Exploring Satellite Image Integration for the Chesapeake Bay SAV Monitoring Program

A STAC Workshop

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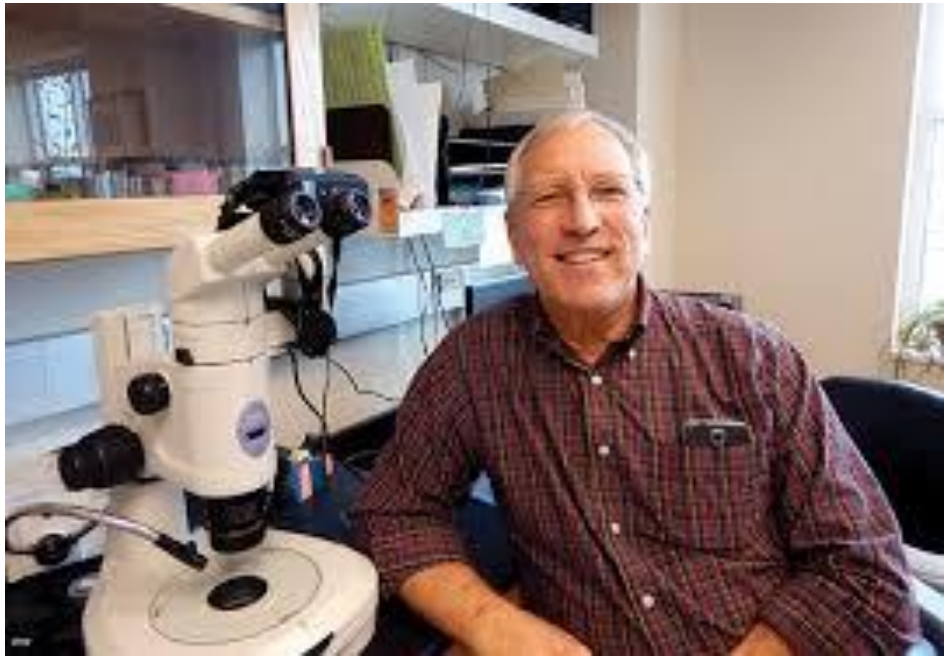
CAP WG Summary

1/22/2020

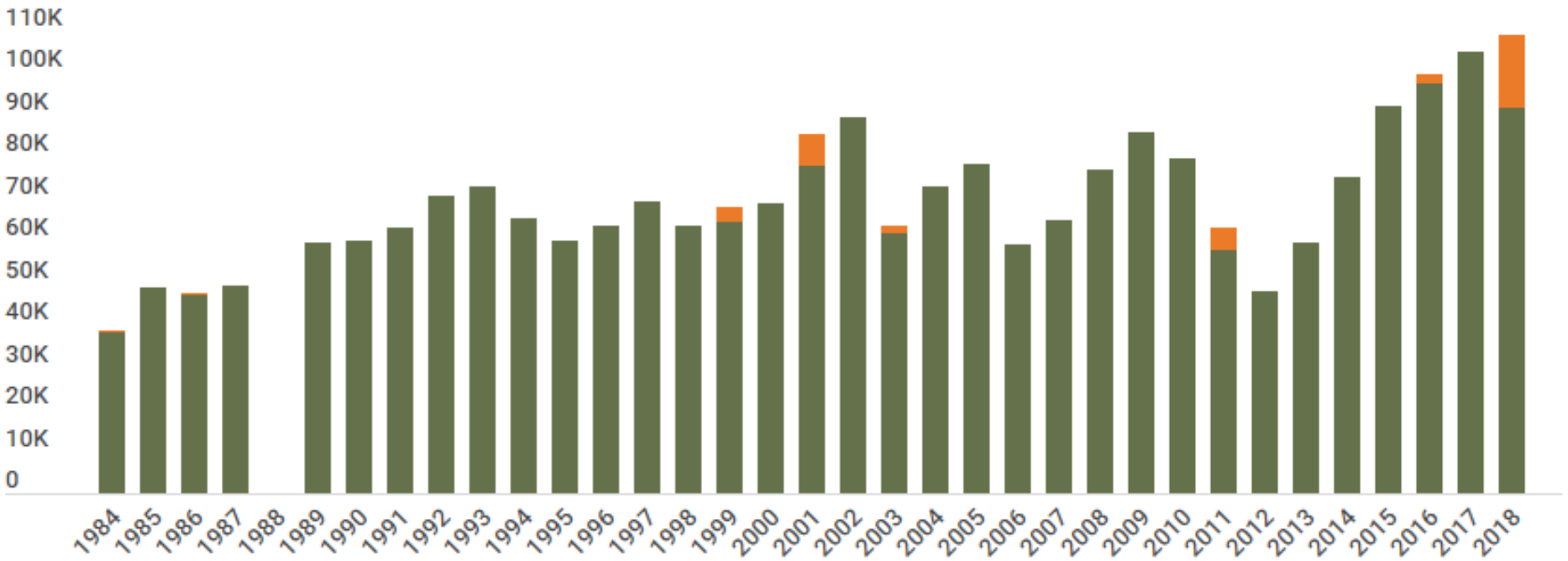
JJ Orth Retired this year!
Congratulations and Thank You JJ!



Baywide SAV Coverage

Orange caps denote estimated additional acreage in years with partial mapping. No bar denotes year with no mapping. Data is shown in both acres and hectares (the metric equivalent of an acre). 1 hectare = 2.47 acres.

Acres | Hectares



Workshop Objective

- Review the science and technology essential to integrate satellite image assessment into the Chesapeake Bay Program's SAV monitoring program.

- The workshop product will be a report-and-guidelines document laying out the information and steps necessary to integrate the use of satellite data and imagery into the SAV monitoring program.

Draft outline directions in the workshop report: 25 questions are guiding the workshop to address these issues:

- The path forward toward integrating satellite-based assessment
  - SAV Program recommendations
  - Data Sources
  - Data Acquisition
  - Data Management
  - Data Interpretation
  - Data Product Development
- Research recommendations
  - Data sources
  - AI: Algorithm development

Findings to date: Data Sources

- Currently there are over 2000 satellites orbiting the earth.

- So far, there are few options for satellites operating that are available and approximate our needs in space, time and resolution (approximately 1m-sq scale).

2018 VIMS SAV Report: The following imagery was used “to augment the aerial imagery in portions of the Bay and tributaries where imagery had not been acquired because of highly turbid water, weather, and security restrictions during the acquisition phase.”

- National Agricultural Imagery Program (NAIP) aerial imagery
- WorldView 2, 3 and 4 satellite imagery, and
- PlanetScope satellite imagery

Data sources for remote sensing SAV: near term.

- Fixed-wing hyperspectral aerial imagery – we still have 2 years left on the existing contract.

- Satellite images – pilot the process of regularly working with satellite images
  - Worldview approximates fixed-wing image resolution
  - Landstat – there is a project project underway evaluating its use. Opportunitiy for emergency back-up (30m resolution)

- Drone-based imagery - TBD

Data acquisition: Good news

- Under existing relationships with EPA and the commercial satellite company, EPA can work with the satellite company on image acquisition available upon request.

  - Our workshop is outlining the details of how this works.
    - Developing a tasking schedule for the year
    - Who do we request tasks from
    - How to make a request of a task for an image to be collected
    - How to make a request on access and use of the image(s)
    - Frequency of image collection for an area
    - Locations of images needed
    - Timing of image collections
    - Details associated with collection that minimizes atmospheric effects, glint, glare, etc.

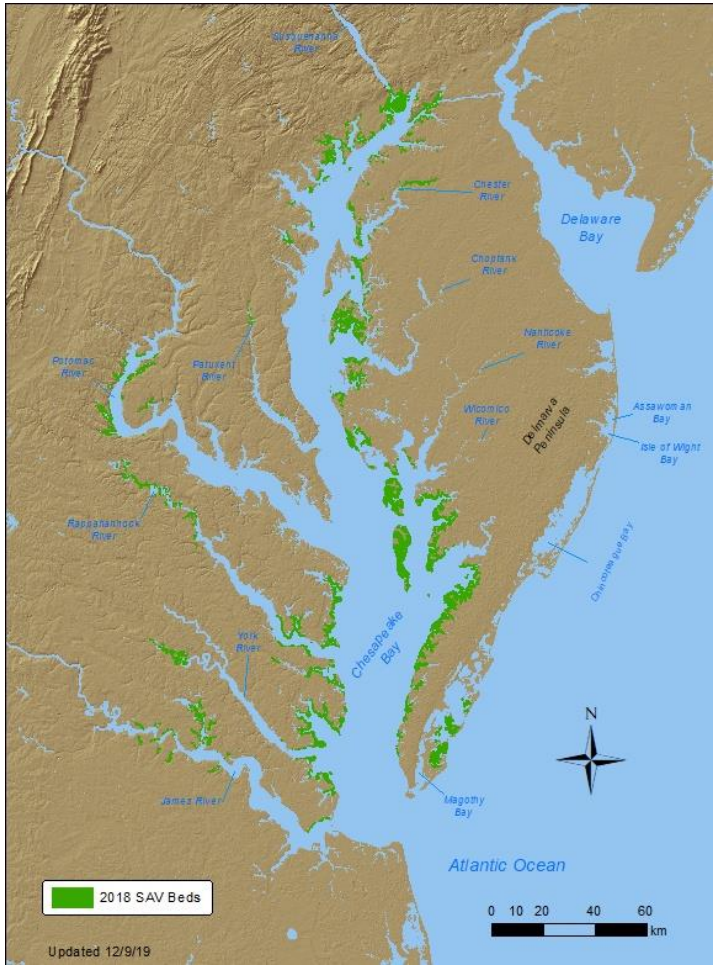
Satellite challenge: Commercial data source presently has some limitations. Sometimes.

Fixed-wing aerial image collection:

- Long time relationship of coordination and collaboration.
- The present aerial image contract has dedicated aerial time to capture images on date/time/places requested by the SAV program managers.
- Aerial overflight images are made publicly available through VIMS.

In contrast, with satellite data collection:

- Satellite – task requests can be made but priority could get bumped, less than optimal times/places.
- Raw images are protected, *typically* not publicly available.
- Derivative products are typically approved for public release.
- Commercial satellites may be decommissioned on short order. This is business.



Example of a derivative product on SAV distribution

Data Management – big files!

- Discussions suggest… we got this ☺.

Data Analysis and Interpretation

- We are discussing and documenting pre-processing needs.
- Initial assessments with satellite images – traditional hand mapping imagery.
- Evolving work by multiple groups – intelligent algorithms. (3-5 years)
  - Certainly successful on a local scale.
  - Using AI to assess wide regions in space and over time is cutting edge.
  - Expect comparisons of AI cover estimates with hand-mapping estimates to calibrate the outputs of the two approaches
- Ground-truthing programs needed (historical survey transects, new Citizen science-based results, drone-derived assessments, etc.)

Research thoughts

- Pilot comparison of cover estimates between methods of assessment
  - Affect on goal assessments?
  - Affect on assessment protocols?
- AI algorithm development for Chesapeake Bay conditions
- Portability of AI algorithms – regions, temporally, globally
- What else can we extract from data rich satellite images (coordination with NASA and others on water quality parameters)
- What else can we extract from repeated measures within a year (what other metrics besides SAV cover can we get for SAV – e.g. bed density is another step in development for algorithm-based assessments
- Planning for future satellite developments

Product outline with guidance will include:

- Existing method summary
- Recent science, monitoring, management based overview on active applications of satellite assessment of SAV/water quality conditions
  - Include uses of other remote sensing technology for assessments like drones, balloons, kites, UAVs, etc.
- Guidance on steps needed for satellite based assessment integration into the SAV monitoring and assessment program:
  - Data Acquisition protocol
  - Data Management expectations and requirements
  - Data Interpretation – assessment via multiple approaches, multiple metrics assessed
  - Data Reporting – standard acreage area assessment, additional/new metrics

Data Acquisition

- Who has the data?
- What is baywide coverage equate to?
- What systems need to be in place to receive the image data?
- How many times per year represent “the minimum” (e.g., given seasonality of species coverage do we need a mimimum of a spring, summer and autumn coverage).
- What privacy relationship may be needed (e.g., Memorandum of Understanding?)
- When is the data available after a fly-by of the region?

Reporting results

- Acreage
- Biomass
- Bed outline maps
- Full satellite image basis
- Masked satellite image basis
- Drone/other remotely-sensed calibration images
- Hand-drawn versus AI derived assessment results
- New metrics – peak acreage and biomass with confidence intervals from multiple assessments each year (compared with a single transect over an area), refuge area assessments, detection duration (when are grasses first detectable, last detectable and relation to changes in climate change impacts) non-tidal vegetation in the Susquehanna and Potomac Rivers, etc.)

Cost Structure

- Document anticipated costs
  - Data acquisition – satellite images, calibration data via other approaches.
  - Data management and storage
  - Data analysis, interpretation
  - Product development and reporting
    - Report in historical consistent fashion
    - Report with new metrics
    - Report via method of assessment
      - E.g., manual
      - E.g., pilot/evolving AI for adoption if not adopted at the initiation of the satellite based work

Session 2 Draft Agenda: Review remote sensing approaches options and active programs

- DigitalGlobe Representative Q&A. Other Representatives/NASA on Sentinel or other?
- Issues to consider when using drones (NASA-Wallops) or other non-satellite tech.
- Drone resources presentation/discussion (USGS Drone program)
- Existing and desired satellite-based water quality layers that may be relevant to AI algorithms for SAV assessment (NASA rep(s), NCCOS rep(s)), USFWS? (wetlands), USGS/NOAA shoreline characterization/definition?

Session 3 Draft Agenda: Review details of recent comparison efforts, needs to move forward

- Science review: Where are active satellite-based SAV assessment programs, what are they doing, how are they doing it?
  - Review Indian River Lagoon program (webinar connection?)
  - Homework: Read 2017 Lake Biwa publication and discuss
  - Other non-Chesapeake Bay examples.

- Local comparison efforts
  - Pre-2018 application of satellite image references to fill SAV monitoring gaps?
  - How were gaps filled with satellite reference in 2018?
  - Dick Zimmerman project
  - Mark Trice efforts?

Session 4. Synthesis: Product development, have we filled in guidance, what do we need

- Workshop objectives
- Reference to strong history and evolution of the program, past workshops (e.g., 2017 workshop).
- Move into overview of satellite assessment of SAV in the literature (we know the existing program, we want to focus on new stuff).
- Cover existing monitoring programs in practice or pilot (e.g. Indian River, Dick Zim program, etc.)
- Recognize that for all the consistency in CBP monitoring, we have been an adaptive monitoring program to adopting new tech and new approaches.
- Present workshop outline of sessions
- Summary of sessions 1, 2, 3
    - Key topics of each session
    - Considerations (e.g., alternative assessment algorithms, hybrid assessment and what technology is part of the assessment like drones, towed arrays, lidar, etc.)
    - Key findings
        - Data acquisition
        - Data management – storage, relationships
        - Data analysis and interpretation – different satellite options, manual versus AI, levels of ground-truthing needed,
        - Data products – allowable product releases
        - Cost structure
    - Key actions undertaken after each session
    - Key recommendations for integration of satellite image basis for program
- Community discussion
    - Refer to 2017 workshop notes on uses of the SAV program findings.
        - Are we retaining/expanding/decreasing our ability to meet the diversity of needs expressed?
        - Do you find enhanced value in the products that can be produced with multiple assessments within a year for areas?
        - Satellite assessment of additional water quality variables desirable?
        - Cost structure review
        - Lingering questions, comments, concerns (Spatial limitations, season limitations, costs limitations, data product limitations, etc.)

Talking points

- We can acknowledge that the CBP monitoring program, while consistent, has been one of adaptive monitoring, i.e., in almost every way we have been through method changes, e.g. SAV, water quality. I have examples if we need…
- What actions can we put in motion today to move this effort forward?
- What satellite imagery is available now for comparison with historical aerial image assessment?
- How far back in time can we go with different products available for calibration with historical assessments?
  - Can we compare multiple satellite products ability to portray SAV
  - Can we compare different approaches to represent ease versus complexity of interpreting imagery from more than one satellite product available?
    - For comparison – can we do this at some subset of sites around the bay to establish a calibration relationship? How much of this can be done during the workshop in time for session 3 and/or 4?
      - Is this a future GIT funded project request to accomplish in 1 year from the end of the workshop?
      - Is this part of a grant analysis supported effort in 1 year through the monitoring grants?
      - Might there be funds via some other request to pursue this in depth and how much is needed for a pilot effort?
      - What is being done already to consider these comparisions?
- Do we need to initiate an acquisition agreement today and establish the storage of imagery through and with EPA-CBPO during the course of this workshop?
  - Is there a national/global need for establishing this effort that CBPO is just one piece of what could be a larger effort to evaluate SAV in nontidal, tidal estuaries and open ocean?

Talking points

- As we look ahead, satellite imagery has the potential to look beyond the limits of the flight lines as well as capture baywide seasonal estimates of coverage.
  - To retain the existing historical comparisons, do we overlay the flight lines and assess images according to those flight line boundaries.
  - Then do we include a more comprehensive baywide estimate eventually facilitated by automated interpretive algorithms or possibly other methods like crowd sourced interpretation of image results?
  - What other metrics will be available from multiple assessments of each area throughout the year? E.g. population duration, maximum extent, species shifts, carbon storage, fishing/aquactulure interactions, bird population overlays with bed changes within a year, etc.