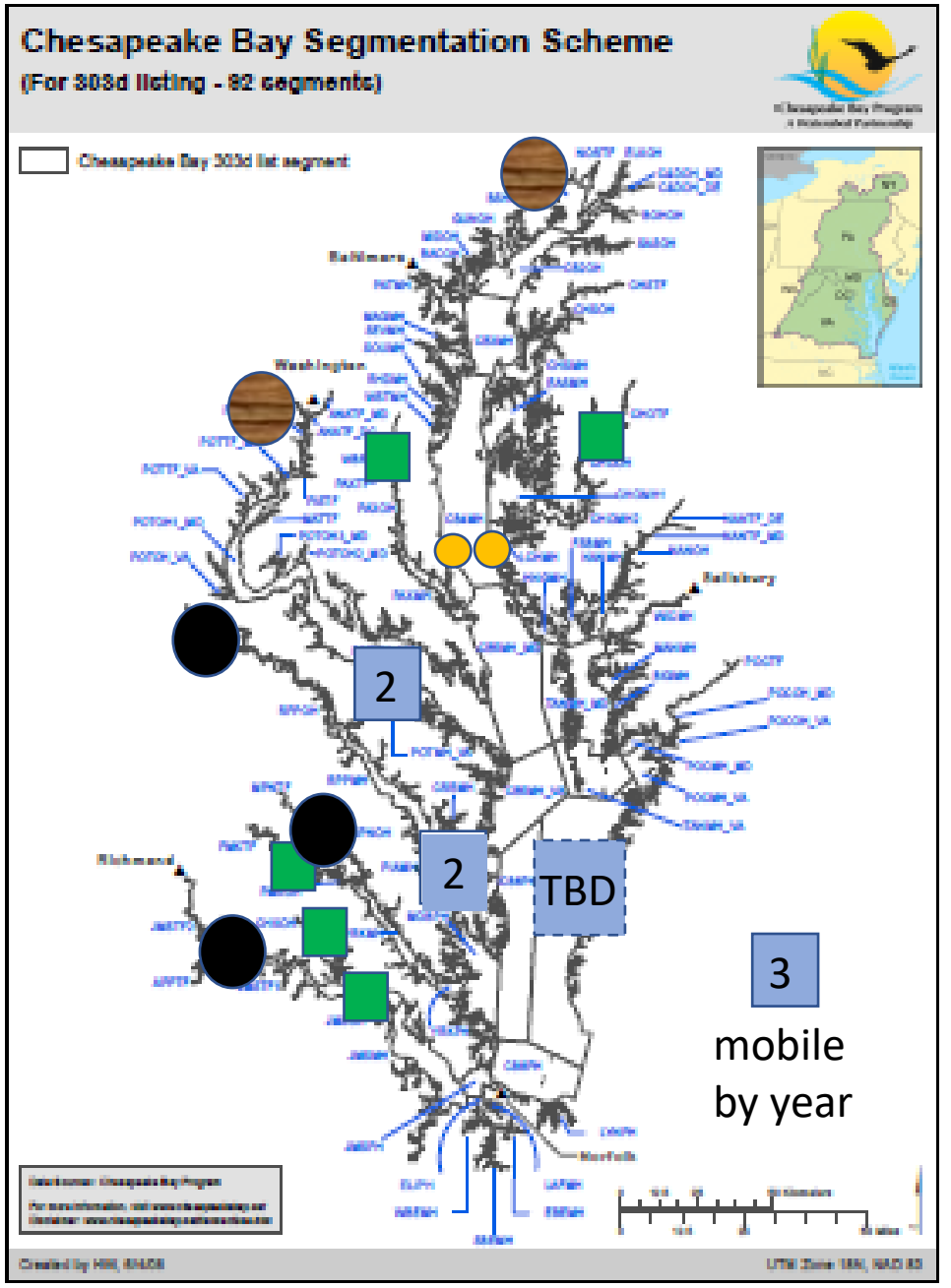
Curriero et al. 2008 STAC Workshop

Addressing high temporal frequency data needs issues by expanding monitoring and assessment capacity 2021+

- NOAA supports 2 vertical sensor arrays
- 3 fully funded river input water quality continuous monitors
- 2 river input water quality continuous monitoring sites with support ending, need funding

- 2021-22 PSC Monitoring Review proposal for capacity to support unassessed criteria assessment, improved fish habitat assessment, modeling calibration and verification:
  - 8 new tidal water vertical array sites
  - 5 new river input con-mons at tidal/nontidal boundary
  - New 4-D water quality interpolator tool development





2023 deployments of 3 vertical arrays

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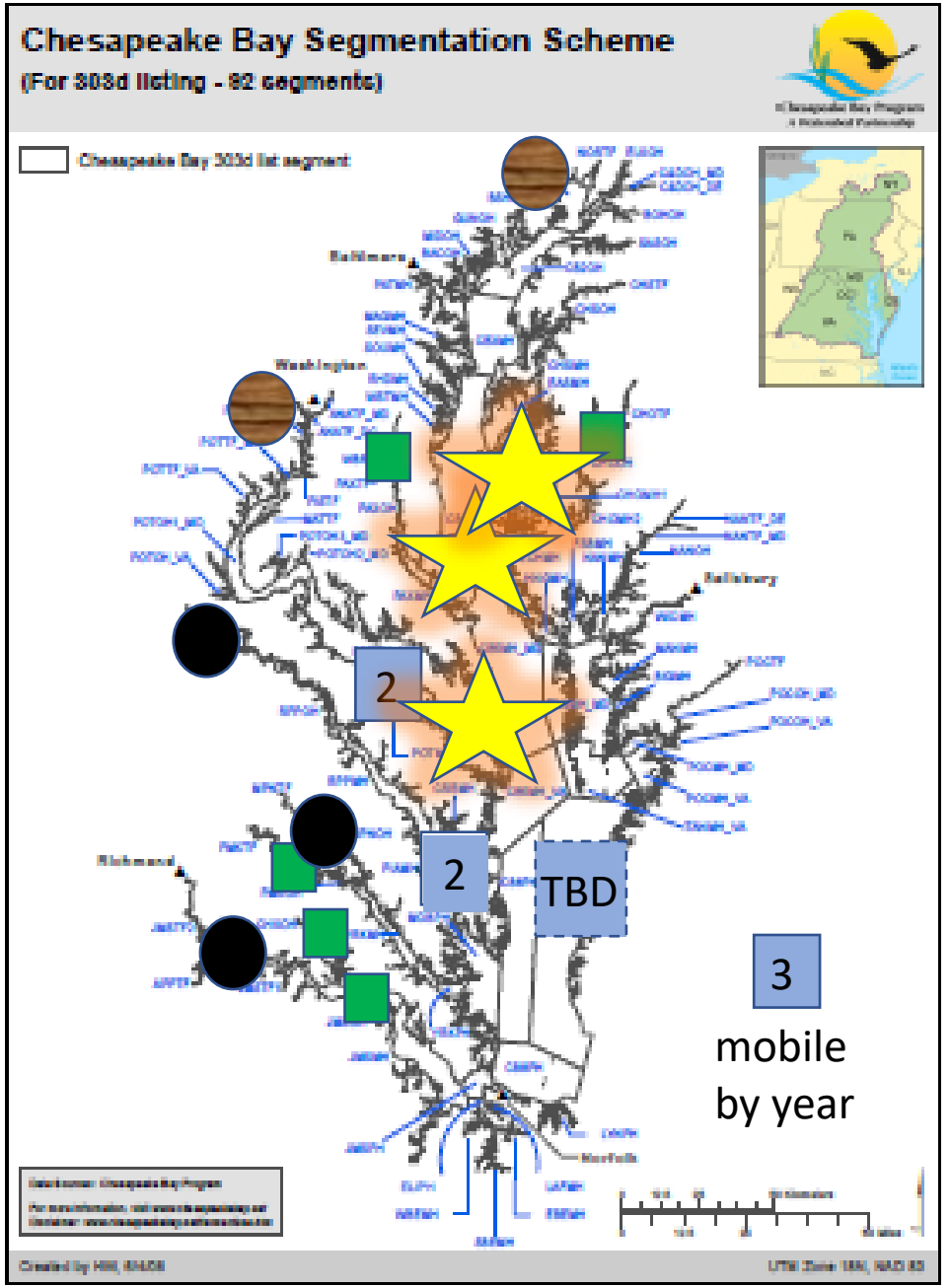


Hypoxia Collaborative work ahead

- Guidance development on decisions supporting future deployments
  - 2023 - Leadership Team is drafting a document

- Guidance development on integrating nearshore con-mon with offshore arrays for effective habitat characterization and criteria assessment
  - 2023 – initiating meetings on developing and testing of sampling designs, reviewing recent publications, discussing support for sampling strategy options and testing
    - USGS is aiming to have support for sampling design development of multiple outcomes
    - Opportunity for GIT-funded proposal, and or a STAC Workshop
    - Aligns with upcoming STA CESR report recommendations directed at importance of working in nearshore habitats

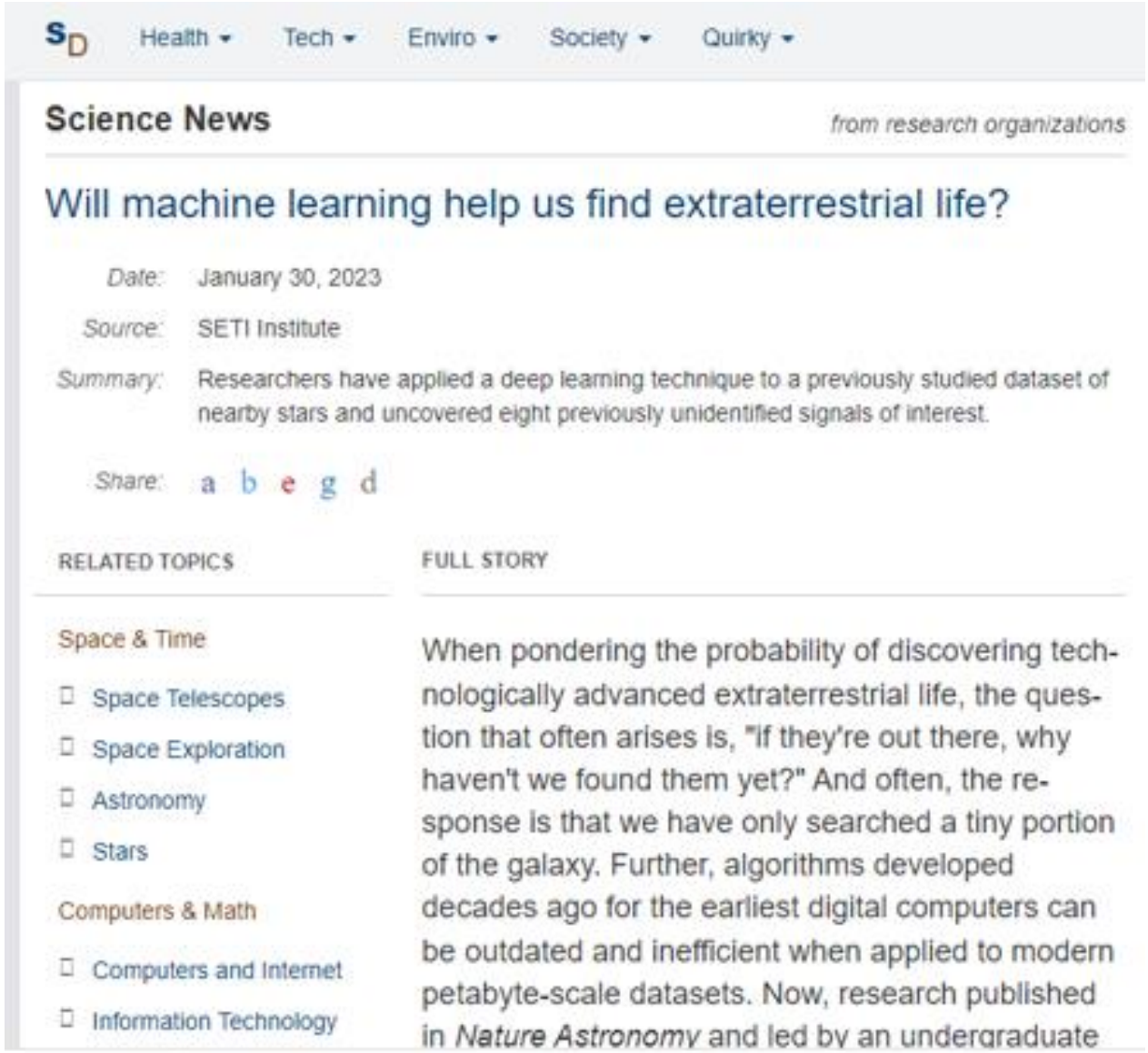
Needs for 2023-24

- *Sampling strategy support, nearshore and offshore*
  - *(see Hypoxia Collaborative support)*
- *Documentation of tool development, methods developments*
- *Updated assessment protocol*
  - *Probability of attainment approach details needed*
  - *Temperature-adjusted d.o. criteria?*
    - *(CAP WG Workshop in 2024-25?)*
- *Development work/documentation will need to run through STAC Review, WQGIT for comment and approval (2025-26)*

Satellite-based SAV surveys - Status

- SAV WG, STAR
- Brooke Landry, Peter Tango, Breck Sullivan, August Goldfischer

New tools are being explored and applied for advancing monitoring efficiency and effectiveness



SD Health Tech Enviro Society Quirky

Science News *from research organizations*

Will machine learning help us find extraterrestrial life?

Date: January 30, 2023

Source: SETI Institute

Summary: Researchers have applied a deep learning technique to a previously studied dataset of nearby stars and uncovered eight previously unidentified signals of interest.

Share: a b e g d

RELATED TOPICS

Space & Time

- Space Telescopes
- Space Exploration
- Astronomy
- Stars

Computers & Math

- Computers and Internet
- Information Technology

FULL STORY

When pondering the probability of discovering technologically advanced extraterrestrial life, the question that often arises is, "if they're out there, why haven't we found them yet?" And often, the response is that we have only searched a tiny portion of the galaxy. Further, algorithms developed decades ago for the earliest digital computers can be outdated and inefficient when applied to modern petabyte-scale datasets. Now, research published in *Nature Astronomy* and led by an undergraduate

Who says we haven’t found it already?

SD Health Tech Enviro Society Quirky

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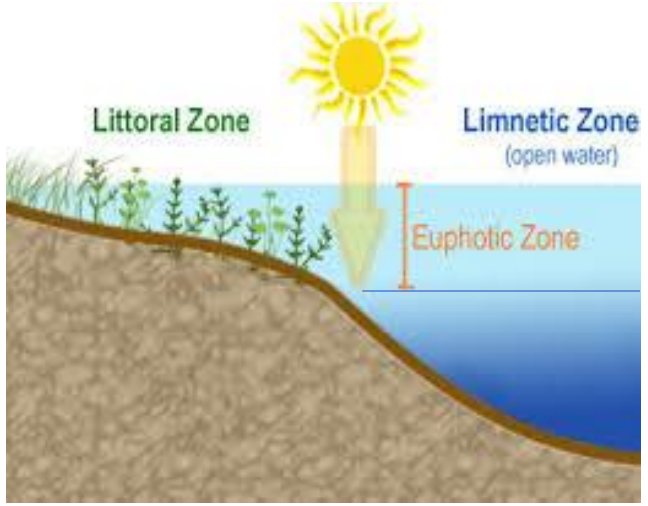
Challenges: With new tools we can see billions of light years across the universe… but we can barely see 2 meters down into the often turbid waters of Chesapeake Bay.

NASA Webb telescope images



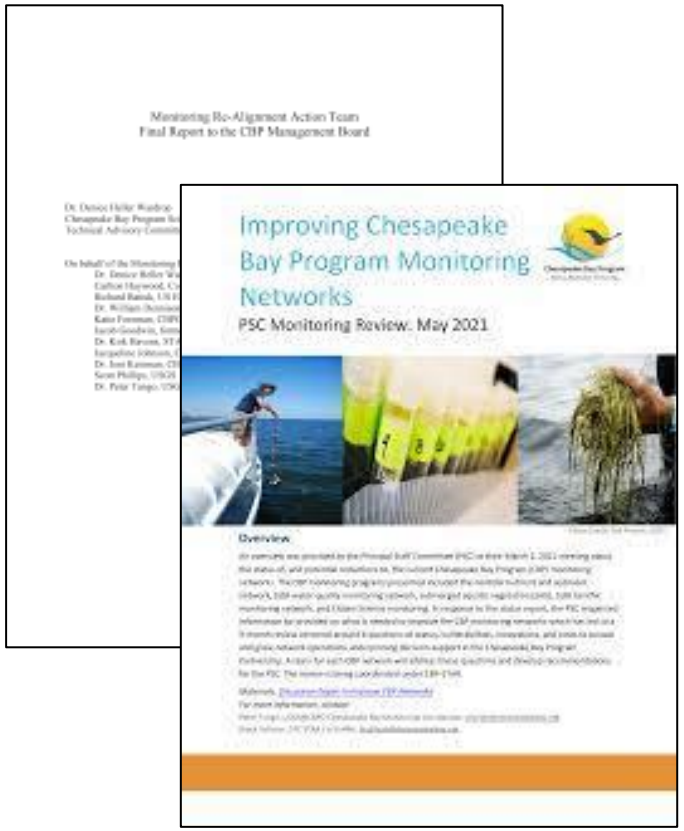
Often < 2m visibility for satellite sensors

24.7% of bay <=2m

Bay water clarity challenges

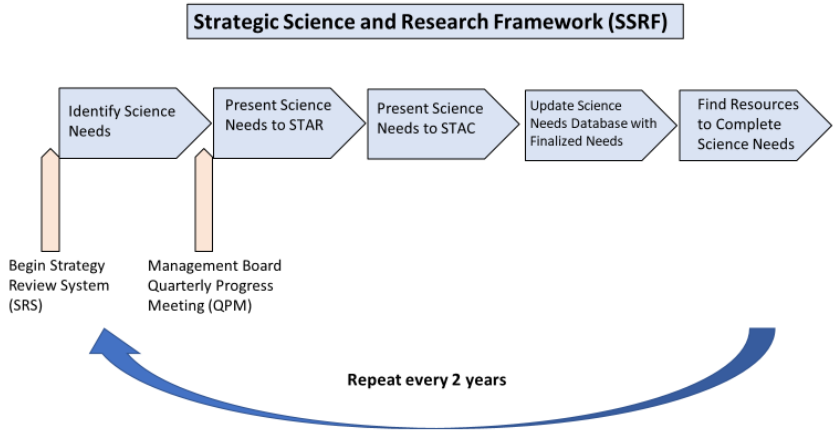
Guidance on the future of CBP monitoring programs

Approximately decadal deep dive **monitoring program reviews**



Topical Workshops with recommendations

CBP **Science Needs Database**
Program-wide data base of science, research and monitoring needs



Targeted research

JGR: Oceans Vol 118

Combining observations and numerical model results to improve estimates of hypoxic volume within the Chesapeake Bay, USA

Aaron J. Bever,[1,2] Marjorie A. M. Friedrichs,[1] Carl T. Friedrichs,[1] Malcolm E. Scully,[3] and Lyon W. J. Lanerolle[4]

Received 15 March 2013; revised 10 July 2013; accepted 25 July 2013.

> Environ Monit Assess. 2022 Nov 29;195(1):163. doi: 10.1007/s10661-022-10725-1.

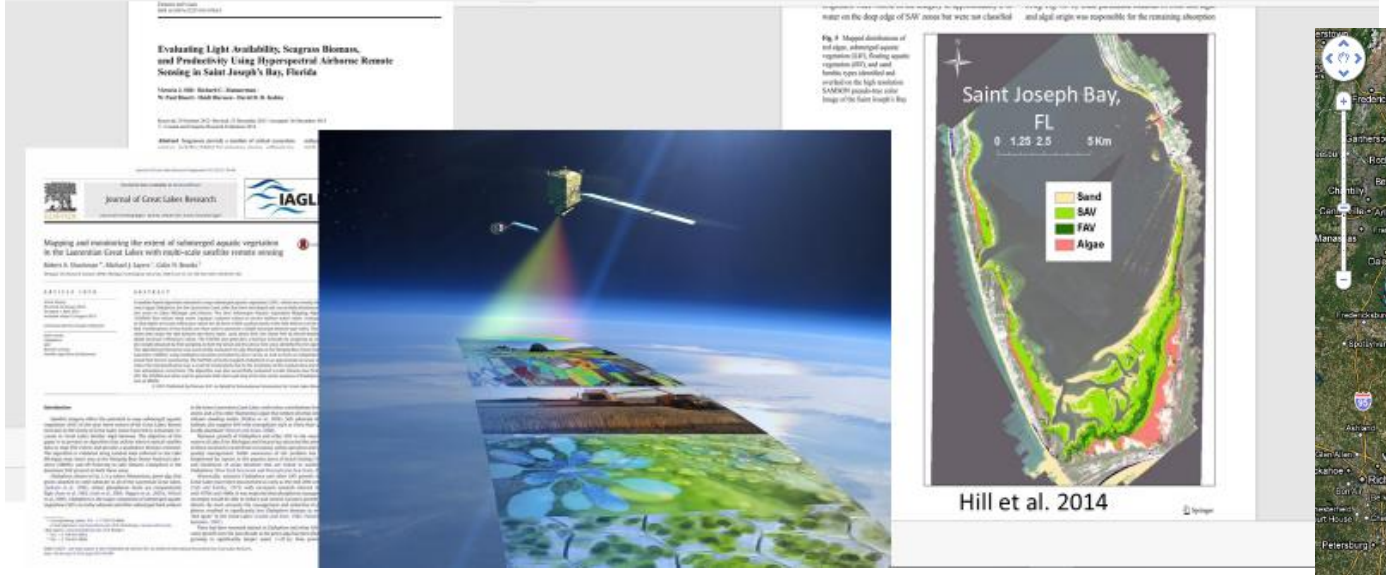
A hydrodynamic model-based approach to assess sampling approaches for dissolved oxygen criteria in the Chesapeake Bay

Dong Liang [1], Jeremy M Testa [2], Lora A Harris [2], Walter R Boynton [2]

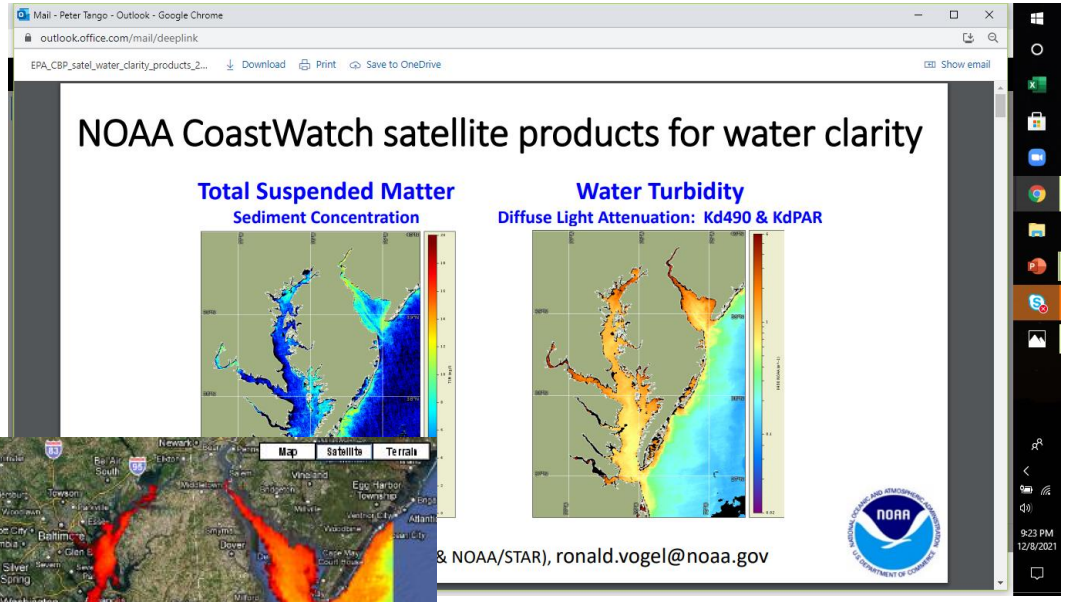
Satellite-based opportunities are maturing

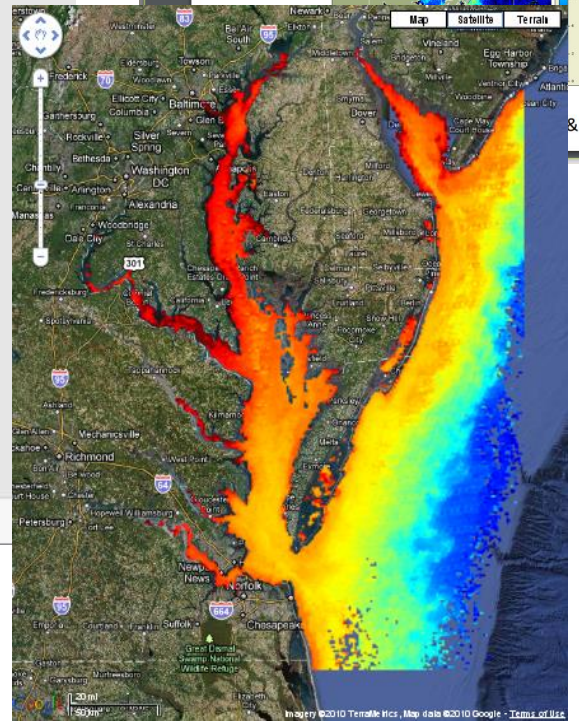
Decision-support needs: Support cost efficiencies, expand seasonal coverage, address blue carbon accounting

E.g. Financing the SAV program: 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



- Notable progress from teams including: V. Hill, R. Zimmerman (ODU), B. Schaeffer (EPA), and M. Coffer (EPA/NOAA)





- Notable progress from teams including: M. Tomlinson, R. Stumpf, R. Vogel (NOAA)

NOAA Coastwatch
Chlorophyll
Satellite: NASA Aqua
https://eastcoast.coastwatch.noaa.gov/info_chl.php

Recent progress – future outlook

- *Satellite-based SAV assessment –*
- Reviewed in the 2022 STAC-sponsored Advanced Monitoring Workshop
  - Report under development

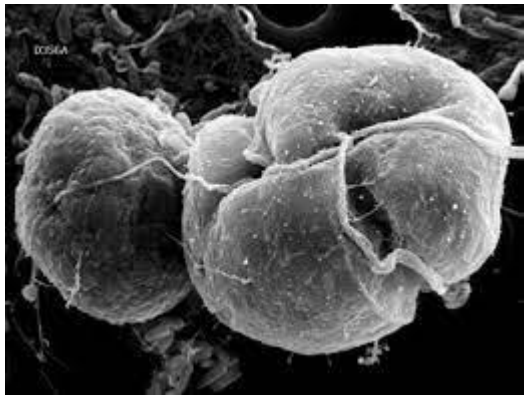
- *2022 PSC Monitoring Report recommendations – **EPA target of support***
  - *Needs for image characterization algorithm tuning*
  - *Drawing polygons from pixel data*
    - *Calibration of AI/ML assessment with existing aerial survey-hand drawing beds methods for historical comparison*
    - *Proposed RFA to close the loop on these particular issues captured in the PSC Review*
    - *Per criteria assessment needs : Expecting any such work to require documentation of the protocol from image acquisition through SAV cover assessment*
      - *stay tuned*
- *New image acquisition costs?*
  - *Meeting notes – work continues on cost relationship with commercial service providers with EPA, USGS, NASA*
    - *Government representatives working on the relationship building here – stay tuned.*

Satellite-based CHLA and HABs assessments

Table 1 Satellite comparisons for bloom applications. Source Richard Stumpf

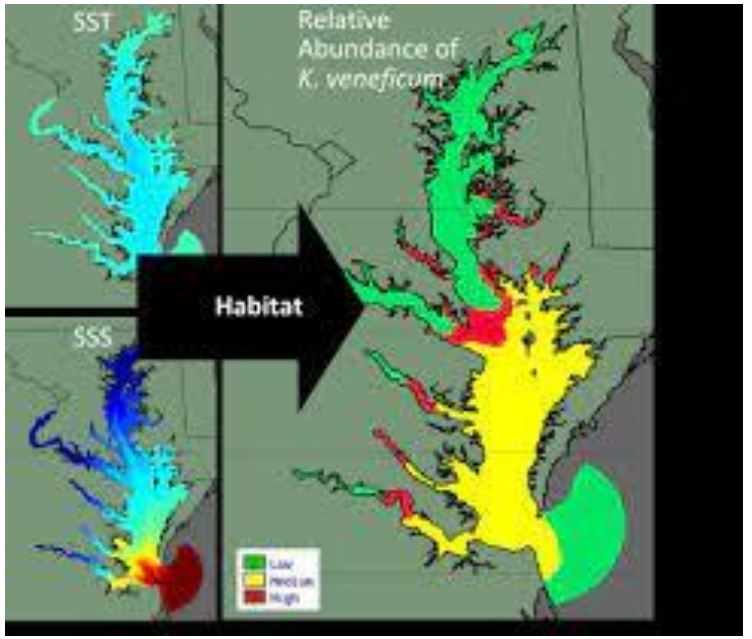
Satellite	Spatial	Temporal	Key Spectral
MERIS 2002-12 OLCI Sentinel-3 2016-present	300 m **OK**	5-6 per week (2 satellites) **Good**	10 (5 on red edge) **Good**
MODIS high-res Terra 1999; Aqua 2002	250/500 m **OK**	1 per 1-2 days **Good**	4 (1 red, 1 NIR) **Marginal**
MODIS low res	1 km **Poor**	1 per 1-2 days **Good**	7-8 (2 in red edge) **OK**
Landsat	30 m **Good**	1 per 8- or 16-days **Poor**	4 (1 red, 1 NIR) **Marginal**
Sentinel-2a (2015), 2b (2017) MSI	20 m **Good**	1 per 5 days with 2 satellites **OK**	5 (1 red; 2 NIR, 1 in red edge) **OK**

20 years ago… early attempts to estimate HABs distributions. (NOAA + MD DNR)



Karlodinium micrum

Karlodinium micrum related fish kill, MD



A 2023 workshop was supported by the

* National Oceanic and Atmospheric Administration's (NOAA)
* National Sea Grant College Program and National Centers for Coastal Ocean Science,
* along with Maryland Sea Grant and
* Florida Sea Grant.

- *Applying novel techniques to assess and forecast HABs in Chesapeake Bay to protect fisheries, aquaculture and human health* workshop held over two half-days, on January 18 and 19, 2023.

  - Report draft completed (March 2023)
  - Under revision before release

Things to follow-up on from this workshop and report

- Workshop goals:
    - To understand how HABs affect the operations of aquaculture, recreational fishing & other water dependent users.
    - To understand the HAB spatial information & forecasting needs of resource managers (and areas of synergy w/ researchers).
    - To learn about potential forecast data products & how output could be used (capabilities & limitations).
    - To compile information on potential uses of (satellite imagery & forecasting) tools and products.
    - To assess current monitoring and observing efforts that could lead to the development of a forecast and identify gaps.

Initial thoughts and discussions?

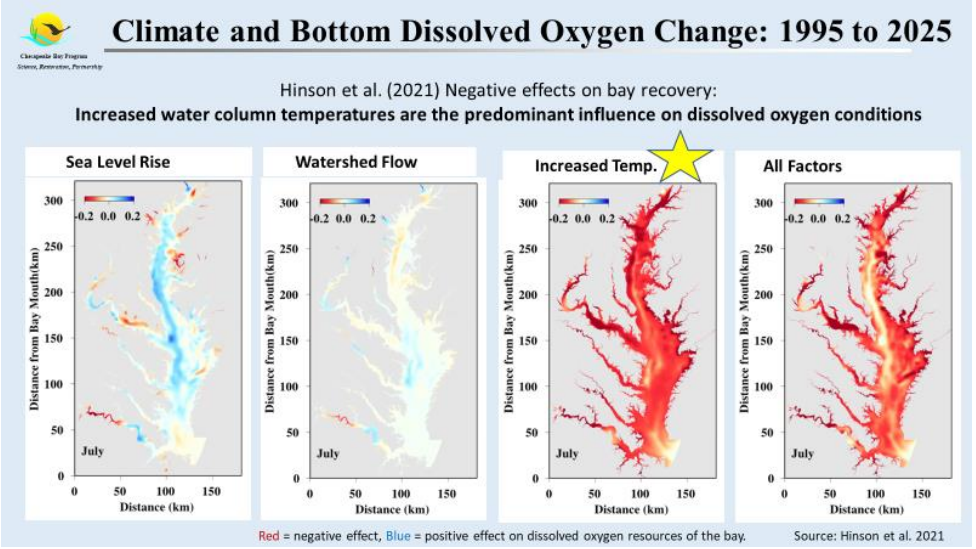
11:15 AM Next Steps/Brainstorming – Discussion, all

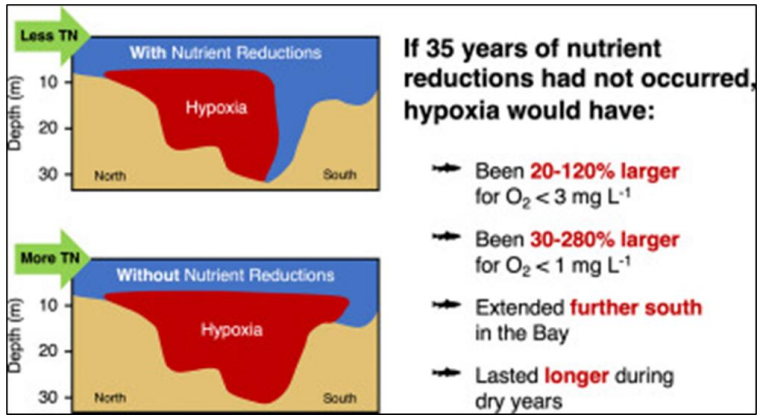
- *Satellite-based SAV Assessment –*
  - *Request SAV WG to develop documentation, provide timeline of activities*
  - *Issue of image acquisition costs – we will need a champion for tracking the government relationships with service providers*

    - *Stay tuned for updates as new work is likely to see some funding, effort, and reporting on progress*
    - *Stay tuned for new publications from key researchers on progress in methods of assessment and reporting*
    - *How else does CAP WG want to be involved/track along with this work and progress?*

11:15 AM Next Steps/Brainstorming – Discussion, all

- ***How do we (CAP WG) address consideration for temperature adjusted dissolved oxygen (DO) criteria?***
  - *Historical methods and decisions focused on sensitive species to drive criteria*
  - *Increasing evidence that warming temperatures impact bay and watershed – Hinson et al, 2021, Tian et al. 2021, and others.*
  - *Variances have played a role in accommodating challenging conditions – need someone to speak to this as an option*
  - *Do we plan for a workshop in 2024 to answer this question of do we adjust the criteria going forward, and if so, how do we adjust the criteria?*
    - *Can we do some pre-proposal planning within CAP WG?*
    - *STAC Workshop proposal submit at the end of the year*





Frankel et al.
Temperature headwinds on progress

HABs and criteria for the future

- *How do we expand criteria for HABs assessment support?*
  - *Need to discuss translating the narrative to quantitative criteria*
    - *James River study findings revisit*
    - *MD state protection translation*
    - *New HAB-quantification – what is needed to implement monitoring with satellite resources to support decision-making*
    - *CHLA criteria assessment with satellite imagery – latest NOAA products using 20m imagery*
  - *Need to lay out the questions – what questions are needed to be addressed so we can*
    - *1) have acceptable quantitative HAB assessment criteria?*
    - *Use satellite imagery for criteria assessment?*
- *And given those questions – how would you like to step forward in creating the updated criteria and documenting the assessment protocol for review and approval?*