The Chesapeake Bay Program Partnership's SAV Aerial and Ground Survey Design Workshop

Chesapeake Bay Program Partnership
SAV Workgroup Report
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Chesapeake Bay Program
A Watershed Partnership

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Executive Summary

Since 1984, the Virginia Institute of Marine Science (VIMS) has conducted the annual Chesapeake Bay Submerged Aquatic Vegetation (SAV) Aerial Survey and synthesized data from various independent Ground Surveys. Using SAV data interpreted from aerial imagery integrated with ground survey data, VIMS has reported SAV acreages throughout the Bay annually and reliably, becoming the most successful and consistent large-scale, long-term SAV monitoring program in the world. SAV scientists and managers across the Chesapeake Bay watershed have grown to depend upon the data for a variety of purposes, from regulatory decision-making to annual public communications on the health of the Chesapeake Bay ecosystem.

Unfortunately, establishing sustainable sources of funding for the program has not been as successful as the program itself. Therefore, the Chesapeake Bay Program's SAV Workgroup recently sponsored the *Chesapeake Bay SAV Aerial and Ground Survey Design Workshop* on March 29th, 2017, in Annapolis, Maryland. At the workshop, a diverse array of SAV data users gathered to discuss potential modifications to the survey design which could reduce costs and ensure the continuation of the monitoring program well into the future. These users represented local, state, regional and federal government agencies, academic institutions, and non-governmental organizations.

The workshop objectives were to reach agreement on: 1) the collective management, regulatory and research needs for and uses of data and information generated by the SAV surveys; 2) a set of aerial and ground survey design options which maximize addressing the Partnership's collective data and information needs; and 3) a more diverse funding partners' portfolio to recommend to the Partnership.

Based on responses to a comprehensive SAV data user questionnaire distributed in advance of the workshop and input from participants during the workshop, four design options for the aerial survey were identified which would meet all or most of the SAV data user's needs and would be logistically feasible with potential cost savings. These four design options were: 1) keeping the existing survey design with no modifications; 2) keeping the existing survey design but upgrading to a semi-automated imagery processing routine; 3) collecting baywide annual imagery but only processing regions of the Bay annually with the entire Bay being mapped every three to four years; and 4) collecting baywide imagery but only processing a statistically random subset. Each option has recognized pros and cons.

There was collective agreement that the ground survey needs to expand into a more integrated and coordinated baywide survey building on more robust surveys conducted by Riverkeepers, watershed organizations, and citizen volunteers and scientists.

Discussion regarding funding was limited, but it was agreed that the States need to provide a greater proportion of the total budget and federal agencies, in addition to the EPA, which are directly benefiting from access to the wealth of data and information generated by the aerial survey, need to be held financially responsible as well.

Following the workshop, draft proceedings and recommendations were distributed to workshop participants for review and comment. The final workshop report and recommendations which follow will be presented up through the Chesapeake Bay Program partnership, including the SAV Workgroup, Habitat Goal Implementation Team (GIT), Water Quality GIT, Management Board, and Principal's Staff Committee. Partnership decisions on recommended aerial and ground survey designs and a more diverse funding partners' portfolio will be sought following this process.

Introduction

Since 1984, the Virginia Institute of Marine Science (VIMS), with the support of the Chesapeake Bay Program (CBP) partnership, has conducted the annual Chesapeake Bay Submerged Aquatic Vegetation (SAV) Aerial Survey and synthesized data from various independent Ground Survey using data interpreted from aerial imagery integrated with ground survey data. The program has evolved over the past three decades to become the most successful and consistent large-scale, long-term SAV monitoring program in the world. Because of the program's endurance and reliability of data, SAV scientists and managers throughout the Chesapeake Bay watershed have grown to rely on the data for a variety of purposes.

Unfortunately, establishing sustainable sources of funding for the program has not been as successful as the program itself. The program has become more expensive as the quantity of data and level of detail, accuracy, and staff expertise have increased, while simultaneously the number and diversity of funding partners has declined.

As a result, the Partnership's SAV Workgroup recently sponsored the Chesapeake Bay SAV Aerial and Ground Survey Design Workshop on March 29th, 2017, at the Chesapeake Bay Foundation's Philip Merrill Environmental Center in Annapolis, Maryland. At the workshop, a diverse array of more than 50 users of the SAV data and products gathered to discuss potential modifications to the survey design which could reduce costs and ensure the future of the monitoring program. These users represented local, state, regional and federal government agencies, academic institutions, and non-governmental organizations (Appendix A).

The workshop objectives were to reach agreement on:

- The collective management, regulatory and research needs for and uses of data and information generated by the SAV aerial and ground surveys;
- A set of aerial and ground survey design options which maximize addressing the Partnership's collective data and information needs; and
- A more diverse funding partners' portfolio to recommend to the Partnership.

In preparation for the workshop, 85 individuals representing a similar array of agencies, institutions and organizations from across the Chesapeake Bay region completed and submitted responses to a comprehensive SAV survey data user questionnaire. The workshop steering committee used those collective responses to structure the workshop's agenda (Appendix B).

Following the workshop, draft proceedings and recommendations were distributed to workshop participants for review and comment. The final workshop report and recommendations will be presented up through the Chesapeake Bay Program partnership, including the SAV Workgroup, Habitat Goal Implementation Team (GIT), Water Quality GIT, Management Board, and Principal's Staff Committee. Partnership decisions on recommended aerial and ground survey designs and a more diverse funding partners' portfolio will be sought following these presentations.

Section I: Evolution of the SAV Aerial and Ground Surveys

Dr. Robert Orth, Professor at the College of William and Mary's Virginia Institute of Marine Science (VIMS), presented the current SAV aerial and ground survey designs, operational logistics, and evolution of the data and products. His presentation can be accessed at [http://www.chesapeakebay.net/channel_files/24937/3_orth_current_sav_survey_design.pptx].

Aerial and ground SAV surveys of Chesapeake Bay SAV have been taking place in some form since the early 1970s. Ground surveys were conducted at hundreds of sites in Maryland in 1971, but the first aerial surveys were of Virginia's western shore tributaries in 1974. The first baywide SAV survey was conducted in 1978, with teams from Virginia and Maryland surveying SAV in their respective waters. The annual survey was re-initiated in 1984 and conducted annually through 2106 (except 1988). VIMS has had sole responsibility of the annual survey since 1987.

The current process of SAV aerial survey data acquisition and release includes seven major steps.

- Pre-planning is done by VIMS with the aerial contractor, Air Photographics. This includes flight timing, flight lines, and all other elements of acquisition.
- Acquisition consists of the collection of multispectral digital imagery under suitable conditions and review by VIMS to ensure SAV is clearly captured. Flights require low wind, minimal cloud cover, low tide, low turbidity, and low sun angle. Conditions are monitored 24/7 and are becoming more complicated with changing weather patterns.
- Ortho-rectification and mosaicing are image processing activities done by VIMS.
- Photo-interpretation involves manual interpretation of the imagery to delineate SAV beds, which are then assigned one of four density classes by VIMS analysts.
- Ground surveys are done independently by partners as well as citizen volunteers to collect SAV species data that are submitted to VIMS.
- A full set of preliminary data is released to funding partners around March 1 of the following year.
- Based on this preliminary data, a press release is created by the Chesapeake Bay Program's Communications Office in coordination with VIMS and the SAV Workgroup. At this time, the final draft report is made publicly available on the VIMS SAV website. The data included in the final draft report are considered preliminary pending final EPA approval.
- A final report is produced and released to funding partners. This report includes all aerial data and SAV species data that were submitted to VIMS.

Acquisition bottlenecks occur in sensitive locations including Washington, DC, Aberdeen Proving Ground in Maryland, Patuxent Air Base in Maryland, and Dahlgren Naval Support Facility in Virginia. These locations require additional planning such as prior approval and armed security personnel in the plane during flights.

Many improvements in accessibility have been put in place since the start of the survey. Results were originally distributed in a printed version. In 1999, VIMS began hosting web based reports on their website. The GIS revolution allowed the VIMS team to transition from manual image interpretation to on-screen photo interpretation and add GPS/IMU (Inertial Measurement Unit) to the acquisition of imagery. The switch from black and white to color film and procuring the imagery in digital files rather than physical maps allows the VIMS team to upload imagery to the online database within

days of obtainment. These GIS advancements also allowed the online maps to become interactive, making online analysis possible for data users and greatly enhancing the ability of partners and the public to utilize the data generated.

Ground surveys done by partner scientists and volunteers are performed to determine species composition and, in some cases, to also measure bed size. The species composition is especially important given changing conditions in the Bay. Over the past 40 years, there has not been an integrated and highly coordinated baywide SAV ground survey program—it has been largely a series of smaller independent ground survey efforts by individuals or organizations reporting their data to VIMS on an ad hoc basis.

In the 1980s, there was a diverse set of state and federal agency funding partners. Over time, all of the federal funding partners except the U.S. Environmental Protection Agency (EPA) eliminated their direct financial support. While the state of Maryland cut back on their funding contributions, Virginia increased their funding with additional support coming from the Virginia Dept. of Environmental Quality. By 2016, the majority of funding for this program was provided by EPA. Other sources include a VIMS match and contributions from VA Department of Environmental Quality (DEQ), MD Department of Natural Resources (DNR), and VA Coastal Zone Management (CZM). Historically, EPA has funded about half of the survey's cost, with significant contributions from VIMS, VA CZM, VA DEQ, and MD DNR and some of that state funding originating from the National Oceanic and Atmospheric Administration (NOAA). Other sources have included, U.S. Fish and Wildlife Service (USFWS), U.S. Army Corps of Engineers (USACE), and NOAA.

The preliminary 2017 budget is $689,086. This figure includes salaries, benefits, the aerial survey contract, indirect costs, and other miscellaneous costs such as travel and supplies. Factors influencing the budget include inflation, staffing changes, additional flight lines and changes in flight line requirements, change of report format, additional data collection, and contracting changes. The aerial survey cost has increased slightly, after accounting for inflation, because of increased capabilities and mapping requirements. A complete history of funding sources (1985-2016) is available in Appendix C.

The annual survey is critical to various regulatory and scientific activities. Maryland, Virginia, Delaware and the District of Columbia have promulgated numerical SAV acreage restoration targets into their respective state water quality standards regulations. All four jurisdictions depend on the data and maps from the aerial survey to determine and publicly report on attainment of their jurisdiction's water quality standards biennially (Appendix D). Aquaculture in the tidal waters, which has expanded substantially in recent years, has state regulations and site evaluations that require SAV bed geospatial data. Federal, state, and local agencies depend on the SAV aerial and ground survey data to make tidal wetland, dredging and filling, pier and marina, and other non-water dependent structure permitting decisions. Propeller scarring in SAV beds is monitored using the aerial imagery to ensure SAV is afforded protection from certain fishing practices including shellfish aquaculture, hydraulic clam dredging, pound nets, and haul seines.

Workshop attendees participated in a robust discussion about data collection need and survey evolution summarized as follows.

- **Short term condition changes**: The VIMS team, along with the aerial contractors, monitor conditions very closely to acquire the best imagery possible, avoiding situations such as reduced clarity due to turbid water from rainstorms. VIMS uses the daily NOAA MODIS satellite imagery along with web-based information on wind direction, speed, and water depth to determine if conditions are right for imagery acquisition. The flight contractor is instructed to stop collecting imagery if they observe poor water clarity conditions.
- **Long term condition changes**: As the Gulf Stream in the Atlantic has slowed over the years of the survey, Chesapeake Bay tides have become less predictable. Cloud cover has also been a more persistent obstacle in recent years. Higher tides, more rapid changes in weather patterns, and increased cloud cover are major changes VIMS has observed over the timespan of the aerial survey program.
- **Potential for collaboration**: The VIMS team is constantly in contact with partners and other mapping agencies to look for new opportunities for collaboration. For example, MODIS (Moderate Resolution Imaging Spectroradiometer) from NASA features real-time radar views and local weather conditions, but currently displays at too coarse of a resolution to analyze SAV.
- **Inter-annual changes in flight lines**: VIMS examines the results of previous years' flight lines to determine if they need to expand certain flight lines or target different areas with additional flight lines.
- **Species distribution**: While in some cases SAV species can be identified from aerial imagery, such as colonizing widgeon grass due to its signature donuts, ground-based verification is normally required for confidence in species classification.
- **Macroalgae**: In most cases, macroalgae has a distinct signature that can be differentiated from SAV. In addition, historical knowledge of SAV beds including notes in the VIMS SAV historical record can also help distinguish between these types of underwater vegetation.
- **Less Common Species/Non-native Species**: Ground data from riverkeepers, watershed organizations, academic institutions and other partners are vital in understanding the distribution and spread of less abundant SAV species as well as non-native SAV species. The timing of the aerial imagery collection does not enable VIMS, for example, to map horned pondweed (*Zannichellia palustris)* beds, but VIMS has ground survey data which has reported the presence of *Zannichellia palustris*.

Section II: Results of the SAV Data User Questionnaire Responses

Brooke Landry, MD DNR and CBP SAV Workgroup Chair, presented the results of the questionnaire distributed prior to the workshop. This session was structured to outline and ensure agreement on the exact survey design requirements of each of those identified management, regulatory and research uses. Her presentations can be accessed at [http://www.chesapeakebay.net/channel_files/24937/4_landry_questionnaire_response_summary.ppt]

Eighty-five individuals responded to the SAV Survey Data User Questionnaire. The respondents represented a variety of user types, with state and federal government employees each making up a quarter of the total surveys submitted. Respondents from non-profit organizations were also a significant portion of the responses, with the remainder consisting of academic, local government, and other. A comprehensive summary of the questionnaire responses is found in Appendix E.

The most frequently used data is the SAV coverage. Density, species, and bed acreage data are also widely used. Data users tend to use the data in the following formats: interactive map, GIS data, and summary data.

Most respondents use the data annually, but a large proportion use the data monthly and even weekly. The data is used for a variety of purposes including permitting, regulation, public reporting, water quality standards assessment, education and outreach, and research. Given that some of these data uses are legally required, users stated that a loss in the annual aerial survey data will likely require changes in existing regulations.

The vast majority of users need these data annually for monitoring and reporting efforts, research, education and outreach, and various legal requirements. In the event this SAV monitoring program is discontinued, most respondents would not collect their own data as it isn't logistically or financially feasible for most to do so.

The majority of questionnaire respondents said that their organizations do not contribute to the ground survey efforts by providing SAV observation data to VIMS. About half of respondents occasionally or frequently requested specific or early information directly from VIMS, while some contact third parties for SAV survey data.

About half of the respondents ranked the annual survey data as 5 out of 5 in importance to their organization and three quarters ranked it 5 out of 5 as important to the restoration of the Bay. Specific tributary data coverage is just as important as baywide data. About two thirds said they would rather contribute to keep the survey going rather than procure SAV data independently, and the majority of the respondents would make this data publicly available.

Workshop attendees participated in a discussion about the questionnaire responses, which is summarized below.

- **Additional Uses of Data:** One of the huge values of this data is that the aerial imagery can be used for additional purposes, such as aquaculture permitting (as discussed before) and tracking shoreline change over time. SAV goal attainment is used as a publically reported performance measure towards water quality and living resources restoration goals. Tracking for other CBP restoration goals such as black duck bioenergetics and protection of essential fish habitat also utilize the SAV aerial and ground survey data. Research toward these other Partnership goals also relies on SAV as a foundational component of the Bay ecosystem. Researchers use the SAV aerial and ground survey data, for example, to answer questions regarding long-term trends in SAV, its importance as habitat, its effects on water quality, and water quality effects on SAV. Shoreline changes and shoreline impacts could be highlighted and mapped through the survey's annual acquisition of aerial imagery. A growing number of agencies are also using the results of the SAV aerial survey as an indicator of climate change impacts and responses.
- **Indicator for Chesapeake Bay TMDL Progress:** This is one of few datasets that can be used as a direct indicator of progress towards meeting the Chesapeake Bay TMDL. This use of the annual aerial survey data in itself should be enough to muster financial support for the program and should be clearly communicated to funding partners.

- **Questionnaire Survey Design:** Most of the responses to the questionnaire were very supportive of the aerial survey. The way in which the survey questions were worded could have led to some of the positive responses, as well as the fact that the questionnaire was targeted to agencies and organizations that use the data, as those are who will be most heavily impacted by any future change in the program.
- **Annual Estimates:** With funding difficulties, it may be necessary to deliver an annual baywide estimate rather than a discreet total acreage of SAV. We need to fully consider a survey design that includes collection and analysis of data across multiple years versus every year.
- **Inter-annual Variability**: The year to year variability in the location of SAV beds is such that a random stratified survey design would have a hard time locating SAV beds over time. Inter-annual change in SAV density and distribution would be more difficult to track.
- **Need for Annual Reporting**: Tributary-specific information is important to local groups (Riverkeepers and watershed organizations). Moving to a survey design that produces a baywide estimate would negatively affect many of the local organizations' ability to create report cards and advocate for their tidal tributary and surrounding watershed. These groups are less interested in the statewide and baywide acreages, but are instead interested in local, region-specific tidal river, creek, and embayment data. Therefore, when we begin discussions of realistic survey design options, we need to factor in the strong interest and need for local-scale SAV acreage data.
- **Awareness:** Making partners and citizens aware of the availability of the data and the aerial photos may increase support.
- **Alternative Funders**: We need to consider alternative funding mechanisms through which others, in various industries for example, can contribute. Many industries are regulated, in part, on the basis of SAV presence or absence. However, we need to recognize that the physical footprint of these industries is tiny compared with the scale of the aerial survey.
- **Measuring Agencies' Performance**: SAV acreage is used as an agency performance indicator for some state and federal agencies.
- **Immediate Access to Aerial Imagery**: Within several days of the acquisition of the digital aerial imagery, the imagery is posted on-line on the VIMS SAV aerial survey web site.

Section III: Alternative designs for the aerial and ground survey

Dave Wilcox, VIMS, presented alternative design options for both the aerial and ground surveys. These design options were the most likely to provide the data and product needs identified through the data user questionnaire. His presentation can be accessed at [http://www.chesapeakebay.net/channel_files/24937/5_wilcox_survey_design_alternatives.pptx]. Detailed pros, cons, feasibility rankings, and estimated costs of each of the 12 aerial and four ground survey designs presented by Dave Wilcox are documented in Appendix F.

SAV Aerial Survey Design Options Presented

1. Continue monitoring program as-is
2. Continue monitoring program as-is plus explore semi-automated classification
    - This more advanced technique would require a higher initial cost but would incur future savings via reduced staff time.
3. Continue monitoring program as-is plus explore fully-automated classification
    - Even higher initial cost and more difficult up front but more future savings.

- No fully-automated monitoring projects on this scale currently exist.
- QA/QC and other staff time still required.

4. Collect annual imagery but process only every other year
    - Collecting all of the annual imagery allows for a revisit of the data if funding becomes available.
    - Collecting imagery less than annually is not feasible with the current flight contractor because Air Photographics is a small business that relies on their annual contract with VIMS. Estimated costs of a new contractor to collect imagery every other year would not provide significant savings over the current contractor collecting annually and may even cost more.
    - Staff could be reduced to either temporary positions or the processing could be drawn out over two years.
5. Collect annual imagery, process only large SAV areas plus subsets
    - Processing imagery from areas with the most SAV (Susquehanna Flats, Smith and Tangier Islands, etc.) would cover a significant portion of the SAV in the bay but this approach would also sacrifice individual tributary data and potential new beds. A baywide estimate could be projected within a margin of error (10-15%), but no baywide totals could be reported.
6. Collect annual imagery, process only a statistical subset
    - A sound statistical design could improve estimate accuracy but there would still be no baywide total.
    - Developing a statistical design would increase initial cost.
    - There are still several questions regarding how much of the Bay would need to be mapped in order to have confidence in the baywide acreage estimates as well as the regional acreage estimates.
7. Collect annual imagery, process sections of Bay over a set of years
    - Areas processed would rotate by geographic zone (upper, middle, lower) salinity range (tidal fresh, oligohaline, mesohaline, polyhaline), state (Maryland, Virginia), etc. This would cover the entire Bay over a set of years but annual detail would be lost.
8. Collect partial imagery to support statistical sample
    - This is the first survey design option which drops the acquisition of baywide aerial digital imagery.
    - A complete dataset would not be available for possible future analysis.
    - Reducing the number of images collected or flight lines flown would not necessarily lead to significant cost savings.
    - There may be minimal cost savings from reduced imagery acquisition (and a reduced number of flight lines) but this avenue may also inadvertently lead to increased costs if it becomes necessary to hire a new flight contractor. The contractor currently working with VIMS, Air Photographics, is dependent on the annual contract with VIMS for baywide imagery.
9. Use satellite imagery for all or part of the Bay annually or biennially.
    - Satellite imagery is expensive and not as precise as the current imagery collection methods.
    - The current imagery is multi-spectrum, acquiring imagery at a 24 centimeter pixel size. With satellite imagery, resolution would be 1-meter.

- For a single acquisition covering 5870 estimated square miles of coverage, Dave estimated a cost similar to the total cost of acquiring aerial digital imagery $132,089 vs. $140,000.
- Given we would need to capture imagery at multiple time periods throughout the entire SAV growing season, the costs for acquisition of the satellite imagery will quickly multiply.

10. Use drones and volunteers either for all or part of the Bay annually or biennially.
    - This would engage volunteers but would require a tremendous effort, training, and start-up expense. The likelihood of collecting imagery of the entire Bay would be minimal, and that imagery would still have to be processed by trained staff.
    - Would need to utilize winged drones that maximize flight time.
11. Use ground survey only
    - Would also require a tremendous effort, training, and start-up expense. The likelihood of creating complete a baywide SAV map would be minimal and therefore goal tracking would be difficult.
    - This would need to be a very quantitative ground survey designed to provide estimates of acreage. There are SAV monitoring programs which alternate between aerial and ground survey through time—Indian River Lagoon in Florida is an example.
12. Discontinue the SAV survey
    - Ending the SAV survey entirely would make it Impossible to track Chesapeake Bay Agreement Outcomes and the burden of SAV monitoring would be shifted from VIMS to individual agencies that require SAV data. Costs to individual agencies that require SAV data may be higher than the overall survey cost.

SAV Ground Survey Design Options Presented

1. Continue with current ground survey design
    - Continue with the current design which is mostly ad hoc, just taking data from groups/organizations willing to send their ground survey data to VIMS.
    - There are costs to VIMS to collect, manage and then apply the submitted ground survey data.
2. Work with Riverkeepers/watershed organizations
    - Incorporate citizen scientists and volunteers into the survey will increase the data collection for minimal funding.
    - A CBP GIT funded project is working on developing such a program.
3. Formal program with specific responsibilities
    - Assigning areas to specific groups can ensure data coverage but also requires a larger commitment from each organization.
    - More structured and organized approach to setting up and running an annual ground survey program.
    - Would require a large coordination effort.
4. Discontinue the current survey. Each organization would collect the data they need.
    - Many agencies that rely on the data do not have the capability to collect.

Workshop participants participated in a detailed discussion about the aerial and ground survey design options, summarized below.

- **Aerial Contractor Options:** The idea of having multiple contractors in order to maximize flights during optimal conditions was brought up but most contractors that inquire about the contract do not bid due to the difficulties and challenges associated with aerial image collection. There is additional capacity but most likely not at a cost effective rate. Due to equipment calibration and other issues, utilizing volunteer pilots is not feasible.
- **Semi-automated classification**: Seems like we need to move at least to a semi-automated interpretation of the digital imagery. The classification system could use all available data including the past year's mapped SAV beds. Taking this approach may also increase the certainty in the mapping of the SAV beds.
- **Other Large SAV Monitoring Programs:** There are a few other large scale SAV monitoring programs in the United States including Tampa Bay, Florida, Indian River Lagoon, Florida, and Puget Sound, Washington, but none are at this scale and frequency of data collection. The Chesapeake Bay also has the most specific management questions driving the design of its SAV aerial and ground surveys and relies on this data for making both collective, collaborative decisions within the Partnership as well as individual local, state and federal agency regulatory and program management decisions.
- **Partial Image Processing:** It is important to, on some timeframe, map and process every part of the Bay. Capturing local changes annually is another important "want" of the assembled group of users and is necessary to measure progress. With all the past data available, a study of estimate effectiveness can be done before moving to a new processing plan. This study will be important to identify in the future which changes in observed data are due to actual changes vs. the change in data collection methods. Overlapping old and new methods for a number of years can help with the transition.
- **Non-processed Images:** The VIMS team would prefer not to post unprocessed images as that may lead to inaccurate data interpretation and uninformed management decisions.
- **Managing the Ground Survey Data for Quality**: The VIMS team manages the ground survey data for accuracy—for example, when eelgrass is reported on the Susquehanna Flats, VIMS would flag that observation and correct it or exclude it from the dataset.
- **Cost for Imagery Acquisition**: Acquisition of the imagery costs $140,000 + indirect costs + VIMS staff time watching all the weather and tide indicators to determine when the contractor flies, which is often on weekends, particularly given the amount of restricted airspace around the Bay. About a 1/4 to a 1/3 of the total program costs are due to the acquisition of the digital imagery.
- **Use Volunteer Pilots**: The answer to the question "Could you set up volunteer pilots to put the equipment in their planes and help fly the flight lines" was "No, due to the cost of the equipment ($1 million) and the steps needed to calibrate the equipment used in acquiring the imagery."
- **Other SAV Surveys around the Country**: Tampa Bay Estuary Program, Florida, maps its SAV beds every other year. Indian River Lagoon Estuary Program, Florida, maps its SAV beds via aerial survey every other year with ground surveys conducted in the alternate year. Puget Sound, Washington, has attempted to carry out an aerial survey but the physical water column depths of the SAV beds have hindered a routine survey program.
- **Combined Options 6 and 7**: One option that was not suggested is a combination of options 6 and 7. This would include acquisition of the aerial imagery annually, but at a scale that makes sense with stratification at locations/geographies that make sense, and randomly

interpret and map 1/3 of those stratified areas so that every third year we get a complete picture of the SAV coverage across all tidal waters.

- **Need for Retrospective Analysis**: We should not select any single survey design without doing the retrospective analysis using the 30+ year history of survey data to full understand the uncertainty estimates.
- **Funding for Statistical Analysis**: Funding should be sought to support the recommended statistical analysis of the optional survey designs.
- **Self-Interpretation of Imagery**: In the options which call for collection of the imagery every year, but not interpretation and mapping of all the SAV bed, the regulatory agencies would have to interpret the imagery for that year themselves if the region of interest was not on the schedule to be interpreted when needed.
- **Understanding Implications of Changes in Survey Design**: If we are planning to change the survey design, we need to understand the implications of the change in the survey methodology. A period of overlap would be necessary during which the old and the new survey designs are implemented simultaneously.
- **CERF Conference**: We could use the opportunity of the SAV survey workshop hosted at each biennial Coastal and Estuarine Research Federation (CERF) conference to raise some of the survey design questions and options with other scientists from across the country and around the world to get their input.

Section IV: Feedback from User Groups

Workshop participants were split into the following breakout groups based on their agency or organization: federal government, state and local government, scientific research, and non-governmental organizations/non-profit organizations. Each of the breakout groups were asked to clearly define their data needs and wants. To get the discussion started, the following six questions were recommended:

1. What do you use the SAV monitoring data for?

2. Is there data that you need that you can't get from the current survey design? For example, is the coverage extensive enough? Is the species data adequate?

3. Do you need annual data?

4. Does the time lag between acquisition and reporting affect your data needs?

5. With unlimited financial resources, what would your SAV Monitoring program look like (brief overview here)?

6. With intensively limited financial resources, how would you get the information you need?

The breakout groups were then asked to select the aerial and ground survey designs that would best meet the collective needs of the group as a whole while still being operationally feasible.

State and Local Agencies User Breakout Group

Two main user types, assessment and regulatory, have data uses that include project permitting and siting, setting and measuring toward strategic goals, water quality standards attainment, and trends

analysis, among others. Many users only utilize data annually but some rely on the data as often as weekly. The frequency and precision required of the survey varies by need. For certain uses, such as measuring progress toward overall Chesapeake Bay goals, baywide SAV acreage data would suffice. To determine water quality standards attainment for the 303(d) List (impaired waters list), States would need SAV acreages achieved in individual Chesapeake Bay segments (mainstem and/or tidal tributary segments) on some regular basis. For other uses, project decisions require accurate location data. Low error is needed to make and defend regulatory decisions and estimates would not be satisfactory. Regulations would have to change if the survey could not provide accurate data annually, but decreased frequency of data could be dealt with.

If funding can be found to move towards semi-automation, along with ground-truthing to confirm that accuracy is maintained, option 2 (semi-automated classification) may meet all state and local agencies' needs. Targeted annual segments synced with priority segments (impaired waters list) and other monitoring programs may suffice for frequency surveyed – the baywide data is not as important as tributary-specific data to most state users. With SAV being so dynamic, certain tidal tributaries need annual assessment. A statistical analysis should be conducted to determine a potential tributary assessment schedule.

Having the complete baywide set of aerial imagery each year is important. Funding mechanisms may come to light that allow for the processing of specific locations for regulatory decisions. The baywide ground survey alone or new techniques of image collection such as satellite or drones will not suffice.

Ideally, other permanent funding sources will come to light that will allow the aerial survey to continue at full capacity well into the future. Agencies and organizations outside of the federal and state governments should be explored as potential funding partners (such as fishing organizations and the Maryland and Virginia Association of Counties). An additional avenue to explore should be included the SAV Monitoring Program as a line item in the two states' budgets passed by their respective General Assemblies.

Survey Design Recommendation: Ideally the Partnership will find funding sources to continue the aerial survey as it is (option 1). Annual baywide aerial image collection is vital. Semi-automated processing (option 2) is state and local agencies' next choice, given that they can confirm the accuracy of the mapped SAV beds. Image processing of either a statistical subset or targeted sections of the Bay and specific tributaries (options 6 & 7) are preferred in the event of required significant budget cuts to the aerial survey program.

Non-governmental and Non-profit Organizations Breakout Group

The majority of users in this group use the SAV survey for reporting purposes. Many riverkeepers and other watershed organizations develop annual report cards, which showcase SAV as an indicator of the health of their waterbody. The report cards are posted online and distributed to volunteers and local citizens, as well as used as part of education, outreach, and small-scale restoration plans.

The non-governmental/non-profit organizations all expressed concerns about loss of spatially explicit data on an annual basis. Any option that cuts imagery collection and processing of any tidal tributary will not meet the needs of the riverkeepers and watershed organizations. Annual collection of aerial imagery by VIMS is vital. Processing is necessary too but may be done ad-hoc. A training academy led by VIMS and coordinated by non-governmental organizations to train staff to process

images may be a better investment of funds and provide cost savings. Automation of the SAV bed classification process is also an intriguing prospect.

While riverkeepers and watershed organizations do not have the capacity to financially support the SAV Monitoring Program, they can provide in-kind support for the program by contributing to a more baywide, coordinated ground-survey program. The Water Reporter app is being enhanced to do just this, and will be presented to riverkeepers and the public when completed. User fees for permitting applications is a potential funding source.

Survey Design Recommendation: Short of increased funding to continue the survey, moving to semi-automated classification (option 2) is ideal for the non-governmental/non-profit organizations to ensure that each tidal tributary has imagery collected and processing done on an annual basis. The move to full automation (option 3) may eventually drop costs even more. Other technologies such as satellite and drones (option 9) should be continually explored as costs fall.

Federal Agencies Breakout Group
This group agreed that complete baywide aerial image collection by VIMS must take place annually. Cost savings may occur in changes to processing and SAV bed classification. The possibility of image interpretation by other groups should be explored.

The National Park Service provides funding through a Cooperative Ecosystem Studies Unit, which could assist in outsourcing data interpretation to universities. Aberdeen Proving Ground, Maryland and the U.S. Department of Defense may have funding mechanisms to explore as well.

Combining efforts with other mapping projects can provide savings as well. The entire watershed is being mapped at 1-meter resolution for land cover data. Collaboration here would potentially be helpful. Other data collection technologies such as drones and satellite imagery should be continually monitored as possibilities as well. The ground survey could be relied upon more heavily to enhance accuracy of any estimates from the aerial survey.

Planning should occur for multiple funding scenarios: average shortfall (~$100,000), moderate cuts, and large cuts. Many of the desired options described above include initial start-up costs that need to be covered somehow as well. It is important to keep in mind that the disaggregation of an established monitoring program often results in increased costs rather than the anticipated decreased cost. This occurs as a result of unanticipated impacts combined with known impacts.

Survey Design Recommendation: Bringing forward additional funding partners would be the best solution (option 1). This may be necessary, as the cost savings options that meet our needs include higher initial costs. An analysis should be done before decisions are made to determine the effectiveness of some cost saving strategies such as processing only a statistical subset of images (options 6, 8).

Researchers Breakout Group
The acquisition of full baywide aerial imagery is needed every year. Losing data is undesirable, so automation should be explored for its accuracy and cost saving potential (option 3). Concerns over accuracy include water reflection.

Subsampling would need to prioritized based on existing criteria such as TMDL timelines. A retrospective statistical analysis should take place if subsampling is pursued. The wide variance of SAV makes subsampling tricky, as areas can develop SAV beds quickly. Monitoring whole segments to obtain segment-specific water quality standards attainment assessments may be a strong option. Subsampling each tidal tributary may relieve riverkeepers/watershed organizations concerns as they'd all have at least some data (option 6).

Moving to a satellite program is not feasible at this time due to the large costs and effort required to develop a new program (option 9). The multispectral aerial imagery is likely marketable, providing an opportunity to develop new partnerships and pursue other grant opportunities.

Survey Design Recommendation: Full Baywide, annual aerial imagery collection is necessary. Semi-automated classification (option 2) is promising but needs to be researched further. If any subsampling is done (option 6), we need a retrospective statistical analysis of the 30-40 year data record to inform that subsampling. Subsampling could be done by segment or tributary (option 7) so each salinity zone and tributary gets data annually. Need to be very clear about the questions we are asking of the aerial and ground survey data sets as the basis of a request for proposals.

Discussion of the Four Breakout Groups' Design Recommendations
The four breakout groups reconvened to examine each group's proposed alternative survey designs. The following summarizes that discussion, which include input from every single workshop participant, and the collective workshop participants' recommendations.

- **Strong Agreement on Need for Annual Aerial Imagery Acquisition**: There is solid agreement among all groups on the need for continued annual acquisition of baywide aerial imagery.
- **Strong Agreement on Semi-automated Classification**: There is solid agreement among all groups on the need to move towards semi-automated interpretation of the aerial digital imagery.
- **Agreement on Need for Analysis of 40-Year Data Record**: If a survey design option is pursued that doesn't include analyzing and processing all data, there is strong support for conducting a retrospective analysis of the 40-year survey record to determine the feasibility and accuracy of using a subset of the images collected to establish a baywide estimate of SAV.
- **Agreement on Need for Enhancements to SAV Ground Survey**: There is solid agreement on the need to enhance the existing SAV ground survey program. The non-governmental/non-profit organization representatives agreed to take the lead on the design of an expanded baywide SAV ground survey which would include the utilization of citizen scientists and volunteers. Jeff Holland offered to serve as a liaison to the Chesapeake Bay waterkeepers group.
- **Communicate Importance of Survey Data and Products**: SAV is the most visible and easily measured indicator of water quality. This survey is incredibly valuable and is done efficiently and relatively inexpensively. This needs to be communicated more often to gain additional support.
- **Importance of Survey Data for Making Regulatory Decisions**: Many permitting and regulatory requirements rely on the survey and will need to be altered with any loss of data or data integrity.

- **Implications for Existing Regulations**: It is necessary to clearly communicate the level of effort that may be required to modify existing regulations if the existing SAV monitoring program is changed or discontinued. Many state regulations explicitly refer to the annual SAV aerial survey data and rely on that data to support regulatory decision making. Need to more clearly spell out the implications for changes to the current aerial survey design and those implications of a reduced or eliminated survey should be further examined.
- **Local Data as Important as Baywide Results**: Specific tidal tributary data is as important to local watershed organizations as the baywide acreage data is to the Chesapeake Bay Program Partnership as a whole as well as to the individual state partners.
- **SAV is One of the Best Indicators of Bay Restoration**: SAV is a highly visible indicator of water quality and one of the few effective story telling methods for Bay restoration easily and widely understood by the public.
- **Many Design Options Cause Significant Changes at Low Cost Savings**: Many of the design options require a significant change in the survey's design but deliver small cost savings. Securing reliable funding for the survey would absolutely be ideal but doesn't seem likely. Having concerned citizens meet with state secretaries or other decision makers could be a fruitful strategy for strengthening current funding and potentially finding additional funding.
- **Consider Identifying Specific Areas for Subsampling**: Prioritizing certain areas and statistical subsampling should be the focus if not all imagery can be processed.
- **Communicate Multiple Uses of Survey Products**: Need to clearly communicate the multitude of different uses of not only the survey data, but the annual digital imagery and other by-products of the existing survey design.
- **Increased State Agency Funding:** Need to advocate for replacing of the current federal dollars supporting the survey with Maryland and Virginia state agency funding given the majority of the benefits from the survey are at the state and local levels.

Findings

SAV aerial and ground surveys in Chesapeake Bay have been taking place since the early 1970s and annually since the mid-1980s. The SAV aerial survey dataset has evolved to improve both data precision and accessibility, and the cost of the survey has correspondingly increased. To this point, funding was made available through various state and federal agency partners but an annual shortfall of funding has made it necessary to consider the need to change the aerial survey design to operate at a lower cost, which was the objective of this workshop.

Twelve options were presented for the aerial survey, with varying elements such as automatic image processing, less frequent image collection or image processing, utilization of alternative image collection methods, and discontinuation of the survey altogether. Four options were presented for the accompanying ground survey, focusing on increased levels of coordination across the participating organizations.

Results from a questionnaire of data users show that the annual SAV aerial survey and the data it generates is critical to a wide variety of users. The aerial survey data are used in various formats and for numerous purposes, including regulatory decisions, monitoring and reporting efforts, research, and education and outreach. The majority of users would not be able to procure the data independently and thus rely on VIMS to conduct the annual SAV aerial survey. A loss of any information or data integrity will affect users and potentially increase their operational costs for

meeting and performing their current programmatic, regulatory and organizational obligations. Users stressed the importance of annual imagery acquisition and ortho-rectification to increase the utility of the imagery to partners.

Recommendations

Aerial survey option 1, to secure funding in order to continue the survey with no changes, is preferred option but likely not feasible with the funding outlook. The group commended and thanked Bob Orth, Dave Wilcox, and the rest of the VIMS team who have efficiently and cost-effectively provided such a strong and useful dataset and report annually for the past several decades.

Aerial survey option 2, utilizing a semi-automated system to process imagery, should be actively pursued to take advantage of evolving technologies that may reduce costs and make the survey even more efficient. A larger initial cost and potential troubleshooting with this option are acknowledged.

Aerial survey options 6 and 7 should be further explored to determine estimate accuracy, frequency of tidal tributary-specific data processing, and potential to target segments to align with existing priorities.

Riverkeepers and watershed organizations will continue to work together to further evaluate enhancements to the existing SAV ground survey, exploring options 2 and 3 with the purpose of bolstering the ground survey and incorporating more advanced technologies in an effort to increase the utility of the ground survey data.

The workshop steering committee will further examine the recommended survey design options and continue to explore funding options, working their way up the Chesapeake Bay Program Partnership's management structure—SAV Workgroup, Habitat Goal Implementation Team, Water Quality Goal Implementation Team, Management Board and the Principals' Staff Committee.

Appendix A: Workshop Participants

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Appendix B: Workshop Agenda

Chesapeake Bay Program Partnership's
SAV Aerial and Ground Surveys Design Workshop
March 29th, 2017
9:00 am – 4:00 pm
Chesapeake Bay Foundation, Philip Merrill Environmental Center
6 Herndon Ave, Annapolis, MD 21403

9:00 am: Welcome and introductions (Brooke Landry, Md DNR)

9:10 am: Workshop objectives and structure (Rich Batiuk, CBP)

9:15 am: Presentation of the current SAV aerial and ground surveys' design, operational logistics, and evolution of the resultant data and products. (Bob Orth, VIMS)

10:00 am: *First session.* Discuss results of questionnaire distributed prior to workshop, and any additional data and product needs. This session will also be structured to outline and ensure agreement on the exact survey design requirements of each of those identified management, regulatory and research uses. (Brooke Landry, Md DNR)

11:00 am: *Second session.* Presentation of options for alternative designs of both the aerial and ground surveys directed towards providing the data and products identified through the questionnaire. This session will be structured to align the exact survey design requirements with a series of potential alternative aerial and ground survey designs. (Dave Wilcox, VIMS)

12:00 pm: Lunch (provided, main conference room)

1:00 pm: *Third session***.** Each user type— 1. Federal, 2. state and local, 3. scientific research, and 4. NGO/non-profit— will form breakout groups to discuss how to best align their specific user needs with different potential survey designs. Each breakout group will be charged with developing alternative, yet operationally realistic monitoring designs for both the aerial and ground survey that meet the user needs of the group. (Facilitators will include Becky Golden [Md DNR], Christine Conn [Md DNR], Peter Tango [USGS], and Mike Naylor [Md DNR].).

2:15 pm: *Fourth session.* Reconvene to examine each group's proposed alternative survey designs. Ideally a final set of designs for the SAV aerial and ground surveys will be created during this process which will meet with the consensus of the workshop participants. If consensus can't be reached, then the workshop participants will be asked to contribute to a list of any required further design evaluations or considerations to be followed up on by the Workshop Steering Committee. (Brooke Landry and Rich Batiuk with facilitators)

4:00 pm: Conclude

Appendix C: Survey Funding History 1989 through 2016

Annual Project contributions from each of the participating agencies for the annual SAV Survey.

Year	NASA	EPA	NOAA	MD DNR / CZM	MD DNR / CBIG	MD DNR / RAS TEA	VA NOAA CRM	VA DEQ	US FWS	ARMY CORPS	TOTAL	VIMS Match
1989	..	$ 130,000	..	$ 40,000	..	..	$ 25,000	..	$ 30,000	..	$ 225,000	$ 50,000
1990	..	$ 130,000	..	$ 30,000	..	..	$ 25,000	..	$ 30,000	..	$ 215,000	$ 55,000
1991	..	$ 130,000	..	$ 30,000	..	..	$ 25,000	..	$ 30,000	..	$ 215,000	$ 60,000
1992	..	$ 122,000	..	$ 32,250	..	..	$ 25,000	..	$ 30,000	..	$ 209,250	$ 65,000
1993	..	$ 135,000	..	$ 32,250	..	..	$ 25,000	..	$ 30,000	..	$ 222,250	$ 70,000
1994	..	$ 135,000	..	$ 37,400	..	..	$ 25,000	..	$ 35,000	..	$ 232,400	$ 75,000
1995	..	$ 135,000	..	$ 37,400	..	..	$ 28,000	..	$ 35,000	..	$ 235,400	$ 56,000
1996	..	$ 135,000	..	$ 39,400	..	..	$ 45,600	..	$ 35,000	..	$ 255,000	$ 61,000
1997	..	$ 135,000	..	$ 41,330	..	..	$ 50,610	..	$ 35,000	..	$ 261,940	$ 61,000
1998	..	$ 135,000	..	$ 44,222	..	..	$ 56,180	..	$ 35,000	..	$ 270,402	$ 66,000
1999	..	$ 135,000	..	$ 47,928	..	..	$ 60,000	$15,000	..	..	$ 257,928	$ 70,000
2000	..	$ 180,199	..	$ 50,219	..	..	$ 62,000	$15,000	..	..	$ 307,418	$ 72,000
2001	..	$ 188,000	..	$ 53,651	..	..	$ 59,010	$15,000	..	..	$ 315,661	$ 72,000
2002	..	$ 175,000	..	$ 60,051	..	..	$ 59,010	$10,000	..	..	$ 304,061	$ 76,900
2003	..	$ 175,000	..	$ 60,051	..	..	$ 59,010	$15,000	..	..	$ 309,061	$ 82,700
2004	..	$ 150,000	..	$ 60,051	..		$ 59,010	$15,000	..	$ 25,000	$ 284,061	$ 80,200
2005	..	$ 175,000	..	$ 62,598	..		$ 59,010	$15,000	..	..	$ 311,608	$ 80,600
2006	..		$ 180,000	$ 86,067	..	..	$ 60,000	$20,000	..	..	$ 346,067	$ 71,200
2007	..	$ 236,065	..	$ 74,620	..	..	$ 60,000	$20,000	..	..	$ 390,685	$ 88,300
2008	..	$ 240,000	..	..	$ 29,520	$ 45,700	$ 60,000	$21,000	..	..	$ 396,220	$ 231,200
2009	..	$ 240,000	..	..	$ 34,520	$ 45,100	$ 60,000	$21,000	..	..	$ 400,620	$ 174,900
2010	..	$ 240,000	..	..	$ 34,520	$ 45,000	$ 60,000	$21,000	..	..	$ 400,520	$ 167,700
2011	..	$ 240,000	..	..	..	$ 45,000	$ 60,000	$22,000	..	..	$ 367,000	$ 132,200
2012	..	$ 240,000	..	..	..	$ 45,000	$ 60,000	$22,000	..	$ 85,000	$ 367,000	$ 150,000
2013	..	$ 300,000	$ 20,000	..	..	$ 45,000	$ 60,000	$72,000	..	..	$ 497,000	$ 150,000
2014	..	$ 360,000	$ 20,000	..	..	$ 45,000	$ 60,000	$72,000	..	..	$ 557,000	$ 150,000
2015	..	$ 360,000	..	..	..	$ 45,000	$ 60,000	$72,000	..	..	$ 537,000	$ 150,000
2016	..	$ 360,000	..	..	..	$ 45,000	$ 60,000	$72,000	..	..	$ 537,000	$ 150,000

Appendix D: Implications of a Modified SAV Survey on Current Regulatory Procedures

State Water Quality Standards-Water Clarity Criteria for Shallow Water SAV Designated Use

Regulation or Statute: 9 VAC 25-260-185 (§ 62.1-44.15 of the Code of Virginia); MD COMAR 26.08.02.03-3 (Environment Article, §§9-303.1, 9-313—9-316, 9-319, 9-320—9-325, 9-327, and 9-328, Annotated Code of Maryland)

States have established specific SAV acreage goals that are based on water clarity standards for each Chesapeake Bay Program segment with shallow water SAV designated use.

A segment has attained the shallow water designated use if:

1) it meets or exceeds the **SAV acreage** restoration goal,

2) the shallow water acreage meets or exceeds the water clarity criterion (expressed as Secchi depth equivalence or % light through water column (PLL), or

3) it meets or exceeds the water clarity acreage goal (derived from SAV acreage restoration goal).

If none of these are applicable, the segment has not attained the water clarity designated use

Criteria assessments are done every three years using the single best SAV acreage for a particular segment. The SAV acreage is determined by the current annual SAV survey. Water clarity acres are determined using Shallow Water Monitoring Program data.

Implications: An accurate SAV acreage for each segment (at minimum every 3 years) is necessary to assess water clarity criteria as stipulated in current regulations. If a segment has no available SAV acreage data or shallow water monitoring data, it does not attain the water criteria designated use.

Compatible design options from alternative design excel file: 1, 2, 3, 9 maybe 4 and 8

Tidal Wetlands Permitting

States have direct and indirect protection of SAV that applies to dredging and filling, piers, marinas, and non-water dependent structures.

Tidal Wetlands

- SAV habitat should be considered within criteria for tidal wetlands permit or license applications (MD COMAR 26.24.02.03)
- Mitigation plan view should include delineation of existing and adjacent SAV (MD COMAR 26.24.05.01)

Dredging and Filling

- SAV presence should be a factor to be considered in application process (VA 28.2-1205, 4VAC 20 400-50; MD COMAR 26.24.03.01, 26.24.03.06)
- No new dredge projects in water < 3ft unless "historic use" (MD COMAR 26.24.03.02)
- Time of year restrictions to assure protection of SAV (MD COMAR 23.02.04, 26.24.02.06)

Piers, Marina, Non-water dependent structures

- SAV presence should be considered in permitting/licensing process for siting of marinas (4VAC 20 360-90, MD COMAR 26.24.04.03), non-water dependent structures (MD Article §16-104),marina expansion (MD Article §16-107)
- Fixed or floating platforms may not be placed over vegetative tidal wetlands, including SAV(MD COMAR 26.24.04.02)
- MDE may not issue a license for a fixed or floating pier, deck or walkway or related structure which adversely affects SAV (MD COMAR 26.24.04.02)
- No new boathouses should be placed over state or private wetlands (MD COMAR 26.24.04.02)

Implications: SAV distribution and location at the project level is necessary criteria for license/permit application approval; increased ground-truthing on a project-by-project basis would increase staff time and costs associated with permit/license reviews; increased risk of "missing" SAV during site surveys.

Compatible design options from alternative design excel file: 1, 2, 3, 12, maybe 9, 10

Fisheries Practices

SAV is afforded some protections from certain fishing practices, including shellfish aquaculture, hydraulic clam dredging, pound nets (VA) and haul seines (VA).

Pound nets

- VMRC should consider effects of placement of new nets on SAV (4VAC 20 25-30)

Haul seines

- Gear restrictions in water less than 3 ft deep (4VAC 20 1070-30, 2003), or
- If in water less than 3 ft, no SAV should be within 15 ft of the pocket (4VAC 20 1070-30, amended 2009)

Hydraulic clam dredging

- In Maryland, hydraulic clam dredging is prohibited in "**SAV Protection Zones**" (MD COMAR 08.02.01.12) and within certain distances from shore (by county) (MD Article §4-1038)
    - "Aerial survey" means the **annual aerial survey compiled by the Virginia Institute of Marine Sciences for the annual baywide Submerged Aquatic Vegetation Mapping Program** (MD Article §4-1006.1)
    - The updated delineations shall include areas where submerged aquatic vegetation has been mapped by aerial surveys during at least 1 of the previous 3 years. (MD Article §4-1006.1)
- In Virginia, clam and crab dredging within 200 meters of SAV is prohibited in Chincoteague Bay (4VAC 20-1030, §28.2-701 Code of Virginia)

Shellfish Aquaculture

- No enclosures, bags, nets or structures shall be placed on existing SAV (4VAC 20 335-30, 4VAC 20 336-30, 4VAC 1130-10 et seq., §28.2-603.1 Code of Virginia, MD Article §4-11A)
- No new leases shall not be located in an "**SAV Protection Zone**" (MD COMAR 08.02.23, MD Article§ 4-11A)

- "**SAV Protection Zone**" means an area of submerged aquatic vegetation with a density greater than 10 percent **as mapped in aerial surveys by the Virginia Institute of Marine Sciences** in 1 or more of the 3 years preceding the designation of an Aquaculture Enterprise Zone, or an application for an aquaculture, submerged land, or demonstration lease

Implications: Decrease in the ability to enforce current regulations; requirements of current regulations could not be met without the VIMS aerial survey.

Compatible design options from alternative design excel file: 1, 2, 3, 9 maybe 4, 8

Appendix E: SAV Survey Data User Questionnaire Responses

85 total responders

Is your organization (84 responses)
Federal government: 22
State government: 19
Local government: 3
Non-profit: 19
Academic: 12
Public School: 1
Private: 3

What SAV data do you use? Check all that apply. (84 responses)
SAV Data Coverage: 78
SAV Density Data: 57
SAV Species Data: 57
SAV Bed Acreage Data: 60
Other: 6

In what format do you use the data? Check all that apply. (82 responses)
Interactive map on VIMS website: 61
Printable quad maps: 21
GIS data/shapefiles: 54
Summary data: 51

How often do you use this data? (81 responses)
Daily: 5
Weekly: 21
Monthly: 16
Annually: 40

How often do you access the VIMS SAV website? (79 responses)
Daily: 3
Weekly: 12
Monthly: 29
Annually: 35

For what specific purposes do(es) you/your agency/your institution access and use these data? Check all that apply. (80 responses)
Permitting: 28
Regulation: 20
Public reporting: 30
Water quality standards assessment: 31
Other: 39 (assessing EFH impacts, research, academic, education, project analysis,

Is annual data important for your purposes, or would less frequent data suffice? What do you use the data for? Please provide a written explanation. (82 responses)

Need annual SAV data: 72
Less frequent than annual SAV data would suffice: 10

If annual SAV data becomes unavailable, would there be impacts to services that your organization provides? (82 responses)
Yes: 15
No: 67

Please explain your response to the previous question. (72 responses)

- Permit reviews and project screening is based on most recent 3 or 5 year annual survey data. A few regulations specifically mention that the data is from VIMS aerial survey
- We currently use the last five years of SAV maps in our reviews in MD. We would need to consider what information we would use in our EFH assessments if annual data were not available. E.g., would we look at historical maps? habitat suitable for SAV?
- We would still provide recommendations, but they would be based on a culmination of data (e.g., over 5 years) and would lack the most recent knowledge of SAV presence/density.
- we would have to incur extra expense to determine the extent and location or SAV on our own, in order to fulfill the purposes we use that data for.
- Assessment of individual year's water quality criteria could not be conducted. Established, codified methods have been developed by state and federal partners, so either the assessments could not be performed or a long process of redeveloping methodologies and realigning monitoring would have to be performed.
- SAV is very important to the health of our river and so is a necessary part of our watershed report card score. Having the information also allows us to have an informative and fact based introduction to our SAV identification workshop aimed at showing boaters and other citizens the importance of SAV.
- No data would severely hamper our efforts to in for the public and to guide lawmakers toward James River and Chesapeake Bay restoration.
- Additional sampling is necessary to fully evaluate resource. It may be better to get biannual data, or every three to five years, and then do drone or other types of sampling to truly evaluate resource.
- Our seventh grade unit of study has been built over 20 years in cooperation with VIMS and the USFWS. Our students and teachers use the data and contribute groundtruthing data as a central component of the unit.
- We wouldn't be able to update the no clamming zones.
- As explained in my email response, out of date or inconsistently collected SAV data will negatively impact efficient permit review by state and federal agencies possibly leading to underestimation of impacts and inadequate mitigation.
- Lower sampling frequency would reduce the information available on how SAV responds to interannual variations in stressors and other environmental factors
- Permitting protections would be weakened
- We'd lose a valuable educational tool that helps rally support for improving fishing and swimming conditions in our watershed.
- We rely on the annual data when looking for restoration sites, and the availability of beds for collections. Because established SAV beds can be persistent over time we would only be partially affected and would still be able to make management decisions from previous years' data.

- Lack of these data will affect our ability to test models we are developing, and this affect future funding/projects for ODU faculty and students, as well as product development efforts for state & federal agencies
- We prefer to use the most recent data and often SAV data can vary a great deal from one year to the next.
- We would not be able to complete our biennial assessment for sediment impairment to the Chesapeake Bay and its tidal tributaries.
- Less frequent SAV data would decrease our ability to conduct rigorous research on questions related to SAV dynamics in Chesapeake Bay
- We have established an environmental center at the museum that focuses on monitoring environmental quality and not having the SAV data would be a major gap in the information available for the center's purpose.
- We need the data in order to communicate with our constituency. Public outreach and engagement is a key element of our mission.
- Simulations on annual time scales would be harder to implement and would not have good data.
- Any interval less than annual compromise the statistical analyses of long term trends, which is vital in tracking the state of Chesapeake Bay. Holes in the data can never be repaired. They have occurred before
- We need to be responsive to many audiences; research work uses these data very frequently
- We would be reduced to guessing how SAV are fluctuating in study areas. It would have us go blind to the resource.
- Loss of this data would limit our ability to associate SAV changes with other biogeochemical/water quality changes in the Bay and its tributaries
- Without these data, we would only be able to assess a small number of Bay segments at a time. The only "assessable" segments would be those where with a sufficient amount of water clarity data has been collected to enable the calculation of water clarity acreage. The number of such segments in any given assessment cycle is tiny compared to the total. The SAV aerial data allows us to assess all the segments.
- Permit and shellfish leasing decisions would be delayed, and the lack of annual data could impact ability to defend permit, leasing and regulatory decisions.
- Annual update on SAV conditions in our annual report card.
- While annual data would be best, we could plan and target areas using data generated every other year. Planning projects through the INRMP process generally occurs over 5 year cycles with annual updates.
- several internal project reviews rely on 3-5 years of SAV data "as mapped by the VIMS survey", which is specifically stated in state code and regulations
- Need to know what is there, where it is to avoid SAV impacts
- This data is not used for my role in the organization
- We do not have a specific program that requires this data. It is mainly used as observational awareness through social media by the use of map development.
- It is a yes and no answer. Of course there are impacts to annual reporting and updating, but no, it is not going to stop us from working with the data available to support the best science and assessments resources allow. Decreasing frequency always gets reflected in whether or not particular events get captured and supporting explainability of phenomena, the power to detect trends in space and time, the time it takes to reflect and quantify a change in space in time, and so on. Less than annual data would be a compromise.

- Without annual data we lose the ability to understand dispersal and to link SAV response with environmental conditions. The annual monitoring data in the Chesapeake are one of the premier long-term datasets on the world. It would be a travesty to lose this resource.
- We believe this information is key to helping us track bay restoration. We use it with our members in our publications, e-news and state of the Bay report.
- Risk of a decline in fundamental research to understand and predict responses of estuarine systems to various human and natural stressors, with the ultimate goal of informing conservation and management decisions for ecosystem restoration and protection.
- The impacts to me would be minimal, but my answer above is indicative of my overall concerns. SAV health and distribution are critical to understanding and documenting Bay health.
- It would make it harder for personnel and take more time to review permits whose projects may affect SAV resources
- Distribution maps are invaluable to some of our ecological surveys and habitat restoration efforts
- The current and continued availability of SAV data is important to my research program and it continues to be incredibly useful, especially now that things in the Bay are changing rapidly. The incredible recovery in the Susquehanna Flats and similar trajectories in other sub-systems highlights how rapidly SAV populations can and do change. Annual data is, at a bare minimum, necessary to study SAV recovery. Understanding how SAV recovery happens is important for designing management strategies to encourage recovery. Furthermore, the Chesapeake Bay Program SAV Monitoring Program is held up as an example for all other programs to follow. Shuttering or downsizing this program could potentially have cascading negative effects on other estuarine monitoring programs.
- unable to track goal
- Would not have the data necessary to provide technical public comment on permits. Would not be able to adequately assess water quality and watershed health.
- I say yes (not for my current position) but answering on behalf of my two previous organizations. Without the VIMS data, there not really a good, standardized, baseline set of information that is provided and QA/QC-ed each year so detecting changes in the future would be more challenging and arbitrary
- Missing one year's data compromises the ability to conduct appropriate statistical tests to understand trends in SAV
- We produce our report every two years, so less frequent SAV data would only affect us if it there was no update within that two-year horizon.
- If data become unavailable, I would be looking for different research directions
- MD DNR would be unable to meet its statutory requirements to screen lease applications against the annual SAV data.
- We could not report annually to the public on one of the most understandable and most ecologically significant Bay living resources. We could not support the legal responsibility of the state and District partners to assess attainment of their Chesapeake Bay water quality standards biennially but based on the most recent 3 years' worth of data.
- We typically look at a five-year timeframe on decision making
- less detailed reporting
- We will not have a valuable piece of information that help us gauge the health of the river, and our progress. Our state of the river report, for example, will lack the SAV information component, therefore the public and our donors will have limited information available about the state of the Anacostia river and how our actions help lever it. SAV is a very "charismatic" water quality variable to show the public since it is about "pretty aquatic

plants that help fish" compared to other variables like oxygen or stormwater.

- No SAV outreach
- This would impact status and trends and water quality attainment measures.
- We need to know where SAV so as to avoid permitting impacts to beds.
- Our members expect an annual report card to assess condition of the River and effectiveness of restoration efforts. MRA uses these data to support grant requests.
- Because restrictions on SAV zones are included in tidal wetland regulations, it is impossible to know how the lack of data would affect our projects, but I would suppose that the result would not be positive for our industry or the health of these beds.
- DNR is responsible for not only research and management, which would both be impacted by a loss of data, but we are also responsible for reporting and dissemination of the SAV data. Every year we have a press release of the SAV numbers for the previous summer. This sparks a great deal of interest in Maryland's citizens that leads to environmental stewardship and environmentally responsible behaviors that are invaluable to the well-being of Maryland's ecosystems.
- Corps-Regulatory would require applicants to ground-truth SAV beds within and near proposed project vicinity and provide this information on a plan view drawing with their application for a Corps permit. The Corps-Regulatory would use this data to evaluate impacts to the aquatic environment from the proposed project and to consult with the resource agencies (NMFS and MD DNR) for essential fish habitat and endangered species purposes prior to finalizing permit decision.
- Not yet a data user, but interested in potentially using annual data.
- have used it sparingly to date without repercussions
- No impacts to services provided, but it would be harder to justify mitigation for potential causes of unexpected SAV/algae blooms (e.g., fertilizer runoff from the surrounding watershed).
- We would continue to very roughly map/quantify SAV at main installation, but would not have data for Bloodsworth Island Range or properties adjacent to our installations
- Would make it more difficult to conduct targeted SAV surveys
- We would have to develop an alternate means of complying with state law.
- Not using Ches. Bay Data - attending this workshop in a listening role to gain experience for Delaware Estuary study.
- With no SAV data it could force DNR and MD Counties to perform their own SAV surveys for potential dredge areas to know impacts
- We provide technical assistance to waterfront property owners on a regular basis. Now when we get a call from a concerned waterfront property owner, we are able to do quick turnaround after doing our research and schedule a site visit at the earliest possible time. If the data frequency is reduced or if the data analysis becomes ad-hoc, it can profoundly affect our customer service, which we pride ourselves on.
- Limit timing of impact to design/wetlands license/permit approval process. Limit potential LS project site inspection Technical Assistance recommendations to property owners.
  Affect ability to provide detailed customer service assistance.
- Would impact the length of time to obtain permits during project design phase and customer service technical assistance.

<u>Would you have to collect SAV data yourself, for example, to approve permits? (81 responses)</u>
Yes: 28

No: 53

If so, is this a feasible option within your organization? Do you have the financial and logistical capacity? (73 responses)
Yes: 12
No: 61

Which geographic portion of the Bay is the most relevant to your organization? (83 responses)
Whole Bay: 28
Virginia: 9
Maryland: 42
DC: 7
Delaware: 1
Maryland and ...: 14
Specific tidal tributary: 19

If specific tributaries are most relevant to your organization, please write them in below. (38 responses)

- all the rivers of the Mid Eastern Shore
- Anacostia and Potomac Rivers
- Any in Baltimore County
- Back Creek
- Bohemia River
- Boundary Channel of the Potomac River
- Bird River
- Bush
- Choptank River
- Eastern Bay
- Elk River
- Gunpowder River
- Great Wicomico River
- James River Basin and its tributaries
- Lafayette River
- Lynnhaven River
- Magothy River
- Maryland Bay
- Middle River
- Miles River
- Patapsco River
- Patuxent River
- Piankatank River
- Potomac River
- Rappahannock River
- Rappahannock River watershed and adjacent western Bay waters
- Sassafras River
- South River
- Susquehanna River and Flats
- Severn River
- Where DoD facilities are located (many)
- Wye River
- York River

Does your organization contribute to the ground-survey efforts by providing SAV observation data to VIMS? (82 responses)
Yes: 27
No: 35
Sometimes: 20

How often do you request specific or early information (before the data is officially released) from the VIMS SAV staff? (82 responses)
Frequently (more than three times a year): 6
Occasionally (1-3 times a year): 36

Never: 44

How often do you contact a third party for SAV survey data? ie. Md DNR, EPA, Va-DEQ (83 responses)
Frequently (more than three times a year): 3
Occasionally (1-3 times a year): 36
Never: 40

On a scale of 1 - 5, 5 being the most important, how important do you think the Chesapeake Bay Annual SAV aerial and ground data is to your organization? (84 responses)
1: 1
2: 5
3: 15
4: 22
5: 41

On a scale of 1 - 5, 5 being the most important, how important do you think the Chesapeake Bay Annual SAV aerial and ground data is to Chesapeake Bay conservation and restoration in general? (84 responses)
1: 0
2: 1
3: 5
4: 14
5: 64

Would you rather financially contribute to keeping the Annual SAV survey program going as is, with Bay-wide data available annually, or would you invest in procuring the data you need for your organization's purposes independently? (69 responses)
Contribute: 45
Procure data independently: 24

If you prefer to procure SAV data independently, would you be willing to make that data publicly available? (47 responses)
Yes: 38
No: 2
Maybe: 7

Are you willing to participate in a one-day workshop this spring to further discuss the future of the Chesapeake Bay Annual SAV Aerial and Ground Surveys? The workshop will be held on March 29th, 2017 at the Chesapeake Bay Foundation's Philip Merrill Environmental Center in Annapolis, MD. (83 responses)
Yes: 63
No: 3
Maybe: 17

Please provide any additional thoughts or comments regarding the Chesapeake Bay Annual SAV Aerial and Ground Surveys.

- Note that my answers are specific to Habitat Conservation Division and do not reflect all of NOAA/NMFS. Also, I do not make funding decisions.

- This is a unique and powerful dataset. It's annual recurrence and broad scope allow for investigation of SAV health and ecology in ways that a more sparse sample would not.
- I think it might be helpful to review SAV data collection methodologies and see if there might be more cost effective collection methods such as high resolution satellite, selective use of drones, etc. If funding does become a problem, it might be helpful to have auxiliary plans that develop rotational sampling or sampling of high priority areas.
- I am a huge supporter of the survey. The amount of SAV is a major indicator of the health of a tributary. The survey provides a large amount of data and it is very well presented so anyone can look back and see how the acreage and the distribution changes over time. It is close to impossible to collect this sort of data from ground level and ground data descriptions would not be as compelling as the aerial imagery.
- Bob Orth is a dependable and courteous representative at VIMS.
- I really like the approach suggested by Neckles et al. (2012) Estuaries and Coasts 35:23-46. This is really similar to Reg 404 approach for wetland delineation and monitoring. The problem is that the Clean Water Act is the driving force behind wetlands mapping, management, and protection whereas it seems perhaps we don't have the same protections in place for SAV, perhaps due to its less static nature? Anyway it'd be interesting to see how robust we can make the mapping program to support permitting and conservation of the resource. This workshop is a great idea!
- This is a critical component of our educational program in the Calvert County Public School system. Over 30,000 students over the past 23 years have participated in this project and have developed a connection to the Bay by contributing to the SAV program. This is a vital element of the CHESPAX program.
- The Severn River Association is excited to be part of the 2017 SAV mapping project. We're already lining up a volunteer crew (mostly neighbors who are new to our organization) to create an ongoing SAV survey and help educate communities about what they can do to help ensure that our river is swimmable and fishable 24/7.
- From a researcher's perspective, the SAV survey data has allowed for many important research questions be explored and answered. Many of these findings have informed Chesapeake Bay management strategies. Our understanding of SAV ecology is, however, still incomplete and continued aerial surveys will be critical for addressing future research questions, particularly as efforts to reduce nutrient loading continue and unknowns related to increasing sediment loads associated with Conowingo remain.
- The HdG Maritime Museum plans to collect SAV data using volunteers if financial support from DNR is available.
- The annual SAV Aerial and Ground Surveys provide critical data. Funding for this program needs to be maintained.
- Couldn't answer some questions as we are not a funding group
- This element of baywide information is one of the cardinal data sets determined as necessary from the earliest stages of monitoring and analysis. Disrupting it would be an intentional, shameful political expedient and an admission of failure in stewardship of Chesapeake Bay
- The SAV program is an ESSENTIAL monitoring component. Must be retained. We really should be talking about EXPANDING this program rather than even thinking about reductions...that is crazy. We are seeing some signs of Bay restoration. This is no time to think reduction in one of the very important tools we have for assessing Bay condition.
- The annual SAV survey is one of the most complete and valuable data sets available for informing management decisions related to permitting and leasing decisions, and is essential for the overall measurement of Bay health and restoration efforts.

- Some of these answers are my best guess, as work at the regional level. I will forward the survey to DoD Installation NR managers directly, as they may have a better idea of how the SAV data us used and who they get it from, share it with, etc.
- At this present time I am not totally I aware if my organization uses the SAV data since I do not really know what it is. I would be interested in learning more about this and could possibly be willing to contribute.
- Keep up the good work!
- "I would ask if the form of the survey could be considered in terms of sampling theory. Could a subset of transects be flown and then population estimates made based on sampling theory for random sampling, stratified random sampling and so on. Could the program sample and evaluate images from 10% (or 20% or 30%) of the transects and come up with a population estimate with confidence bounds on the estimate that serves as the estimate for the year? Could 10% (or 20% or 30% or some portion) of the transects be assessed in spring and summer to get seasonal estimates with confidence bounds in order to get baywide coverage in more than one season and extract seasonal trends as well as annual trends? Could a subsampling approach result in more information for a smaller investment? Could we couple Citizen monitoring of small tribs with GPS and boats to improve our local scale assessments?
- I think in particular the evaluation of subsampling and the use of survey statistics compared with the census approach is something that should be compared for the workshop and the program to help everyone consider options for how to sustain programming while providing decision-making support. A set of objectives being supported will be important to any cost benefit analysis. Is it the number of acres that is important which is what subsampling can provide estimates of, or, is it the actual knowledge of the complete coverage and bed locations and responses for everywhere in the whole bay that is important? Think about the BIBI for the Bay which has a fixed site and random site assessment. The random site assessment is what provides a condition estimate for a region with confidence intervals on the amount of the bay in that region that is impaired. This BIBI assessment supports for example the regulatory aquatic life uses decisions, an important item to the States. It provides trend assessments on the health of the Bay and within regions. The BIBI use to have a 2 season assessment but is now conducted only in the summer - a resource limited decision. Therefore, defining the objectives becomes key to whether the program should continue in its present form with greater commitment of support, or, if the program should be retooled to according to resources available recognizing just what information matters most.
- Going back to subsampling regions in a stratified manner for example, that would likely provide regional and baywide status and trend assessment information and estimates of coverage. That is important for communications, provides some scale of discriminatory power on how the bay is responding in regions and baywide to management actions, however, for regulatory purposes, the number of acres of SAV in a Chesapeake Bay Program segment is how decisions are made for water quality attainment. It is the annual baseline of assessment. The National Marine Fisheries I believe provides decisions on critical fisheries habitat and dredging permits based on very local scale SAV information that is only going to be available if the whole Bay is mapped.
- Perhaps then we need to have a list of uses/objectives and say - this 'X' collection of data uses could be supported by less than annual surveys and be conducted based on subsampling the Bay for status and trends at the regional scale, this other 'Y' collection of data uses needs data surveys annually but temporal evaluation of a number is more important that spatial detail, and finally this other set of data uses 'Z' requires high quality spatial and temporal detail annually to seasonally and everywhere. Now, there are $ resources available which could support X or maybe Y but no longer Z for example. In the end, if your use isn't going to be met with the existing resources, you had a chance to make the investment. Will permitting for dredging projects come to an end if SAV data are unavailable? How does that result impact every waterside county of the Bay? Does it just mean that with the data no longer available NMFS gets cut from

the decision-making process for example? Can fishery managers explain habitat health and fish response to management actions without annual level data? It would be helpful to hear how agencies that depend on the data now will make decisions in the absence of data OR, how will they address the need, will they fund project specific assessments instead of a pooled resource approach? What is plan B or C, and do they know the direct and indirect impacts from changes in the existing SAV program outputs? Many questions. However, a community decision must be made on what is and is not supported, what objectives are affordable, what comes off the table with changes in resources and what will be continued into the future with or without additional investments. I am confident there is a program that will continue into the future, it may be shaped differently, but I am confident it goes forward. "

- Increased, stable funding for this as well as intensive water quality monitoring conducted by professionals are required to assess and understand the factors behind changing SAV abundances as well as measuring the success and effectiveness of all the bay restoration efforts, especially at the local and state levels.
- At Workshop
- I would not have the capacity to collect these data on my own, nor do I have the financial capacity to hire someone to collect such data.
- I cannot speak for my organization (USGS) or its funding
- Up until this point, I have not had any cause to use any of the information
- SAV data is collected by my office from Poplar Island and surrounding mainland areas of Tilghman and such data can be made available if needed. Data has been supplied to VIMS on numerous occasions.
- The surveys are an incredible program that have yield important information about the state of the Bay. Now that the TMDL program is underway and we're in an era of rapid change it is more important than ever to keep the program running.
- I'm disappointed the Coastal Bays was not included in the 2017 ground monitoring grant cycle and hope this might change in 2018. We had an interested group of citizen monitors ready to be trained and to engage. As a training exercise and for experience I may still do a program with them this spring/summer, based on the training workshop Brooke Landry organized last summer if I can find independent funding elsewhere.
- I currently work at DCL so the Bay surveys don't impact me per say but when I was with the Army and the Reserve, they were extremely helpful
- VIMS comments are well known for keeping this as annual survey.
- I am not currently a data user; however, I am interested in mapping SAV throughout the Northeast to identify fish habitat for federally important fish species and plan to become a data user. These types of data should allow for more accurate designations of essential fish habitat in nearshore coastal waters for species that utilize SAV habitat during specific life stages (such as summer flounder).
- Attending in a listening role - new to this type of research so I am attending to observe and learn.
- The SAV that we access from VIMS website is invaluable to our Program and citizens. It helps us offer exemplary customer service to our taxpayers. Pls keep the Program as it is.
- They provide valuable information that has been of use to agencies and the public since 1984. The Corps concurs that the aerial survey and interpretation for maintaining the VIMS dataset is an important tool for both our Civil Works projects as well as permitting through the Regulatory Branch. This database is also used by the public and for academic work.

Appendix F: Optional Designs for Aerial and Ground SAV Survey

	Aerial Option	Frequency of Aerial Imagery Collection	Brief Explanation	Pros	Cons	Overall Feasibility	Estimated Annual Cost
1	**Continue with the current aerial survey design which consists of collecting multi-spectral aerial imagery of SAV in the entire Chesapeake Bay, manually processing, and reporting that data annually.**	Annually, bay-wide	A thorough description of the current SAV survey design can be found on the VIMS website at: http://web.vims.edu/bio/sav/sav15	This program has evolved over the years to improve efficiency, accuracy, and output. Will seamlessly continue the long-term SAV monitoring dataset, supporting trend analysis. Provides detailed monitoring data at the local level.	The cost of aerial acquisition of the full Bay and technical staffing time would continue to need to be covered.	High with sufficient funding.	720K
2	**Collect multi-spectral aerial imagery of the entire bay annually but set up a semi-automated classification of the individual SAV beds and their density.**	Annually, bay-wide	This design alternative takes advantage of an identical imagery collection and reporting process, but automates aspects of the data interpretation process, thereby saving staff time.	In addition to seamlessly continuing the long-term dataset, automation could result in cost savings due to reduced staff time.	Would require an up-front investment to do the development work and set up all the classification routines.	Medium high with sufficient time and resources.	$745K 1st year $620K remaining years

3	**Collect multi-spectral aerial imagery and set up a fully-automated classification of the individual SAV beds and their density.**	Annually, bay-wide	This design alternative takes advantage of an identical imagery collection and reporting process, but automates the entire data interpretation process, thereby saving staff time.	In addition to seamlessly continuing the long-term dataset, full automation could result in additional cost savings due to further reduced staff time.	Would require a larger up-front investment to do the development work and set up all the classification routines. There are no known programs using fully-automated classification at this point.	Medium low with sufficient funding	$770K 1st year $520K remaining years
4	**Collect multi-spectral aerial imagery every year as presently performed, but interpret and map all the imagery every other year for bay-wide total SAV acreage.**	Annually, bay-wide	This design alternative takes advantage of an identical imagery collection and reporting process, but allows more time to process the data, allowing for a reduction in staff. Only alternate years would be processed and reported, but imagery would be collected every year so that a record of SAV in the Bay is available for every single year if financial resources eventually allow for processing of those images.	This scenario would allow for a reduction in staff or staff time, resulting in decreased expense. Annual imagery would still be collected, maintaining VIMS' relationship with flight contractors (Air Photgraphics) and likelihood of maintaining reasonable rates for flight lines and imagery collection.	This scenario presents challenges with staffing as well as continuity of data availability. Review and permitting processes could be interrupted, delayed, or otherwise made more difficult.	High	$620K

5	**Collect aerial imagery every year as presently performed, map the subset of the Bay and tidal tributary shorelines where the majority of SAV is located and then statistically subsample and interpret areas every year to develop a bay wide estimate of SAV acreages.**	Annually, bay-wide	Collect bay-wide imagery as per usual, but because the vast majority (65%) of SAV in the Bay grows in ten primary areas such as the Susquehanna Flats and around Smith and Tangier Islands, only these areas would be mapped every year to determine the bulk of the bay's acreage. Remaining tributaries would be sub-sampled and mapped to develop a bay wide estimate of total acreage.	This scenario could potentially reduce staffing, save time, and decrease expenses.	There would be no actual bay-wide total or segment totals reported to determine how close we are to reaching our SAV acreage goals. Errors in the bay-wide total based on these areas could exceed the amount of annual change in SAV in the Bay.	High	$570K
6	**Collect aerial imagery every year as presently performed, but statistically subsample and interpret areas every year to develop a bay-wide estimate of SAV acreages.**	Annually, bay-wide	In this scenario, bay-wide imagery would be collected annually, but only a sub-sample of those images (or segments or tributaries?) would be processed to provide an estimate of total SAV in the Bay.	By reducing the area that needs to be processed and analyzed, staff time and expense would be reduced. A sound statistical design should improve estimate accuracy.	There would be no actual bay-wide total or segment totals reported to determine how close we are to reaching our SAV acreage goals. The amount of area that would need to be mapped could be fairly large to achieve the desired accuracy.	High	$745K 1st year $620K remaining years

7	**Collect bay-wide aerial imagery every year, but only interpret and map specific salinity zones or specific regions on a rotating basis, thereby developing a bay-wide map every 3-4 years.**	Annually, bay-wide	In this scenario, bay-wide imagery is collected annually, but only one salinity zone (polyhaline, mesohaline, oligohaline and tidal fresh) or region (south, middle, and north bay) is processed and analyzed.	This maintains the bay-wide collection of annual imagery, but reduces staff time by decreasing the amount of imagery processed and analyzed. It also gives a complete picture of an entire salinity zone or region, rather than an estimate based on randomly selected sub-samples.	There would be no actual bay-wide total or segment totals reported to determine how close we are to reaching our SAV acreage goals. Annual detail would be lost sacrificing continuity.	High	$470K
8	**Collect aerial imagery from selected set of flight lines and statistically subsample and interpret areas every year to develop a bay-wide estimate of SAV acreages.**	Annually, sub-sample of flight lines	This is the first scenario that decreases the number of flight lines flown annually. Select flight lines would be flown and from the images collected, a subsample of those would be processed and analyzed to determine a bay-wide estimate of total SAV acreage.	Reduced cost for imagery collection and reduced staff time for processing.	There would be no actual bay-wide total or segment totals reported to determine how close we are to reaching our SAV acreage goals. A complete data set would not be available for future analysis should the need or opportunity arise.	Medium	$745K 1st year $600K remaining years

9	**Use satellite imagery in place of aerial imagery and: 1) interpret and map all the imagery every year; 2) interpret and map all the imagery every other year; or 3) statistically subsample and interpret areas every year to develop bay-wide estimate of SAV acreages.**	n/a No aerials	This is similar to the scenarios above but takes advantage of satellite imagery rather than aerial photographs.	This scenario eliminates the expense of the flight contractor and produces a total SAV acreage annually.	Depending on the source, the satellite imagery could cost more than the aerial imagery. Additionally, existing high resolution satellite imagery is about a quarter of the resolution of current SAV aerial imagery. There may be additional unknown acquisition constraints.	Medium	$727K
10	**Use drones in place of aerial imagery and train individuals from a multitude of organizations to interpret and map the SAV beds.**	n/a No aerials	In this scenario, VIMS coordinates volunteer drone operators to produce aerial imagery from tributaries rather than imagery collected from planes.	The use of drones permits acquisition of aerial imagery under a larger variety of conditions. A large number of volunteers would be engaged in monitoring the Bay.	This would require a tremendous coordination effort, training, and start up expense. Drones and drone operator training would be necessary. It is unlikely that the entire Bay and all its tributaries would be covered in a single season (requiring approximately 5000 days of flying); therefore, determining how close we are to reaching our SAV acreage goals would be challenging.	Low	$680K

11	**Discontinue the aerial survey entirely and replace it with a comprehensive SAV ground survey carried out by a multitude of organizations.**	n/a No aerials	States and locales would have to coordinate to conduct in the water SAV surveys.	Species diversity data could be collected while mapping, which would improve our knowledge of SAV species distribution around the Bay.	This would require a tremendous coordination effort, start up expense, and training. The likelihood of creating a complete bay-wide SAV map would be minimal and therefore SAV goal tracking would be difficult.	Low	$300K
12	**Discontinue the survey entirely and rely on individual agencies, institutions and organizations to collect their own data.**	Unknown	In this scenario, the VIMS SAV Monitoring Program is discontinued and agencies, institutions, and organizations are responsible for collecting whatever SAV data they require for regulatory needs, permitting, or research, independently.	Potentially will save money if SAV monitoring by others is done on a significantly limited basis.	Bay-wide SAV data would no longer be available. Reaching our bay-wide SAV acreage goal of 185,000 acres would become impossible to determine, and consequently the Bay would never be de-listed. The burden would shift from VIMS to individual agencies, institutions, and organizations that do not have the financial, equipment, or staffing resources to collect their own data.	Low	Unknown

	Ground Option	Frequency of Data Collection	Brief Explanation	Pros	Cons	Overall Feasibility	Estimated Annual Cost
1	**Continue with the current baywide "ad hoc" SAV ground survey design.**	Annually	A thorough description of the current SAV survey design can be found on the VIMS website at: http://web.vims.edu/bio/sav/sav15	There is a large network of individuals and organizations that currently contribute observations to the ground survey effort. They're familiar with the data requirements and logistics.	This "ad hoc" survey design lacks continuity from year to year and place to place. Some species are reported more frequently than others. There are spatially driven data gaps.	High	There is expense associated with entering the data into a database, but the expense to the individuals and organizations contributing the data must vary and is unknown.
2	**Work with all the riverkeeper organizations to set up a more structured SAV ground survey for their respective tidal rivers/embayments as the Chesapeake Bay Program and Maryland Department of Natural Resources are currently doing.**	Annually	With funding provided through the Bay Program's Habitat Goal Implementation Team, the SAV Workgroup and Maryland DNR are leading a project to incorporate Riverkeepers and Watershed organizations into the SAV ground survey and monitoring process. 2017 is the first year with four watershed organizations funded to set up SAV Survey programs in their tributaries. Species and distribution data will be collected in areas both mapped and not mapped by the VIMS aerial survey.	This effort incorporates citizen scientists and volunteers into the SAV survey and monitoring process throughout the Bay, increasing environmental stewardship and SAV visibility as an essential habitat. It also provides more systematically collected species and abundance data as sampling strategies are designed uniquely for each tributary and organization participating.	Limited to participating organizations and funding availability, although some watershed groups are intitiating SAV Surveys without funding.	High	The initial set up cost for each watershed organization is approximately $10,000. Once equipment is purchased, expense is minimal aside from staff time, especially when using volunteers.

3	**Establish a more well-structured SAV ground survey program by mapping out and formally assigning specific organizations the responsibility for specific lengths of Bay, tidal tributary and embayment shorelines supported and overseen/coordinated by a clearly defined team of partners.**	Annually	This would be similar to the second option but incorporating more groups into the effort (e.g., watershed organizations, Chesapeake Bay Foundation, additional riverkeepers, museums, universities, colleges, federal facilities, parks, wildlife refuges, local agencies, state and county watermen associations, and angling organizations)	This effort makes multiple types of groups responsible for the SAV survey and monitoring process throughout the Bay, increasing environmental stewardship and SAV visibility as an essential habitat. It also provides more systematically collected species and abundance data as sampling strategies are designed uniquely for each tributary and organization participating.	Limited to participating organizations and funding availability. Coordination of this scale of effort would also be difficult, but not impossible.	High, depending on willingness of outside agencies to take part and their capacity for the work.	Cumulatively quite high but unknown - would vary by organization.
4	**Discontinue the current baywide "ad hoc" survey entirely and rely on individual agencies, institutions and organizations to collect their own data.**	As needed by individual organization or agency.	In this scenario, the VIMS SAV Monitoring Program is discontinued and agencies, institutions, and organizations are responsible for collecting whatever SAV data they require for regulatory needs, permitting, or research, independently.	Potentially will save money if SAV monitoring by others is done on a significantly limited basis.	Bay-wide SAV data would no longer be available. The burden would shift from VIMS to individual agencies, institutions, and organizations that do not have the financial, equipment, or staffing resources to collect their own data.	Low	Unknown