

**Exploring Satellite Image Integration for the Chesapeake Bay SAV Monitoring Program**  
**Proposal for a Responsive STAC Workshop**  
**Submitted by the CBP's SAV Workgroup**  
**February 22<sup>nd</sup>, 2019**  
**Re-submitted with revisions: March 6<sup>th</sup>, 2019**

**Background**

Since 1984, the Chesapeake Bay Submerged Aquatic Vegetation (SAV) Monitoring Program has used aerial imagery, coupled with ground-truthing surveys, to map and assess the distribution and abundance of SAV throughout the Chesapeake Bay and its tidal tributaries. This program is globally esteemed and program products have been instrumental in guiding the assessment, management, and restoration of the Bay since the program began. For more than 30 years, annual SAV acreage assessment results have provided citizens, managers, scientists, and policy-makers with the information necessary to advocate for, manage, and restore this quintessential indicator of bay ecosystem health. Consequently, in 2017, Chesapeake Bay SAV reached a Bay-wide acreage of nearly 105,000 acres – 57% of its restoration goal – representing the largest known example of SAV recovery and response to management actions in the global literature (Lefcheck et al. 2018).

Since its inception, the Chesapeake Bay Program's annual SAV survey has evolved its assessment approach with updates to equipment and interpretation protocols consistent with the latest advances in aerial image acquisition and mapping technology. Presently, SAV monitoring through aerial image assessment makes use of sub-1m scale resolution photographs. This is ideal, but coordinating the aerial imagery acquisition is logistically cumbersome, time consuming, expensive, and may be interrupted by extended periods of poor water quality resulting from abnormal weather patterns and storm events. It is also highly dependent on the company contracted to perform the overflights and acquire the imagery necessary for assessment.

Alternative monitoring approaches were evaluated during *The Chesapeake Bay Program Partnership's SAV Aerial and Ground Survey Design Workshop* held on March 29<sup>th</sup>, 2017 in Annapolis, MD. Based on responses to a comprehensive SAV data user questionnaire distributed in advance of the workshop and input from participants during the workshop, three alternative design options for the aerial survey were identified for further exploration based on feasibility and potential cost savings. These three design options were: 1) keeping the existing survey design but upgrading to a semi-automated imagery processing routine; 2) collecting baywide annual imagery but only processing regions of the Bay annually with the entire Bay being mapped every three to four years; and 3) collecting baywide imagery but only processing a statistically random subset. The first option - keeping the existing survey design but upgrading to a semi-automated imagery processing routine – is currently being explored by a post doc at VIMS. This option would maintain use of aerial imagery but reduce the cost of the program by decreasing the number of staff and man-hours necessary to interpret the imagery collected during flights. The second option - collecting baywide annual imagery but only processing regions of the Bay annually with the entire Bay being mapped every three to four years – has been accepted as an “if all else fails” option because the management needs of the community would be greatly interrupted if baywide SAV coverage is unavailable each year. And finally, the third option - collecting baywide imagery but only processing a statistically random subset – was explored by a statistician at UMCES and deemed unlikely to generate any actual cost savings while ultimately reducing the quality of the annual assessment.

One option that was not fully explored for the SAV monitoring program, however, was the use of satellite imagery. At the time, this option was generally dismissed based on the fact that high-resolution satellite imagery of the Bay was either unavailable or obtaining it was financially prohibitive. However, acquiring satellite imagery either at a reduced rate or for free has become a possibility at this time based on an agreement made between the federal government and Digital Globe, an independent company that was subsidized by the government to develop the technology necessary to collect high-resolution imagery from satellites. Part of the agreement is that any federal agency that *requires* satellite imagery can request and obtain said imagery for free. As 2017 updates to the Water Resource Development Act, which amends Section 117 of the Clean Water Act, called for an annual survey of Chesapeake Bay SAV, it is statutorily required that the Environmental Protection Agency (EPA) conduct an annual SAV survey, making it feasible for the EPA to now request and obtain satellite imagery necessary for an annual SAV assessment, for free.

With that, however, the question remains if the satellite imagery available is adequate to perform a comparable assessment of Bay-wide SAV acreage. Recent advancements in satellite-based image acquisition technology are generating data and images with resolution scales below 1m, which is in fact comparable to the aerial imagery used in the SAV survey program, and a preliminary exploration of these images is currently being conducted to potentially fill coverage gaps that occurred during the tumultuous 2018 SAV survey. Furthermore, in addition and in collaboration with the research at VIMS, other CBP community researchers are also working to develop new techniques for the task of mapping SAV beds using artificial intelligence (AI)/machine learning algorithms. These efforts are generating advances in SAV acreage assessment protocols that, once fully evaluated, may also support a transition to satellite imagery.

Another option that may prove useful in the future is the use of drone technology. As drones and their cameras become more sophisticated and the prices continue to drop, this approach may augment airplane and/or satellite imagery acquisition. Assessing the employment of this technology would be included in this workshop.

It is therefore both timely and necessary to conduct a thorough review of the science and technology associated with the use of satellite (and potentially drone) imagery for Chesapeake Bay SAV acreage assessment. Exploring what is necessary for satellite image acquisition on a consistent annual basis and integrating satellite image interpretation as part of an updated Chesapeake Bay SAV monitoring program and assessment survey offers the community potential scientific, logistical, and financial benefits. Scientifically, there would be more potential opportunities throughout the year for baywide snapshots that can be used to assess abundance, distribution, and density while offering new insights into inter-seasonal comparisons, seasonal succession, etc. Logistically, it may take less time to coordinate image acquisition. And finally, there may be financial benefits associated with a transition to a satellite-imagery based survey if we are able to acquire the imagery for free or at a reduced rate. Likewise, if protocols are developed to successfully map SAV using AI, this would further reduce the program budget by reducing the man-hours spent interpreting the imagery to produce SAV acreage maps.

Details are needed to

- establish the relationships and protocols necessary for new satellite image acquisition, access, storage and management,
- demonstrate and document the comparability of the methods between historical data outputs and satellite image-based results, defining precision and accuracy and any geographic limitations on satellite image assessment,
- establish community agreement on algorithms implemented for image interpretation and outputs of results since the indicator of acreage is also a regulatory based endpoint to water quality standards attainment in the tidal bay jurisdictions.

### **Objectives and Workshop Format**

We propose a responsive STAC workshop with a focused but distinguished array of technical and management personnel to review and determine the science and technology essential to integrate satellite image assessment into the Chesapeake Bay SAV Monitoring Program. We propose a workshop rather than a review because we will be making decisions and designing the next generation of the monitoring program rather than simply reviewing the technology available to do so.

During the workshop, we would define the feasibility of the integration (related to the science), and document costs, benefits, and any potential disadvantages of the integration (logistical, financial, scientific). With that, we would then determine the steps, information necessary, and timeline in which to officially integrate satellite data and imagery into the SAV monitoring program. Furthermore, much of the focus on the SAV aerial surveys is the data acquisition phase, but the data processing and data synthesis/communication phases are equally important and equally resource intensive. An additional goal of this STAC workshop would therefore be to develop an integrated strategy for the overall program, including data acquisition, data processing, and data synthesis/communication.

At this time, it is anticipated that a non-traditional workshop format would be adopted. Rather than a standard two-day workshop with a series of presentation, plenaries, and breakout sessions, we propose three separate two-day events that would take place every other month between October, 2019 and February, 2020 and culminate in a final two- to three-day synthesis effort that would occur in April, 2020. Our proposed schedule is below. Timing is, of course, flexible and we anticipate no more than 15 participants at each session.

Oct 2019 – Initial meeting of the minds. Review of the state of the science for Chesapeake Bay SAV. Develop game plan.

Dec 2019 – Review of remote sensing methods used elsewhere. Bring in outside experts. Include review of drone technology and consider for inclusion in hybrid assessment design.

Feb 2020 – Review and comparison of recent SAV survey results (which will have incorporated some satellite imagery).

Apr 2020 – Final Meeting. Develop final product and review materials. Develop an integrated strategy for the overall program, including data acquisition, data processing, and data synthesis/communication.

Each meeting would follow the two half-days format, commencing at approximately 10:00 am the first day and adjourning at approximately 3:00 pm the following. This format would reduce lodging expense. Also, recognizing that this workshop format would increase STAC staff time, the SAV Workgroup would petition for assistant from the Habitat GIT/SAV WG staffer.

### Workshop Product(s)

The anticipated product would be one final report and guidelines document laying out the state of the science and the information and steps necessary to integrate the use of satellite and potentially drone-captured imagery into the SAV monitoring program.

This report and guidelines document would benefit the Bay Program's SAV Workgroup\* and Habitat Goal Team in its mission to ensure the continuity of the Chesapeake Bay SAV Monitoring Program. The SAV Workgroup would furthermore be responsible for working with Bay Program Management to move the results of this workshop forward and ensure that recommended actions are taken and guidelines are followed. This effort would also inform future Bay Program RFPs for this work as well provide a defensible explanation for the integration of satellite imagery if integration is deemed beneficial. Additionally, workshop products would benefit other Bay Program workgroups and goal teams looking to incorporate satellite technology or otherwise renovate their monitoring programs.

\*The SAV Workgroup was approved for funding in 2018 for a responsive STAC Workshop titled *Microplastics in the Chesapeake Bay and its Watershed*. This workshop was originally scheduled to take place on Feb 4<sup>th</sup> and 5<sup>th</sup> at George Mason's Potomac Science Center in Woodbridge, VA but was postponed due to the government shutdown and on a second occasion due to snow. It is rescheduled to take place on April 24<sup>th</sup> and 25<sup>th</sup>, 2019 at the same venue.

### Logistics and Funding

The proposed steering committee anticipates that the final synthesis effort would take place in Annapolis, MD, but that single day events may occur in other representative locations, including VIMS and ODU. We anticipate a small, focused group of 10-20 participants given that this workshop would be highly specific and of limited scope. Most participants are located either in tidewater Virginia or Annapolis, so we do not anticipate significant air travel costs, although we do hope to bring in experts in satellite imagery interpretation from other regions. The small size of the workshop will also allow us to secure a venue at no cost, as we'd be able to use facilities at the Bay Program or one of the Universities involved for free.

Venue: no cost

Food: Coffee service and lunch for 20 participants for 8 days – max \$5000

Travel: Flights and lodging for out-of-town participants – max \$5000

Total: Not to exceed \$10,000

Matching: Several of the steering committee members will provide in-kind match in the form of salary from their respective institutions (Md DNR, USGS, VIMS, ODU, UMCES)

### Proposed Steering Committee

Brooke Landry, Chair, Chesapeake Bay Program SAV Workgroup, Biologist, MD DNR (**Workshop Co-Chair**)

Peter Tango, Chesapeake Bay Monitoring Coordinator, USGS, CBP (**Workshop Co-Chair**)

Bill Dennison, Vice President for Science Application, UMCES, **STAC Member**

Robert (JJ) Orth, Professor of Marine Science and Director of CBP SAV Monitoring Program, VIMS

David Wilcox, Manager of CBP SAV Monitoring Program, VIMS

Richard Zimmerman, Professor of Ocean, Earth, and Atmospheric Science, Remote Sensing expert, ODU

### List of anticipated Speakers/Moderators/Key Participants

All members of the steering committee are experts in the fields of SAV biology and ecology, resource monitoring, data interpretation and reporting, and/or remote sensing and all are included in the list of anticipated speakers, moderators, and key participants. Additional participants potentially include:

Russell Ives, PhD candidate in remote sensing, ODU

Victoria Hill, Remote sensing expert, ODU

Lien Pham, Post-doc in semi-automation techniques, VIMS

Greg Allen, Grants Manager, CBP

Blake Schaeffer, Remote sensing expert, EPA Raleigh Durham

Megan Coffey, Remote sensing tech, EPA Raleigh Durham

Becky Golden, Program Manager, MD DNR and Vice-Chair for CBP SAV Workgroup

March 6, 2019

To: STAC Membership

From Scott Phillips, Co-chair of CBP Scientific, Technical Analysis, and Reporting (STAR) team

Subject: Letter of Support for a Responsive STAC Workshop titled *Exploring Satellite Image Integration for the Chesapeake Bay SAV Monitoring Program*, Submitted by the SAV Workgroup.

Dear STAC,

On behalf of STAR, I want to thank you for hosting the STAC workshops each year. The workshops offer one of the best mechanisms for addressing an acute need of the CBP community and bringing together scientists and stakeholders to discuss status of knowledge and innovative ways to address a topic.

STAR has been advocating for identifying new approaches to sustain and improve monitoring for SAV, which is one of the most important indicators of Bay health. The recovery of SAV is one of the major success stories of the Bay restoration and an important standard to measure for the Bay TMDL. Unfortunately, the sustainability of the SAV monitoring program has been uncertain for too many years. New logistical complications with the SAV monitoring during 2018 further demonstrate an acute need for new approaches for monitoring.

The STAR leadership supports the proposal for a responsive STAC workshop “*Exploring Satellite Image Integration for the Chesapeake Bay SAV Monitoring Program*”, since it can explore new approaches for monitoring SAV. The recent advances in higher resolution imagery, both from satellites and drones, offers truly innovative approaches to enhance monitoring of SAV in the Chesapeake, and other estuarine systems.

The proposed workshop would be critical and timely to help address our current limitations with SAV monitoring and suggest exciting new directions for the program.

Thank you for considering this proposal for a responsive STAC workshop.

Sincerely,

Scott Phillips, USGS, and Co-Chair of STAR

**Re: Letter of Support for Responsive STAC Workshop *Exploring Satellite Image Integration for the Chesapeake Bay SAV Monitoring Program***  
Submitted by the SAV Workgroup on February 22, 2019

STAC Members,

This is to enthusiastically endorse and support of the proposal for a responsive STAC workshop that will explore the utility and integration of satellite-derived imagery for the annual Chesapeake Bay Submerged Aquatic Vegetation (SAV) Monitoring Program. Since the Chesapeake Bay Program's (CBP) inception in 1984, annual SAV acreage assessment results have allowed CBP managers and policy makers to track, manage, and restore the Bay's SAV. As a consequence, in 2017 SAV reached 57 percent of its ultimate Bay-wide restoration target and exceeded 100,000 acres for the first time since the CBP began. This represents the largest known case of SAV recovery in response to management actions in the world and serves as an example of ecosystem recovery possible when decisions are based on sound science and long-term monitoring data.

However, despite the demonstrable utility of the SAV monitoring program, its sustainability has been in question for some time. Rising program costs combined with difficulties in imagery acquisition (resulting from regional climate trends, storm events, air-space closures, and flight-contractor specific constraints) have led to an exploration of alternative program designs and options. The planned workshop aims to determine if the use of satellite data would provide the information necessary for a comparable assessment of SAV acreage in the Bay and also lay out all of the logistical information and steps necessary to actually acquire the data, integrate its use in the program, and possibly even fully transition to satellite data for the SAV monitoring program with attendant cost and efficiency benefits.

I fully support this effort because if integration is successful, the long-term sustainability of the Chesapeake Bay SAV Monitoring Program is more assured. Tracking recovery of SAV in the Bay is in fact also tracking a key living-resource-based water quality standard of the CBP (the Water Clarity/SAV Standard) which is on track to being achieved because of the SAV Monitoring Program and the management actions taken based on the data it provides. It is vitally important to ensure its continuity.

Thank you for your consideration of the proposed responsive STAC workshop *Exploring Satellite Image Integration for the Chesapeake Bay SAV Monitoring Program*.

Best,

Lew Linker  
CBP Modeling Coordinator and  
Acting Associate Director for Science, Analysis and Implementation (OSAI)