stac Chesapeake Bay Program's Scientific and Technical Advisory Committee

Exploring Satellite Image Integration for the Chesapeake Bay SAV Monitoring Program

A CBP STAC Workshop

October 2019 – February 2020

Co-chairs Brooke Landry (CBP SAV Workgroup) and Peter Tango (CBP Monitoring Coordinator)

VIMS | William & Mary
Virginia Institute of Marine Science

Old Dominion University

United States Environmental Protection Agency

USGS science for a changing world

Maryland Department of Natural Resources

Steering committee and key participants

Brooke Landry: Chair, Chesapeake Bay Program SAV Workgroup; Biologist, Maryland Department of Natural Resources *(Workshop Co-Chair)*

Peter Tango: Chesapeake Bay Monitoring Coordinator, United States Geological Survey *(Workshop Co-Chair)*

Bill Dennison: Vice President for Science Application, University of Maryland Center for Environmental Science *(STAC Member)*

Robert (JJ) Orth: Professor of Marine Science and Director of the Chesapeake Bay SAV Monitoring Program, Virginia Institute of Marine Science

David Wilcox: Manager of the Chesapeake Bay SAV Monitoring Program, Virginia Institute of Marine Science

Richard Zimmerman: Professor of Ocean, Earth, and Atmospheric Science, Remote Sensing expert, Old Dominion University

Blake Schaeffer: Remote Sensing expert, EPA Region 4 headquarters in Raleigh, NC

Carin Bisland: Partnerships and Accountability Branch, EPA Chesapeake Bay Program Office

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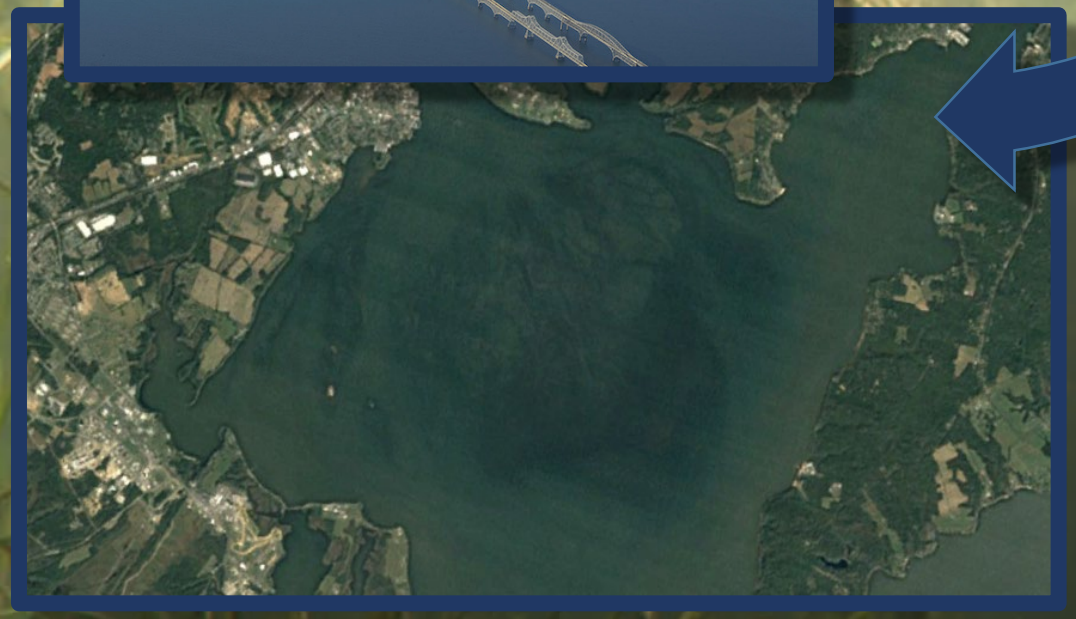
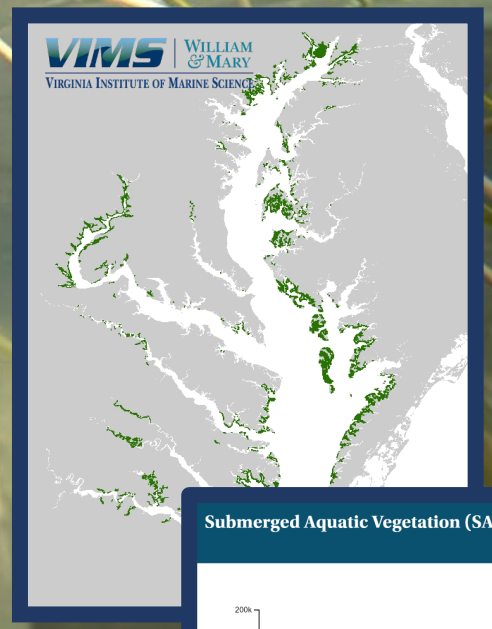
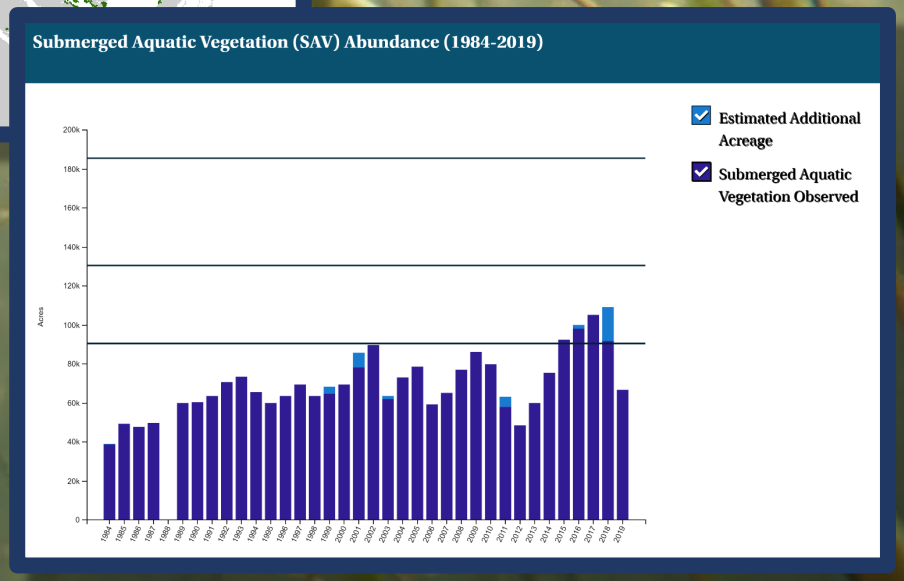
The Chesapeake Bay SAV Monitoring Program is the most successful large-scale, consistent, long-term SAV monitoring program in the world.







Bay-wide SAV Data is used for multiple purposes

1. State Water Quality criteria assessments and tracking progress toward SAV Goal Attainment

2. Aquaculture site evaluations and permitting decisions

3. Bay-wide SAV violations (i.e., propeller scarring)

4. Shoreline structures, alteration, and erosion control permitting decisions

5. Peer-reviewed science


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

Impetus for STAC Workshop: to increase the program's long-term sustainability

The Program is:

1. Increasing in price while partner funding is decreasing (and new flight contractor will raise acquisition costs more)

2. Logistically cumbersome to coordinate with flight contractors (clouds, wind, tides all need to be perfect)

3. The weather itself is becoming more difficult to deal with (more clouds, more rainy days, more flood events that create turbidity issues)

4. Increasing airspace restrictions (DoD doesn't like us taking pictures over installations)

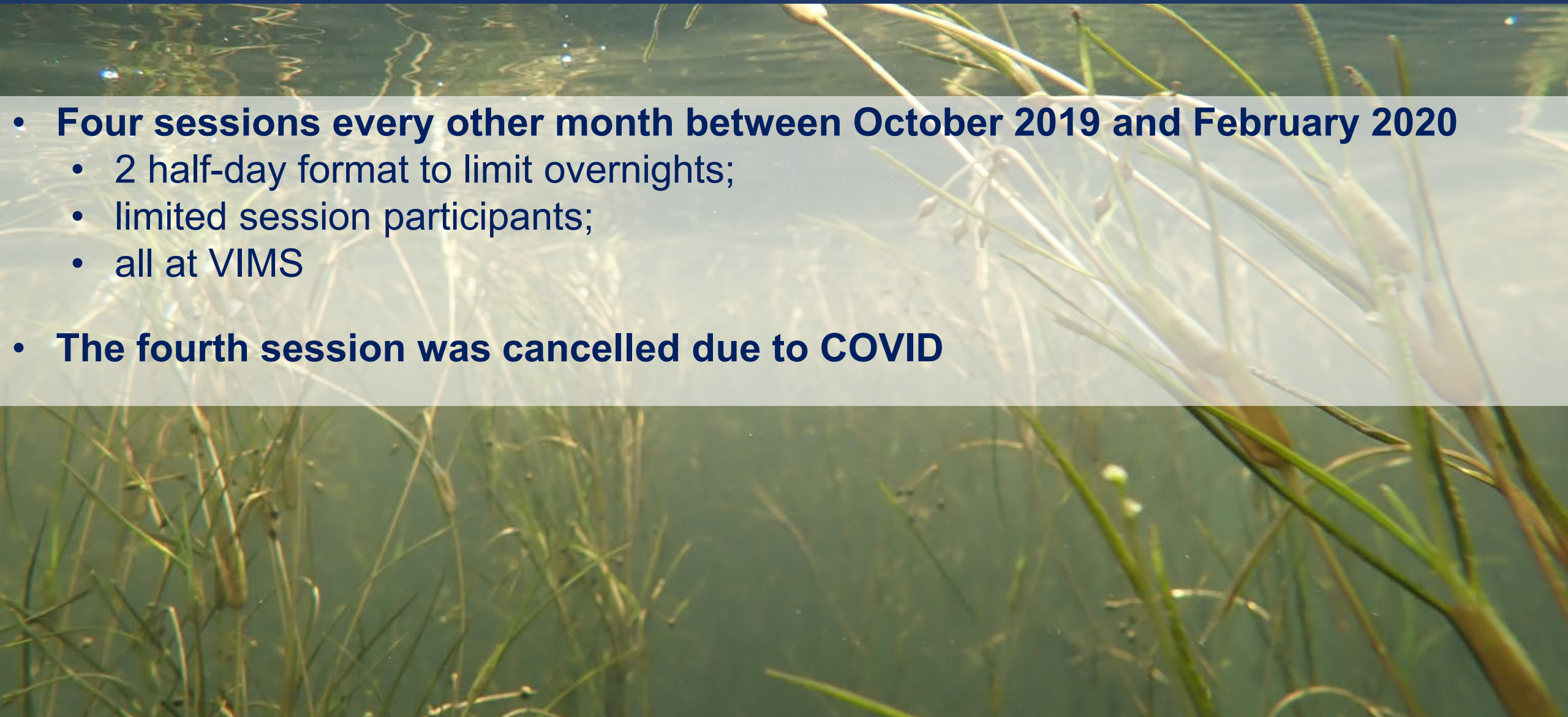
Workshop Objectives

The overarching purpose of the workshop was to determine if *High-Resolution* Commercial Satellite Imagery (CSI)

- could be obtained and processed in a more efficient and cost-effective manner than aerial imagery collected from fixed-wing aircraft, and
- could provide imagery of sufficient quality and spatial cover to monitor SAV populations throughout the Chesapeake Bay.
- could provide a route to automated processing using machine learning algorithms and artificial intelligence

Adoption of monitoring and assessment approaches with significant cost and programmatic efficiencies are needed to ensure the long-term sustainability of the SAV monitoring program.

Workshop Format



- **Four sessions every other month between October 2019 and February 2020**
  - 2 half-day format to limit overnights;
  - limited session participants;
  - all at VIMS
- **The fourth session was cancelled due to COVID**

Workshop Results: NextView License Agreement and Data Acquisition

Data Acquisition: Acquiring High Resolution CSI at no cost is an option under the NextView License agreement between the National Geospatial Intelligence Agency (NGA) and Maxar

- The NextView License was developed by the NGA to accommodate United States Government (USG) agencies, contractors, partners, and other entities that ***require*** CSI to support USG interests.
- The basic premise of the agreement is that any federal agency that ***requires*** satellite imagery from contracted commercial sources can request and obtain said imagery at no cost to the local agency.
- 2017 updates to the Water Resource Development Act, which amends Section 117 of the Clean Water Act, called for the U.S. EPA to carry out an annual SAV survey in Chesapeake Bay. This makes it feasible for the EPA/CBP to request and obtain the high-resolution CSI necessary for the annual SAV assessment at no cost.

Workshop Results: WorldView 3 Satellite Constellation

WorldView 3 Satellite Constellation:

Resolution, orbital paths, tasking capacity, tilting capacity all vary among and between public and private satellites based on their specific missions. For the purposes of the CB SAV Monitoring Program, WorldView 3 (owned by Maxar) is the best and most appropriate satellite constellation. Once launched, WorldView Legion may be even better.

WordView-3

Bands:	Panchromatic: 450-800 nm 8 Multispectral: (red, red edge, coastal, blue, green, yellow, near-IR1 and near-IR2) 400 nm – 1040 NM
Resolution:	0.31 m Panchromatic 1.24 Multispectral
Swath width:	13.1 km

Workshop Results: High Resolution CSI is adequate for SAV mapping

If acquisition of usable data and imagery is achieved, the resolution is adequate for hand-delineation of SAV beds in Chesapeake Bay:

VIMS analysts verified that given a good satellite image, they can hand-delineate the SAV just as they do from aerial imagery.

Workshop Results: Tasking the Satellites

The NextView License Agreement allows TASKING:

There's an expansive archive of CSI to browse but many of the images are obscured by cloud cover, turbid conditions, were taken during high tide or off-season, etc.

Tasking for image acquisition on specific days and under specific conditions is possible with the NextView agreement and is necessary for the SAV survey.

Workshop Results: Publication and Retention Complications

There will be multiple complications regarding CSI publication and retention.

- The imagery belongs to Maxar. Permission and licensing is required to publish each and every image, and permission is not guaranteed.
- Derived products (i.e., SAV maps) are not subject to this licensing requirement.
- EPA primarily needs the derived maps and acreage values, but state agencies need the imagery to provide transparency in the review of aquaculture lease applications and permitting decisions.

Workshop Results: Automating the Process using AI

Algorithms/AI/machine learning will eventually automate mapping, but there's significantly more work to do before algorithms are ready for CB: With funding, algorithms could be ready in 3-5 years.

Using AI may yield more precise results but skew long-term trends:

Current method of hand delineation clumps SAV patches, whereas AI would split them, excluding the sparsely populated space in between patches.

Steering Committee Recommendations

2020 and 2021: Conduct contracted aerial acquisition of Bay SAV with complimentary CSI tasking exercise and calibration study (VIMS)

- **TASKING EXERCISE**: Task for FULL BAY as back-up and mimic to determine likelihood of actually acquiring necessary data.
- **CALIBRATION EXERCISE**: Conduct a calibration exercise to determine if imagery produces similar results using 2020 CSI and aerial imagery.*

*This work was funded following this STAC workshop and VIMS has been working through the steps since spring 2020.

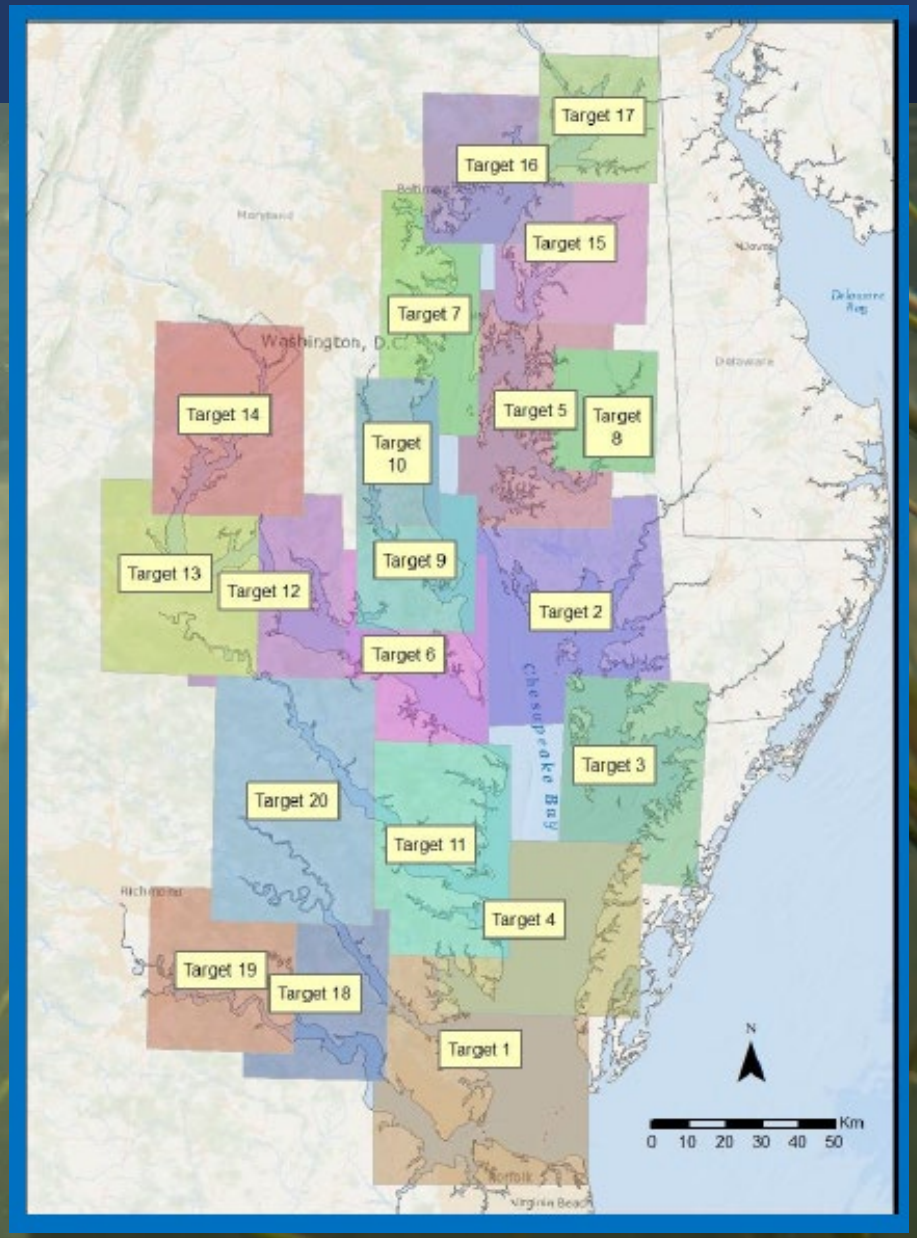
2021: Reconvene and make final recommendations based on success of tasking and calibration. Write addendum to report.

2021 and beyond: Continue algorithm development for automated mapping.

Tasking and Calibration Studies: Preliminary results

Divided the Bay into 20 target areas for potential satellite imagery acquisition.

Only one area was selected per day to avoid competing with ourselves.

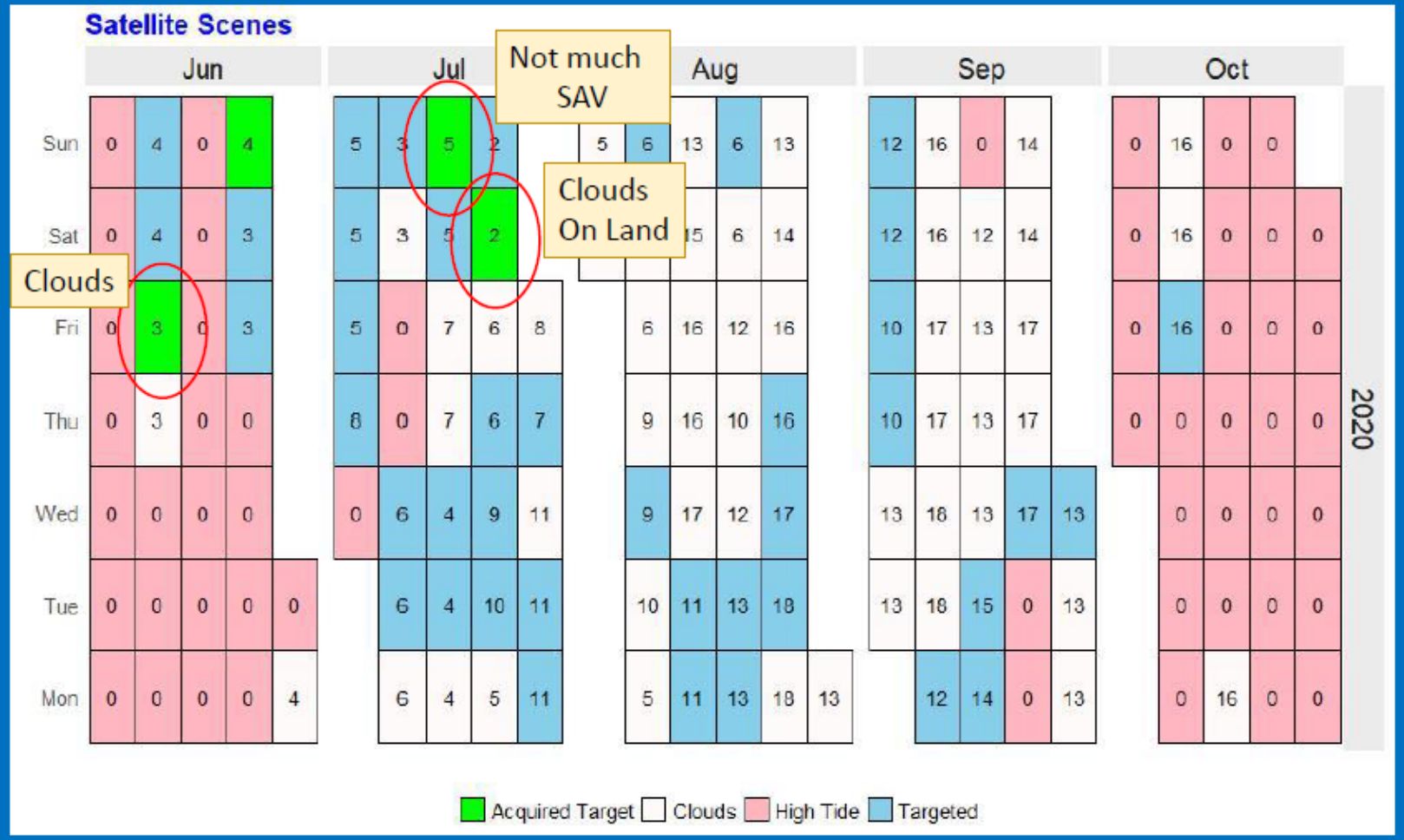


Tasking and Calibration Studies: Preliminary results

Within those 20 target areas, made 99 acquisition requests for different areas on different days throughout the growing season based on tide and region.

***Four** out of 99 requests were successful.*

One out of four were usable.

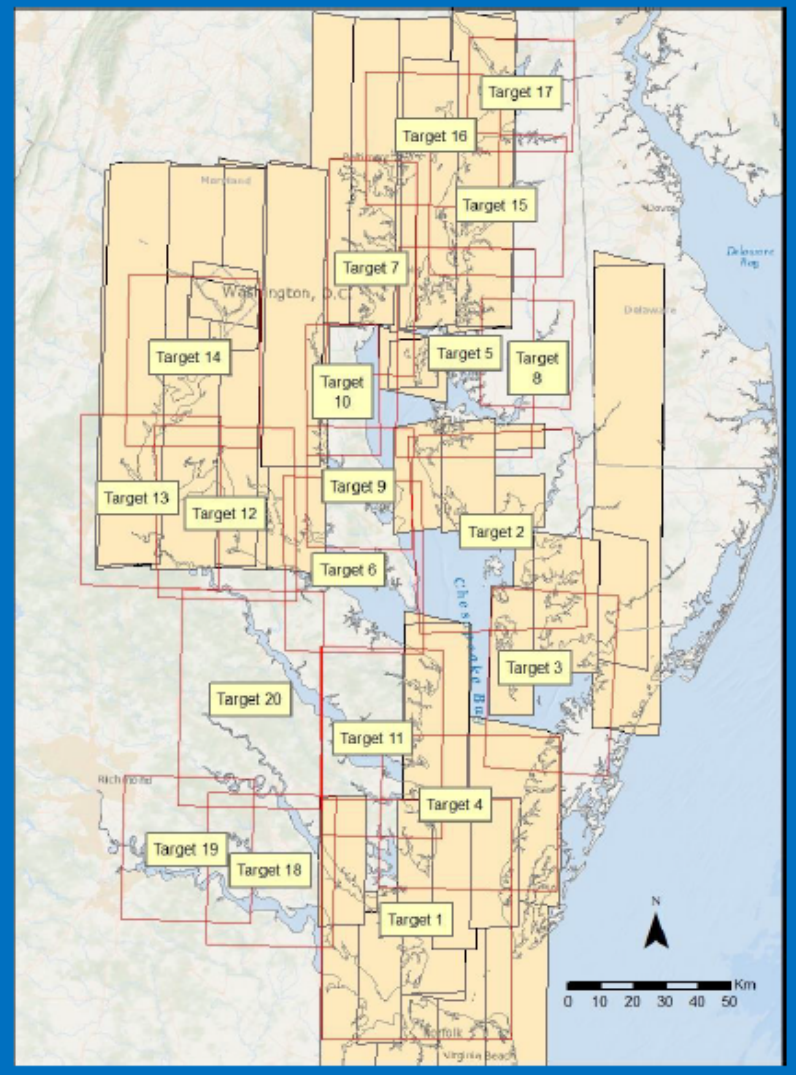


N.B. Numbers in cells represent different sections of the Bay

Tasking and Calibration Studies: Preliminary results

Overall, the tasking exercise was not a success, but a lot about the process itself was figured out.

Ultimately 4 of 99 requests were successful and only 1 was usable…



Satellite Scenes Captured

79 scenes were captured over Chesapeake Bay
- 4 of the scenes were specifically requested
- 75 scenes from areas that may have wrong tide or growing season

26 scenes were rejected immediately
- Covered non-tidal areas only
- Obscured by clouds
- Extensive sun surface reflection

53 scenes were downloaded for a closer look
The scenes
- cover 24 dates
- are large, covering a wide tidal range
- often contain at least some cloud cover
- will require additional funding to fully evaluate usability for SAV monitoring

Tasking and Calibration Studies: Preliminary results

The calibration exercise is not complete yet, but preliminary results suggest that where acquired data is comparable to aerial imagery, hand-delineation will be straightforward (same as 2018).

Satellite vs. Aerial Comparison

Six areas were selected

- Satellite imagery was available
- Aerial and satellite imagery in the same time frame
- No obvious defects in the satellite imagery
- Covering the majority of a USGS quadrangle
- Fairly large amount of SAV in the area

Process

- Each area is mapped by two analysts
  - One using the satellite imagery
  - One using the aerial imagery
- The resulting raw SAV polygons are compared
- Once both are complete, the area is reviewed by both analysts and the PI to evaluate potential sources of difference

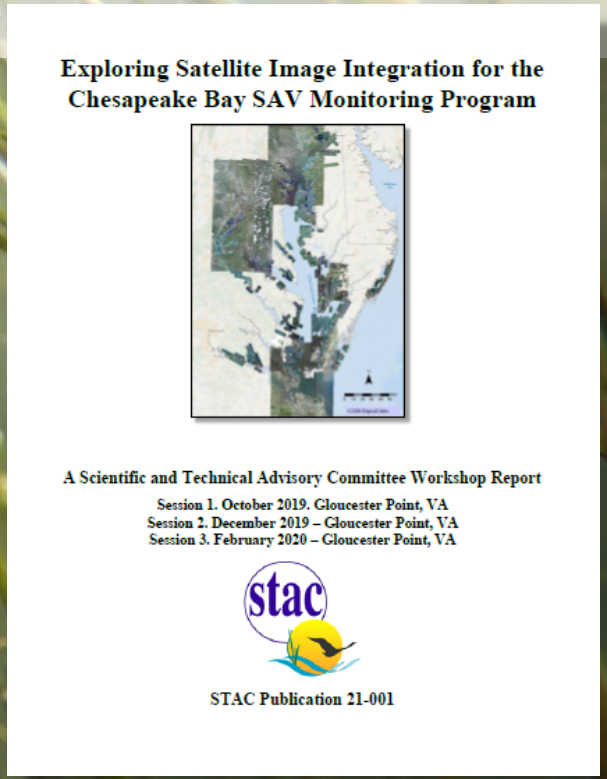
The Final Product

- Reviews the Chesapeake Bay SAV Monitoring Program
- Summarizes each workshop session and the information gleaned
- Provides a recommended timeline and next steps
- Suggests that the steering committee reconvene after VIMS has completed the tasking and calibration studies*.

*A report addendum will be added after the tasking and calibration exercises are complete and based on results, the steering committee will recommend – or not – satellite data integration into the SAV monitoring program.

The final report is online now at:

https://www.chesapeake.org/stac/wp-content/uploads/2021/03/FINAL-STAC-Report_Exploring-satellite-data-for-the-CB-SAV-Monitoring-Program.pdf



Unfortunate Recent Development

In early March, we found out that Congress cut the budget for accessing Maxar imagery

- The approved budget for G-EGD was reduced by 50%, by Congress.
- In order to meet the new budget, access to EV-WHS has been reduced or suspended to civilian agencies until fund's are hopefully restored September 2021.
- The total amount of data that can be used during the months prior to September 2021 is capped at 14 terabytes each month on the open internet site
- Maxar charges NGA by the gigabyte used.

- **If your agency still needs access, NGA is asking that those users be vetted by the agency before their accounts are re-instituted.**

Implementing SAV Workshop Recommendations

Peter Tango
STAR Co-coordinator

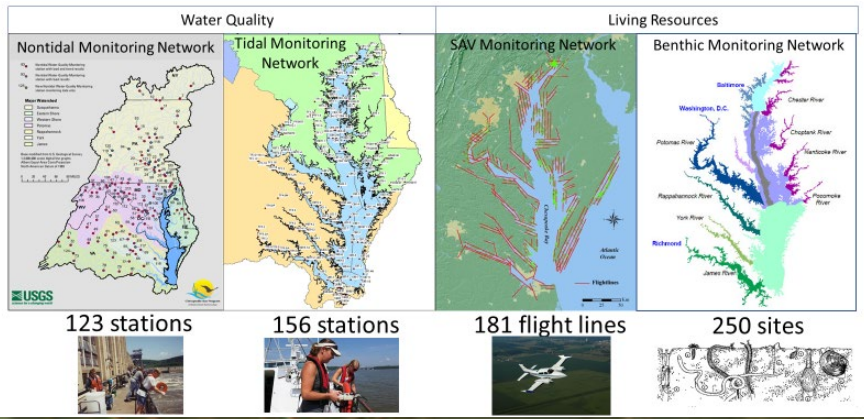
STAC meeting

March 23, 2021

Expectations: 2014 Watershed Agreement Maintain & Grown Monitoring and Assessment Capacity

Traditional networks

CBP Partnership Monitoring Networks: Annual Monitoring



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

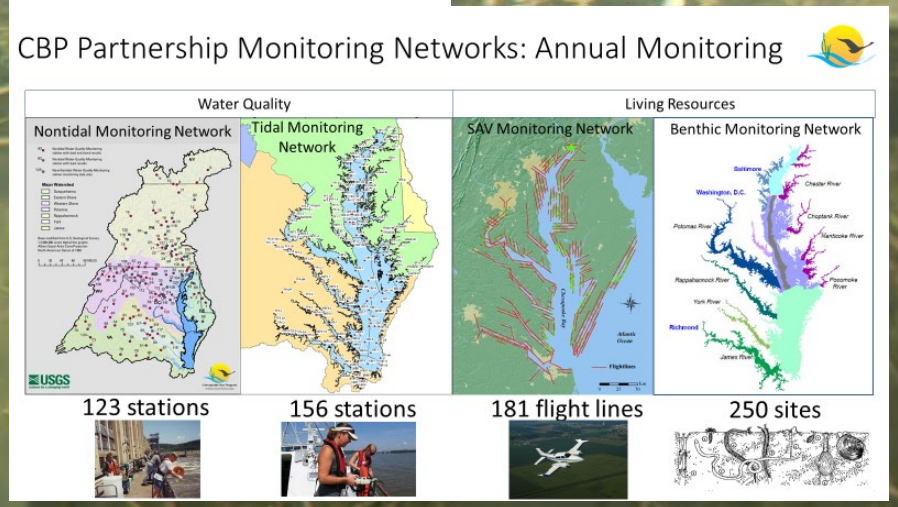
Goal: *Water Quality*

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.

Challenges

Traditional networks

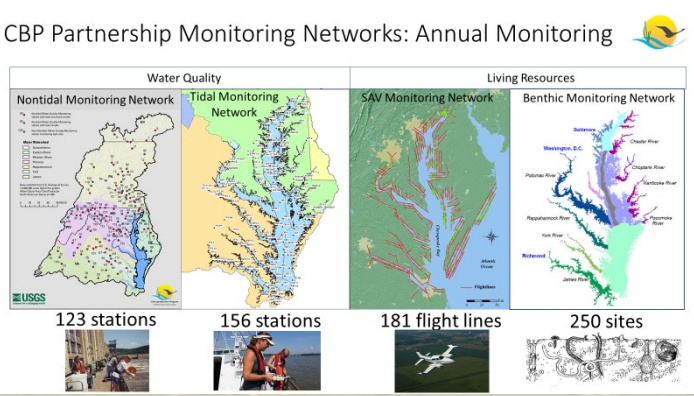


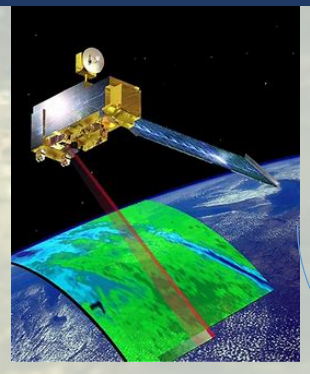
- **Water quality standards** – **0 of 92** segments have ever been fully assessed with our existing investments in traditional monitoring and evaluation tools since the publishing of USEPA (2003) Chesapeake Bay criteria on dissolved oxygen, SAV/Water Clarity and Chlorophyll *a*.

- We need to address capacity.
- We need to adapt our program.

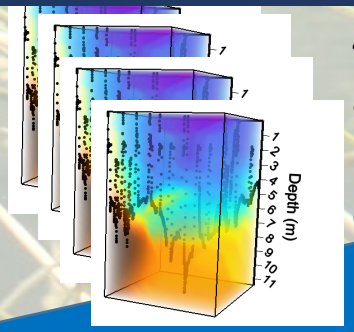
We need to leverage successful research, adopt and adapt to address capacity shortfall

Traditional networks





2. Adapt to baywide satellite-based data (SAV, Kd, CHLA)



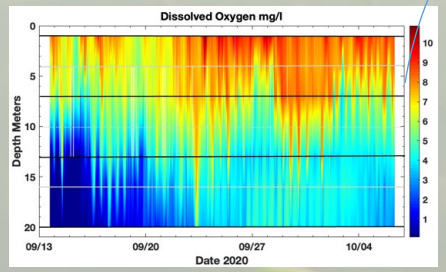
4. Improve assessment tools (4D water quality estimator)

Expanded capacity

Monitoring and assessment capacity building beyond traditional monitoring

Expanded capacity

1. Apply Citizen-based observations (MOU 2018)



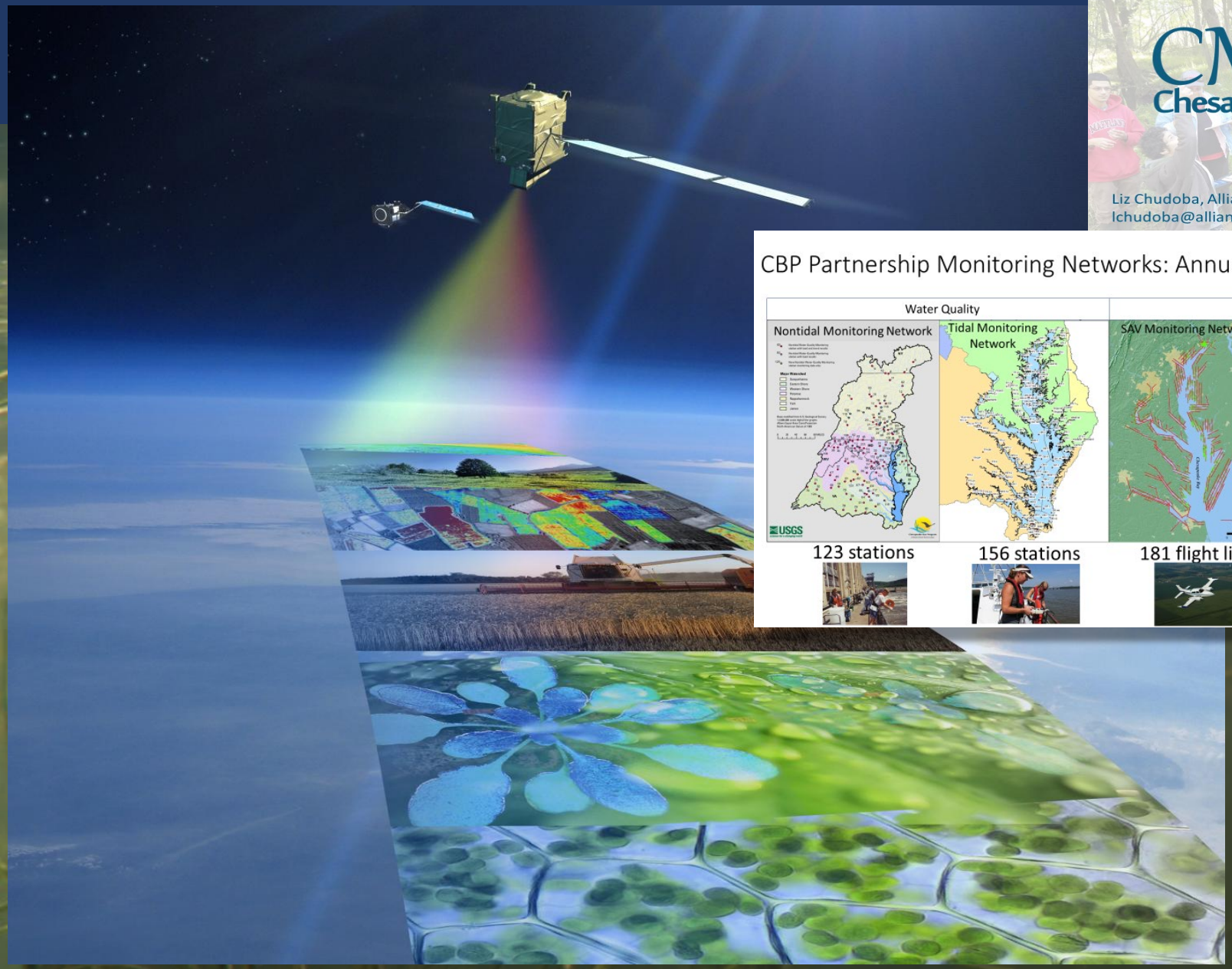
3. Innovate and adopt new WQ and living resource monitoring at needed data scales (CBT 2020 work, Bever et al. sampling design insights)

Full

Water Quality Standards Attainment Assessment for Chesapeake Bay + CrossGIT Benefits

2021 Monitoring Review: 9 months. Define programming to fully address WQ stds assessments and watershed WQ trends

- **March 2, 2021. Principal Staff Committee request:**
  - Provide information to improve CBP monitoring networks, including: (1) Current status and threats to the networks, (2) what is needed to improve the monitoring networks.

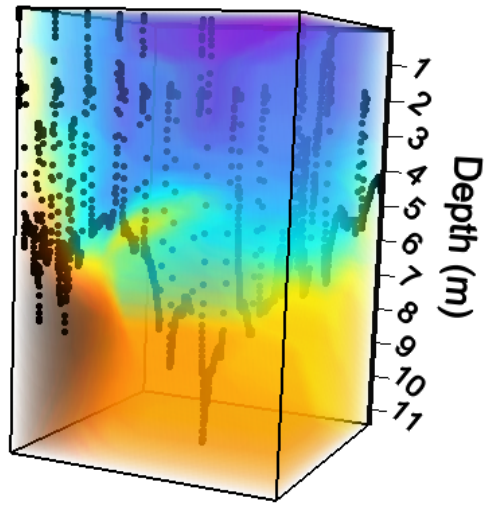


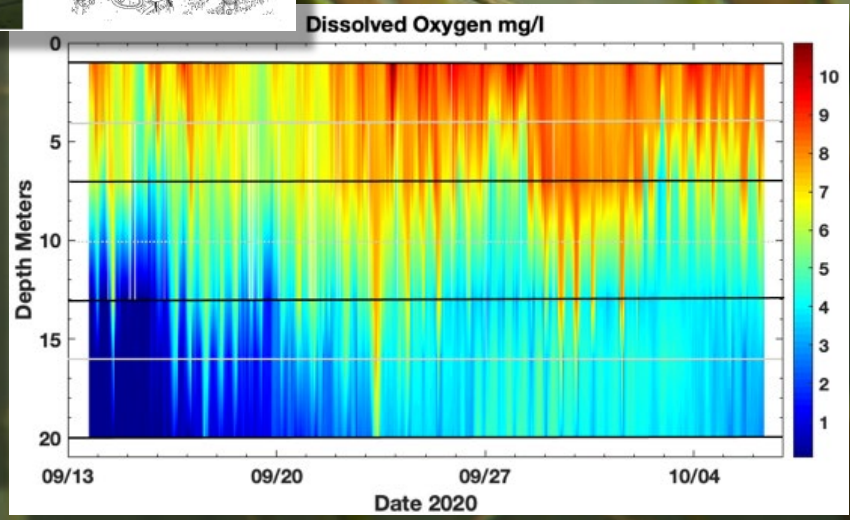
CMC Chesapeake Monitoring Cooperative

Liz Chudoba, Alliance for the Chesapeake Bay
lchudoba@allianceforthebay.org

CBP Partnership Monitoring Networks: Annual Monitoring

Water Quality		Living Resources	
Nontidal Monitoring Network	Tidal Monitoring Network	SAV Monitoring Network	Benthic Monitoring Network
123 stations	156 stations	181 flight lines	250 sites



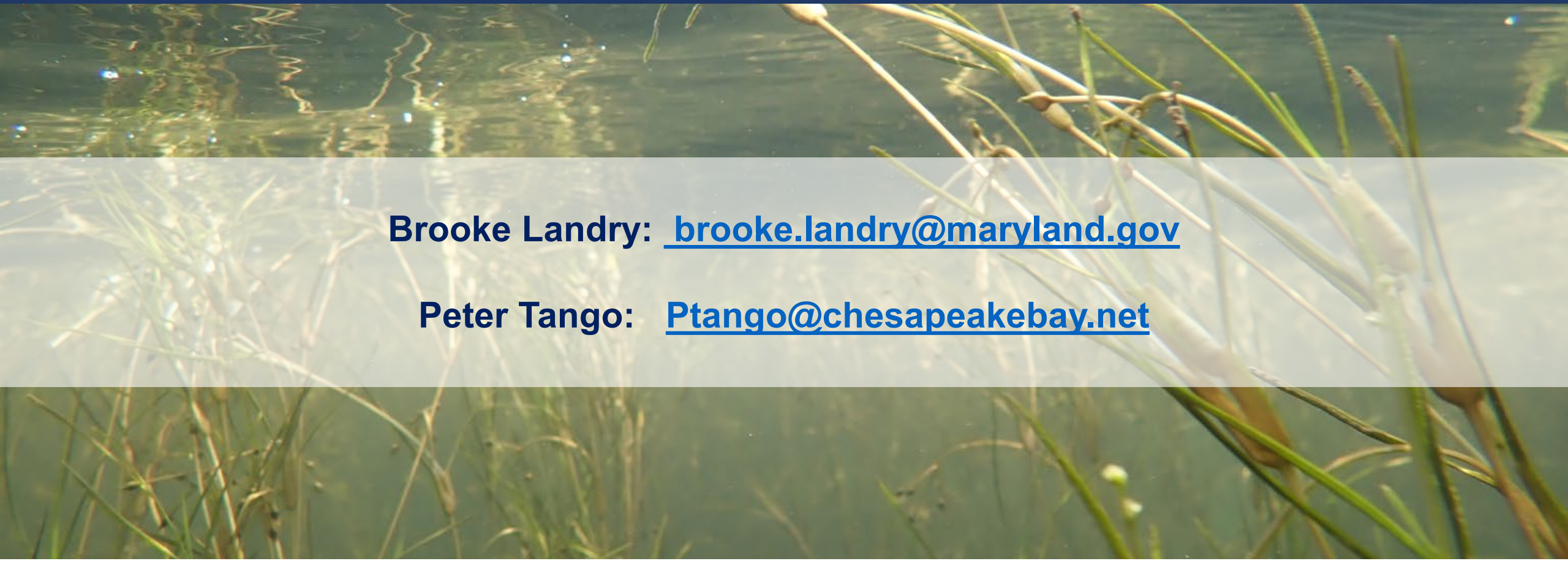


STAR: Integrated Monitoring Networks WG

- **Nontidal Network Team**: Network design, sampling design, capacity utilization
- **Hypoxia Group**: High frequency monitoring – vertical profiling, habitat assessment
- **Criteria Assessment Protocol WG**: Protocols for adopting and adapting assessment
- **Data Integrity WG**: Quality Assurance, Data Management needs, capacities
- **Citizen Science**: new RFP targets support for CBP monitoring needs
- **4D BORG**: 4-Dimensional Interpolation Team (STAC 2008 Workshop comes to life)

- Other key parties for shaping program directions, contributing guidance on network and assessment developments:
  - SAV WG, Modeling WG, Climate WG, Fisheries programs, Forage Action Team, Black Duck Team, Healthy Habitats GIT, STAC Workshop Proposal

Questions?



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