

CHESAPEAKE BAY SAV WATCHERS



***A methods manual for volunteers monitoring
submerged aquatic vegetation***

Version 4, Updated March 2025

TABLE OF CONTENTS

AN INTRODUCTION TO SUBMERGED AQUATIC VEGETATION (SAV).....3

Introduction

Biology

How does SAV differ from algae?

How does SAV compare to terrestrial plants?

Distribution & habitat requirements

Biodiversity

Affiliated species

Ecosystem services

Threats

SAV IN THE CHESAPEAKE BAY....9

A history of SAV research in the Chesapeake Bay

The importance of SAV

Threats to SAV

Bay salinity regimes and effects on SAV distribution patterns

Conservation efforts

INTRODUCTION TO THE VOLUNTEER MONITORING PROGRAM.....13

What is the history of SAV volunteer monitoring in the Chesapeake Bay?

Why is it important to monitor SAV?

Where does the data go?

How is the *Chesapeake Bay SAV Watchers* monitoring protocol set up?

How does the training and certification program work?

What materials are available for *Chesapeake Bay SAV Watchers*?

Contact Information

BEST PRACTICES FOR DATA COLLECTION.....17

How should site locations be selected?

What qualifies as a site?

When and how often should I sample?

What are the best sampling conditions?

How should I collect SAV specimens?

How can I stay safe while sampling?

How can I take high-quality photos?

MONITORING PROTOCOL.....22

Overview

Field packing list

Guide to Submitting Data and Observations

SAV SPECIES GUIDE.....37

Complete species list

SAV species pages

APPENDICES.....64

Leaf arrangement terminology

Harmful algal blooms

Guide to other macrophytes

Affiliated species

Shoreline types guide

Printing instructions

How to digitize and share data

How to retrieve a GPS location using a smartphone

Contact list

SAV and other species photo attributions

Recommended references

Acknowledgments

AN INTRODUCTION TO SUBMERGED AQUATIC VEGETATION (SAV)

Introduction

Submerged aquatic vegetation refers to flowering, vascular plant species that grow in salt, brackish, and fresh waters around the world. Some SAV species resemble grasses that grow on land; hence saltwater species are frequently referred to as seagrasses. Species inhabiting the Chesapeake Bay are collectively referred to as “Bay grasses”. Like terrestrial grasses, SAV species have leaves, seeds, roots, and stems. They can survive in diverse climates, including fresh tidal waters, under Arctic sea ice, off the shores of tropical islands, and in brackish estuaries like the Chesapeake Bay.

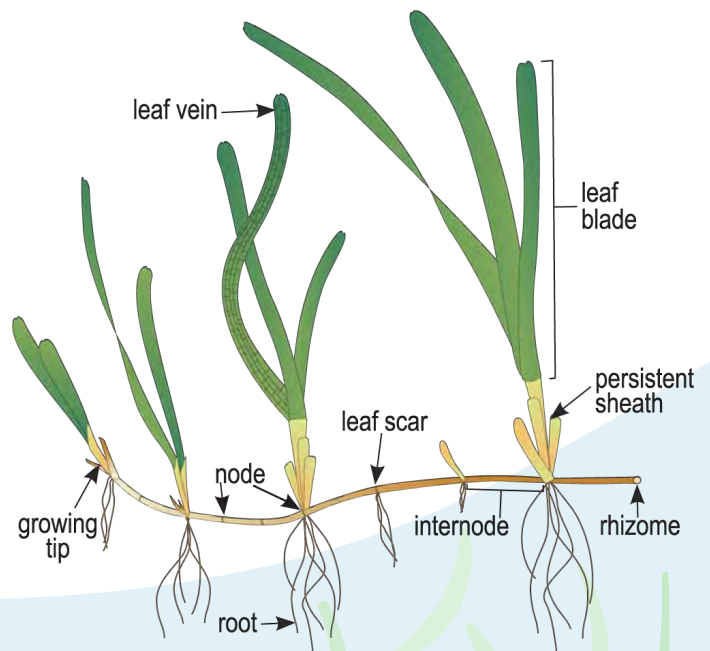


SAV specimens collected by volunteers. (Sky Swanson)

Biology

Anatomy

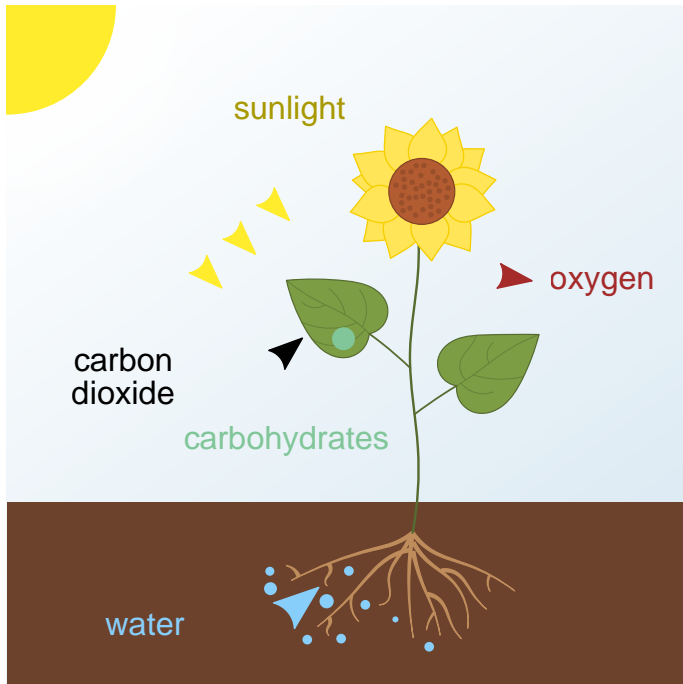
SAV species, like many of their terrestrial relatives, have roots and rhizomes (horizontally-growing underground stems that connect one clone to another) that anchor them in substrate and absorb nutrients. Veins and vessels, part of the plant vascular system similar to that of animals, spread from the roots and transport nutrients throughout the rest of the plant. As in other flowering plants, SAV species have stems to which leaves are attached. These leaves contain pigment cells (most often chlorophyll) that absorb sunlight. Seeds and flowers that grow on stalks make up the reproductive system of SAV, although many also reproduce asexually. In some species, the flower stalks grow above the water.



SAV is anatomically similar to many flowering land plants. (Catherine Collier from the IAN Image Library)

Photosynthesis

Like terrestrial plants, SAV species need sunlight for photosynthesis. Photosynthesis is the process by which specialized pigment cells (chloroplasts) in plants absorb certain wavelengths of sunlight. They combine this absorbed light energy with carbon dioxide and water to produce the energy they need to grow and live. Oxygen is a byproduct of photosynthesis.



During photosynthesis, plants use energy from the sun to convert carbon dioxide and water into carbohydrates and oxygen. ([Nefronus](#), from Wikimedia Commons)

Vascular System

The vascular system is made up of veins and vessels that circulate both the nutrients absorbed by the roots and the sugars produced by photosynthesis throughout the plant.

Reproduction

SAV reproduce both sexually and asexually. Both types of reproduction have advantages and disadvantages. Likewise, some species are monoecious (individual plants have both male and female flowers) and some are dioecious (plants are either male or female).

In sexual reproduction, male flowers release pollen that is distributed by currents. When

pollen reaches female flowers, fertilization occurs and a seed forms. Mature seeds are released and dispersed again by currents. In some species, seeds are attached to shoots that break off of the plant, and the seeds are released from the shoot once they are mature. Seeds eventually settle into the substrate and germinate into new plants. Seeds can be dormant for months or even years before germinating. This allows shoots to emerge when growing conditions are favorable.

Asexual reproduction in SAV occurs in a variety of ways, and some plants that reproduce sexually can also reproduce asexually. The most common form of asexual reproduction in SAV is called vegetative expansion. In vegetative expansion, rhizomes grow horizontally under the substrate and produce shoots that grow into new plants. Asexual reproduction can also occur when buds grow on the stems of already established, mature plants. These buds break off of the mature plant and sink into the substrate to grow. Some species also reproduce asexually through fragmentation. This usually occurs when a plant is physically disturbed and fragments of the parent plant float away with the current. Those fragments eventually settle and grow into new plants.

How does SAV differ from algae?

Although SAV and algae have their similarities, they evolved separately from one another. SAV evolved from terrestrial flowering plants and returned to the water, whereas algae never left the water in the first place. Algae and SAV are similar in that they both photosynthesize, but algae do not have roots or a vascular system like SAV species. Some species of algae do have a holdfast that anchors them to rocks or other surfaces, but it does not absorb nutrients like the roots of SAV do. Instead, algae have unspecialized cells that absorb nutrients directly from the water column.

How does SAV compare to terrestrial plants?

Although SAV species are flowering plants, they lack some common characteristics of terrestrial flowering plants. For example, most terrestrial flowering plants have pores, called stomata, that open and close to regulate water loss and nutrient exchange with the environment. SAV species do not have these structures; instead, they have a thin cuticle layer on their leaves that controls the exchange of oxygen, carbon dioxide, and nutrients with the surrounding water. Unlike terrestrial plants, SAV do not need strong stems or trunks to support them against gravity. Their weaker stems and leaves are supported by the surrounding water, and small air pockets within their tissues, called lacunae, help keep SAV buoyant.

Distribution & habitat requirements

SAV species are found in salt, brackish, and freshwater habitat on or around all continents except Antarctica. SAV species are sensitive to light availability, temperature, salinity, water currents, water quality, and substrate type. Overall water quality is extremely important. Because SAV species are rooted and cannot escape unfavorable conditions, they are susceptible to changes in water quality. Furthermore, different species have different environmental requirements, therefore habitat and environmental conditions strongly influence species distribution.



SAV depend on light to grow. ([Will Parson](#) from Flickr)

Light

Like terrestrial plants, SAV species require sunlight in order to photosynthesize. Because of this, they typically inhabit shallow, clear waters. Most species live in waters shallower than three meters, but some low-light adapted species can survive at depths of up to 58 meters. Many factors influence water clarity and therefore SAV distribution; these factors include depth, the amount of nutrients and sediments in the water, and the density of algal growth. Chesapeake Bay species are generally limited to waters no deeper than two meters because of turbidity; however, they could grow at greater depths with improved water clarity.

Salinity

SAV occupies fresh, brackish, and salt waters, but each species of SAV has a particular range of salinities that it can tolerate. The role of salinity in SAV species distribution is nicely illustrated in the Chesapeake Bay (see “Bay salinity regimes and effects on SAV distribution patterns” section for more details). In addition to driving species distribution, salinity may also affect SAV health. Changes in salinity caused by increased rainfall (which lowers salinity) or drought (which increases salinity) can lead to die-offs of particular species.

Temperature

Temperature can play an important role in SAV survival and reproductive capability. Some species require warm waters in order for seeds to germinate and develop into mature plants. Temperature requirements differ between SAV species. Coupled with seasonal changes, long-term temperature changes impact the ability of SAV to survive and persist in areas where they have historically thrived. One example of a temperature-dependent SAV species in the Bay is eelgrass. Eelgrass is a cold-water species with a historical range that includes the lower Bay; however, when the waters of the lower Bay where it lives get too warm, the eelgrass dies back.

Substrate and wave action

Substrate type influences SAV growth and distribution. Some species need sandy substrate, while others prefer muddy or silty areas. Most SAV do not tolerate strong waves or currents, and instead grow in calmer areas. Saltwater species typically inhabit gently sloping coastlines in areas of low wave activity.

Biodiversity

SAV are incredibly diverse with over 500 species worldwide. This number includes fresh, brackish, and saltwater species. Among these, 72 are considered true seagrass species that inhabit brackish and saltwater. There are over 20 species of SAV in the Chesapeake Bay, but only one of them, eelgrass, is a true seagrass. Widgeongrass inhabits many of the same areas and salinities as eelgrass, but it also thrives in less salty waters where it competes with other species, such as redhead grass and sago pondweed, for space. Species diversity increases in the freshwater areas of the Bay where over 17 species are commonly observed. Although many SAV species resemble land grasses, some look markedly different. Some species have round or oval-shaped leaves, others have cylindrical leaves, while still others resemble ferns. SAV species vary in height from less than three centimeters to just over 10 meters, though none grow that high in the Bay. SAV can grow in bushy clumps of a few plants, but many grow in vast underwater meadows.



Multiple species of SAV co-existing in one bed (Brooke Landry)

Affiliated species

SAV species form the foundation of many marine, brackish, and freshwater communities around the world, including in the Chesapeake Bay. At their base and below the substrate, SAV provides habitat to benthic invertebrate species, including microscopic zooplankton, blue crabs and other shellfish, amphipods, isopods, and shrimp. Invertebrates such as sea scallops cling to SAV stems and leaves, which provide them not only with substrate to attach to, but also shelter from potential predators. Algae (called epiphytic algae) also grow on the leaves of many SAV species. These algae, along with other microorganisms, are a source of food for fishes and other predators that inhabit SAV communities.



Fish rely on SAV beds for food and shelter ([Will Parson](#) from Flickr)

Larval fishes take advantage of the shelter provided by SAV beds, using them as nursery habitats and consuming abundant smaller organisms and detrital materials. Juvenile and adult fishes also find shelter and food in SAV, inhabiting it either permanently or ephemerally. They consume smaller organisms and sometimes the SAV plants themselves. Waterfowl, both migratory and resident, find nutrition in the seeds, leaves, and roots of SAV, in addition to any endemic shellfish and fish species.

Ecosystem services

SAV beds impart a wide diversity of ecosystem services beyond providing nursery habitat and feeding grounds for many commercially important fish and shellfish species. They absorb massive amounts of carbon, which is a crucial function in our warming world. They take up excess nutrients and trap sediment,



SAV beds slow waves as they approach shorelines, thereby minimizing erosion. (Pete McGowan, Eastern Bay)

keeping water clear. They also protect shorelines by slowing tidal action and helping control for erosion.

Of critical importance is SAV's contribution to blue carbon, which is a term that describes any carbon that is captured and sequestered by the world's marine and coastal ecosystems. As these underwater plants photosynthesize (turn sunlight into energy), SAV species, like terrestrial plants, take in carbon dioxide to make plant tissue. However, carbon sequestration in SAV beds differs from sequestration in terrestrial ecosystems. On land, carbon is stored almost entirely within the tissue of individual plants. When a terrestrial plant dies, its stored carbon is released back into the atmosphere via decomposition. SAV stores carbon in a similar manner while alive, but when the plants die, the carbon released from their decaying tissue accumulates in the sediment. Carbon can remain buried in the sediment for decades or longer. In this way, SAV is vital to mitigating climate change. Meadows of underwater grasses are responsible for more than 10% of all carbon buried in the global

oceans each year, and per unit area, they store up to twice as much carbon as the world's temperate and tropical forests!

In addition to mitigating climate change through carbon sequestration, SAV absorbs excess nutrients, including phosphorus and nitrogen, from the water. This reduces the abundance of phytoplankton and the risk of harmful algal blooms, which feed on excess nutrients in the water column. SAV also traps sediment from the water column. This reduction of excess nutrients and suspended sediments improves water clarity, allowing for better light penetration and increased SAV productivity. The more productive an SAV bed is, the more productive the whole SAV ecosystem is. Productive SAV ecosystems provide sustenance for filter feeders, microorganisms, and small herbivores, which in turn sustains a food web that is comprised of small predators, large fishes, and aquatic birds.

SAV is thought of as an ecosystem engineer because it modifies the surrounding physical environment. The physical structure of SAV dampens wave and current energy, reduces wave height, and stabilizes sediment by trapping it in its root system. This helps prevent shoreline erosion and provides storm surge protection for coastal communities. Additionally, SAV oxygenates the waters around them through photosynthesis, benefiting all of the organisms that inhabit the nearby environment.

Overall, ecosystem services provided by SAV are important not only to the natural world, but also to humans. SAV beds support communities of commercially important fish and shellfish and prevent algal blooms that could harm both aquatic organisms and people. SAV also protect coastal communities from erosion and storm surge. Perhaps most critically, SAV beds store larger amounts of carbon, for longer periods of time, than terrestrial plant systems, making SAV beds an extremely important component of climate change mitigation.

Threats

Over the last 100 years, large amounts of SAV, including one quarter of seagrasses, have been lost worldwide. Although past declines in SAV were attributed to disease and storm events, today's threats are mainly human driven. Poor water quality, due in part to nutrient pollution, and climate change are the two greatest contributors to declining SAV habitats, but other human-driven threats include damage caused by boat propellers, dredging, and excessive shoreline armoring (the installation of bulkhead and rip rap, which changes wave energy and affects SAV).

Water quality poses such a great threat to SAV because these plants have high light requirements, and declines in water quality reduce the amount of light that penetrates the water column. The greatest cause of poor water quality is nutrient pollution. As stormwater runoff from developed areas enters coastal and estuarine systems, it introduces excess nitrogen, phosphorus, and sediment to the waters. This reduces water clarity and stimulates the growth of phytoplankton floating in the water and attached to SAV blades. This increase in phytoplankton density reduces the amount of sunlight that reaches SAV, which inhibits photosynthesis and ultimately results in reduced productivity or large-scale die-offs.

The effects of nutrient pollution on SAV are exacerbated by rising water temperatures. Recent declines in some species of SAV, like eelgrass, are due in part to the nearly 3 degree Fahrenheit (1.67 degrees Celsius) increase in average summer temperatures. The combined effect of increasing temperatures and nutrient runoff pose a major threat to SAV and the communities that depend upon it.



Marine debris collected by volunteers. ([Will Parson](#))



Stormwater runoff carries excess nutrients and other pollutants into the Bay. ([Jane Thomas](#) from the IAN Image Library)



An algal bloom blocks light from penetrating beyond the surface of the water in the Potomac River. ([Eric Vance](#) from Wikimedia Commons)

SAV IN THE CHESAPEAKE BAY

A history of SAV research in the Chesapeake Bay

Some of the earliest observations about Chesapeake Bay SAV are well-preserved in herbarium collections and in the journals of early explorers, but frequent, extensive, or thorough studies of Chesapeake Bay SAV were not conducted until more recently.

As the human population expanded in the Chesapeake Bay watershed throughout the mid-1900s, water quality deteriorated and negatively affected the Bay's overall abundance of SAV. By the late 1960s and early 1970s, SAV loss became a major concern as degraded habitats could no longer provide ecosystem services. Then in 1972, Tropical Storm Agnes swept through the region, caused significant damage and flooding, and destroyed more

than half of the remaining SAV in the Bay. The following year, U.S. Senator Charles Mathias called for and appropriated congressional funding for a study to analyze the degradation of the Chesapeake Bay ecosystem. The study officially took place between 1976 and 1982. The final report determined that excess nutrient pollution from the Bay's watershed was the primary culprit for increasingly poor water quality and loss of aquatic life.

Motivated by the results of the study, the Chesapeake Bay Program was formed in 1983. In 1984, a Bay-wide aerial SAV survey began, the first of what would become an annual event. Although aerial photography had been collected from regions of the Bay prior to 1984, a comprehensive Bay-wide survey had never been conducted. At the time of the first aerial survey, only about 38,000 acres of SAV were observed.



The amount of SAV in the Chesapeake Bay decreased over the second half of the 20th century, but has increased in recent years. ([Jane Thomas](#) from the IAN Image Library)

The documentation of the Bay-wide decline of SAV and its associated ecosystem services led to a spike in academic and public concern over SAV health, as well as the health of the Bay overall. Prior to the implementation of the SAV survey, only a couple of dozen papers had been published about Chesapeake Bay SAV. Both the frequency and scope of research projects increased dramatically in the years following. Today, SAV research in the Bay spans such topics as species distribution and abundance, species diversity, reproductive ecology and genetics, impacts associated with land-use, the effects of climate change, trophic studies, and restoration science - all in part due to the positive impact of the survey.

A comprehensive bibliography of all peer-reviewed journal papers, conference proceedings, and book chapters focused on Chesapeake Bay SAV is available at https://www.vims.edu/research/units/programs/sav/pubs/sav_biblio/index.php.

The importance of SAV

SAV has long been recognized as an important component of a healthy Bay ecosystem. Beds of SAV provide food, habitat, and nursery grounds for a number of commercially, recreationally, and ecologically important finfish and shellfish, such as the Bay's iconic blue crab. Even resident and migrating waterfowl depend on SAV for food. Physically, SAV absorbs excess nutrients from the Bay, which reduces algae abundance, and it also reduces wave and current energy, which reduces shoreline erosion and promotes water clarity.

Threats to SAV

SAV in the Chesapeake Bay is vulnerable to multiple threats, but because SAV depends on light for photosynthesis, water clarity is the primary limiting factor for SAV productivity in the Bay. Watershed land use, in turn, is one of the primary determinants of water clarity in the Bay. Land use affects water clarity through

a number of pathways, including deforestation, agricultural expansion, and urban development. All pathways contribute sediment and nutrient pollution (in the form of excess nitrogen and phosphorus) to the Bay's waters. In the Chesapeake Bay, nutrient pollution stems from a number of sources, including overburdened wastewater treatment plants, urban stormwater runoff, and agricultural runoff (particularly from fertilizers and manure).

Suspended sediments reduce light directly by increasing the turbidity, or cloudiness, of the water, while excess nutrients lead to algae growth. Algae can grow in very large forms (like sea lettuce or kelp) or very small forms (like phytoplankton). Large-form algae, generally called macroalgae, compete with SAV for space and can block out light that would otherwise reach SAV tissue. In high densities, macroalgae can smother SAV. Small-form algae, on the other hand, blocks light from reaching SAV by "blooming" in the water column (e.g. phytoplankton) or growing directly on SAV leaf-blades as epiphytes.



Sediment plumes decrease water clarity in the Choptank River. (Jane Thomas from the IAN Image Library)

In addition to reduced water clarity from nutrient and sediment pollution, other threats to Chesapeake Bay SAV include:

1. Shoreline armoring, which affects SAV by altering near-shore wave energy.
2. Boating, which can lead to propeller scarring of SAV in shallow water.
3. Climate change, which includes a number of threats ranging from the introduction of new pathogens and increased heat stress, to intensified storm events and longer-term changes to salinity and sea level.

SAV in the Chesapeake Bay has experienced fluctuations in its abundance due to various threats. Continuing restoration efforts are and have been working to mitigate these losses, especially through addressing the threat of nutrient pollution. For example, the Chesapeake Bay Total Maximum Daily Load (TMDL), or pollution diet, aims to reduce the amount of nitrogen, phosphorus, and sediment entering the Bay by implementing Best Management Practices (BMPs) throughout the watershed.

One way the Chesapeake Bay Program partnership tracks its progress towards restoring the Bay is through various monitoring efforts like the Chesapeake Bay SAV Monitoring Program and *Chesapeake Bay SAV Watchers*. Through the Bay-wide SAV Monitoring Program, we know that in 2017 SAV reached its highest acreage ever recorded - close to 105,000 acres - showing that restoration efforts are paying off and that there's hope here and across the globe when sustained restoration efforts are prioritized.

Bay salinity regimes and effects on SAV distribution patterns

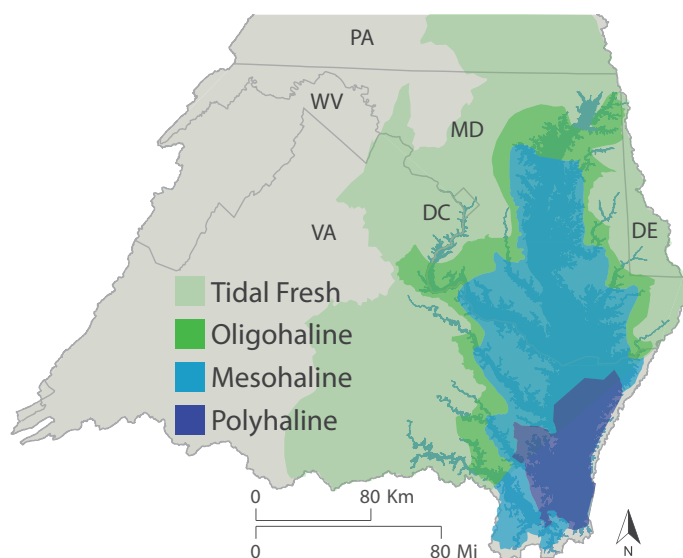
There are approximately seventeen species of SAV commonly observed in the Chesapeake Bay. While a number of factors influence SAV

species diversity and distribution throughout the Bay, including sediment type, wave energy, and light availability, their distribution is based primarily on their salinity tolerance.

There are four salinity zones in the Bay:

1. Polyhaline, the saltiest zone where salinity is greater than 18 ppt
2. Mesohaline, where the water is moderately salty and ranges from 5 - 18 ppt
3. Oligohaline, where the water is close to fresh and salinity ranges from 0.5 - 5 ppt
4. Tidal Fresh, where the water is fresh and the salinity is negligible at below 0.5 ppt

For the purposes of the *Chesapeake Bay SAV Watchers* project, the oligohaline and tidal fresh ranges will be jointly referred to as the oligohaline zone.



Salinity regimes in the Chesapeake Bay. (Dylan Taillie)

In the southern, saltier portion of the Bay, species diversity is low. There are only two species of SAV that thrive in that saltier (polyhaline) environment: eelgrass (*Zostera marina*) and widgeongrass (*Ruppia maritima*). As you move up the Bay and into only moderately salty (mesohaline) water, diversity increases but is still limited. Approximately four species live in this region, including widgeongrass (which has a very broad salinity tolerance), redhead grass (*Potamogeton perfoliatus*), sago pondweed (*Stuckenia pectinata*),

and horned pondweed (*Zannichellia palustris*). In the freshwater reaches of the Bay's tributaries and in the upper Bay proper (oligohaline, SAV species diversity increases dramatically. Some of the most common species you'll observe in those areas include wild celery (*Vallisneria spiralis*), water stargrass (*Heteranthera dubia*), Eurasian watermilfoil (*Myriophyllum spicatum*), *Hydrilla*, and a number of pondweeds (*Potamogeton* sp.) and naiads (*Najas* sp.).

As species diversity increases from the southern Bay to the upper Bay, so does the morphological and physiological diversity of the plants. The southern Bay species - widgeongrass and eelgrass - are relatively simple and resemble actual grasses, whereas several of the freshwater species grow in bushes and clumps, with leaves alternating on the stem or in a whorled arrangement. Diversity - both species and morphological - is important to the resilience of the SAV bed itself and also to the animals that use it as habitat. The more SAV species that are present, the higher the likelihood that some of those species will survive major environmental changes and stressors. Likewise SAV beds that contain higher levels of morphological diversity can provide habitat and refuge for a greater abundance and diversity of animal species.



Increased species diversity within SAV beds make them more resilient to various threats that impact the Chesapeake Bay. (Brooke Landry)

Conservation efforts

To conserve and restore SAV in the Chesapeake Bay, the Bay Program's SAV Workgroup has adopted five primary management approaches in its SAV Management Strategy (<https://www.chesapeakebay.net/what/publications/2022-2023-sav-management-strategy>). The five management approaches are:

1. Support Efforts to Conserve and Restore Current and Future Submerged Aquatic Vegetation Habitat and Habitat Conditions
2. Protect Existing and Recovering Submerged Aquatic Vegetation
3. Restore Submerged Aquatic Vegetation in the Chesapeake Bay
4. Enhance Research and Monitoring in the Chesapeake Bay Watershed
5. Enhance Community Involvement, Education and Outreach

The Chesapeake Bay SAV Watchers Monitoring Program will directly or indirectly contribute to all management approaches for conserving and restoring SAV in the Bay! By helping Bay scientists collect SAV data, program participants will help protect SAV throughout the Bay. The more we know about what's out there, the better we can protect it. Participants will also help restore SAV! With more detailed species information, Bay scientists will be able to choose sites that will benefit the most from restoration efforts. Participants may also have opportunities to assist Bay scientists with actual restoration projects! And finally, research has shown that the more involved a community is with its environment, the more the individuals of that community do to help protect and conserve it.

INTRODUCTION TO THE VOLUNTEER MONITORING PROGRAM

What is the history of SAV volunteer monitoring in the Chesapeake Bay?

Citizen scientists and volunteers have played a major role in the conservation and restoration of Chesapeake Bay SAV over the last several decades. From the Chesapeake Bay Foundation's Grasses for the Masses program to the Riverkeeper groups and watershed organizations that monitor the Bay's tributaries, much of what we know about the distribution and abundance of various species of SAV is because individuals have gotten involved, volunteered their time, and shared their observations. Most recently, the Chesapeake Bay Program's SAV Workgroup has coordinated with citizen scientists and volunteer groups to conduct either ad hoc or organized surveys of SAV in tributaries throughout the Bay.

Why is it important to monitor SAV?

SAV is one of the most easily visible indicators of water quality and overall Bay health. Historically, it's been estimated that anywhere from 200,000 to 600,000 acres of SAV grew in the Bay. As the human population expanded throughout the watershed and land was developed, the Bay's water quality deteriorated and SAV disappeared from the waterways where it was once abundant. In response, the Chesapeake Bay Program and its partners have mounted a tireless effort to restore SAV by improving the Bay's water quality through various best management practices.



Staff from Maryland Department of Natural Resources lead a SAV species identification workshop on the Susquehanna Flats. ([Will Parson](#) from Flickr)

The ultimate Bay-wide restoration goal is 185,000 acres of SAV, with individual tributaries assigned specific restoration targets. The Chesapeake Bay SAV Monitoring Program conducts an annual aerial survey to determine how much progress we have made towards both Bay-wide and tributary-specific acreage goals, but the survey does not tell us everything we need to know about which species are



Trays of redhead grass are grown in a lab and planted at selected restoration sites throughout the Bay. ([Adrian Jones](#) from the IAN Image Library)

thriving in various locations, or where SAV beds are growing undetected by the aerial images. Having in-water observations gives Bay scientists key information about habitat characteristics such as species richness and diversity. These two measurements reveal how many species are present in an area, as well as their relative abundance, and that information in turn gives Bay scientists an idea of an SAV bed's resilience.

Where does the data go?

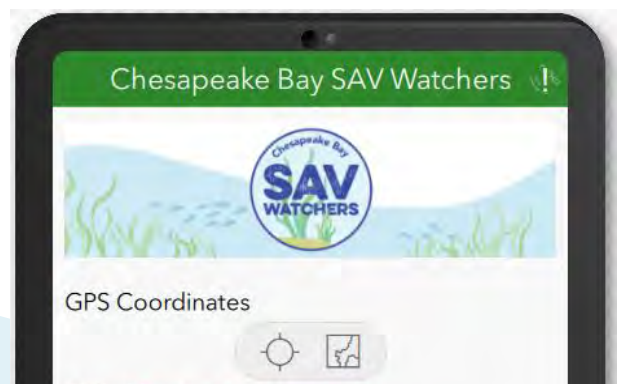
The Chesapeake Bay Program's annual SAV monitoring program has been ongoing since 1984 and is conducted by the Virginia Institute of Marine Science (VIMS). VIMS maintains a website where all SAV data is stored so that any Bay research scientist, environmental professional, or citizen can view and use it.

All of the data collected for the *Chesapeake Bay SAV Watchers* Monitoring Program gets entered into the VIMS SAV website as well, but first the data goes through the Chesapeake Bay Program's SAV Workgroup. Sending the data through the SAV Workgroup first allows the Workgroup to review which tributaries are best or least represented in the data. This pre-entry step also allows the Workgroup to monitor the number of citizen scientists or volunteers participating in data collection. Then the data

will be given to VIMS to load onto their website for public use. All volunteers participating in the *Chesapeake Bay SAV Watchers* Monitoring Program record their SAV observations on a standardized data sheet. Our monitoring protocol is therefore able to not only streamline SAV data entry, but also to standardize the data so that web users can more readily access a broader assessment of the Bay's SAV population.

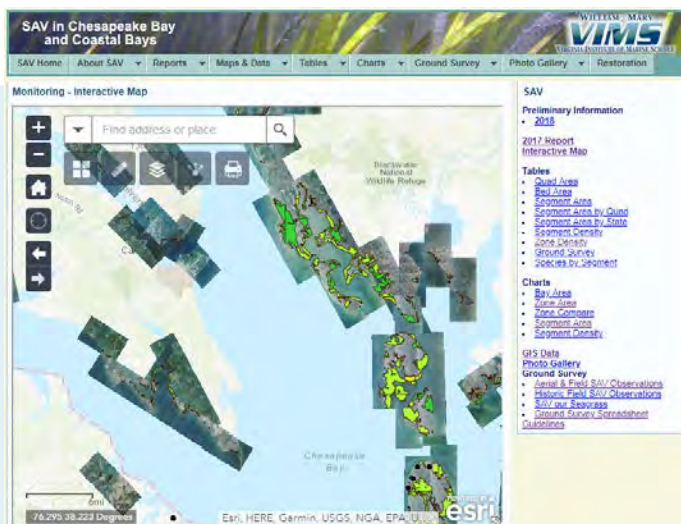
How is the Chesapeake Bay SAV Watchers monitoring protocol set up?

The *Chesapeake Bay SAV Watchers* Monitoring Program uses ArcGIS Survey123 to collect and enter SAV data. Please see *Chesapeake Bay SAV Watchers: Guide to Submitting Data and Observations* for detailed instruction on how to use ArcGIS Survey123. Participation in the program is open to everyone. Volunteers can participate on their own or as part of an organized group. Those collecting data on their own, while out kayaking, for example, can collect data without training or certification.



All volunteers participating in the program submit their data to the *Chesapeake Bay SAV Watchers* survey using the ArcGIS Survey123 app. (Kaitlin Scowen)

Those who are affiliated with an official volunteer monitoring group go through a certification process to ensure accuracy of data collected, though training and certification varies by group. Training is not required in order to participate; however, volunteers are encouraged to join groups and attend trainings if possible.



A screen capture from the Virginia Institute of Marine Science 2017 Interactive Map of SAV beds along the Eastern Shore of the Chesapeake Bay. (Suzi Spitzer)

Trained and certified volunteers are asked to collect all data parameters whereas non-trained volunteers may leave data parameters blank if unknown.

This program involves data collection on a diverse number of parameters including SAV species, Secchi depth, SAV density, shoreline type, other macrophytes, and more.

How does the training and certification program work?

Volunteers who wish to become certified in the *Chesapeake Bay SAV Watchers Program* must complete a training course and receive certification. The training and certification requirements vary depending on whether a participant is a member or a leader of an SAV Watcher monitoring group. Group leaders are required to complete an in-person Train-the-Trainer session with the Chesapeake Bay SAV Watchers Monitoring Program coordinator.



The certificate template features a light blue background with a wavy line separating the header from the body. The header contains the Chesapeake Bay Program logo on the left and the SAV Watchers logo on the right. The text reads: "This is to certify that _____ has successfully completed the Chesapeake Bay SAV Watchers Volunteer Monitor Trainer Certification course on _____ (date of completion)". At the bottom, there are two lines for signatures: "_____" and "_____" with the name "J. Brooke Landry, Chair, Chesapeake Bay Program's SAV Workgroup" printed below the second line. The bottom of the certificate is decorated with a stylized illustration of green seagrass and blue fish.

Certified trainers will receive a certificate confirming that they have attended the Chesapeake Bay SAV Watcher training session and have met the requirements needed to train and certify members of their monitoring groups. (Suzi Spitzer)

This training session includes an orientation on the monitoring protocol, during which participants practice how to identify SAV species and learn how to properly collect, record, and digitize data so that it is compatible with the VIMS SAV website and all its features. Participants will be tested on their

ability to complete these tasks at the end of the training session. Once volunteer monitoring group leaders complete the training session, they become "certified trainers" who can then train and certify members of their monitoring groups. Certified trainers are only required to complete one official *Chesapeake Bay SAV Watchers* training session in order to achieve certification, though we do encourage trainers to attend subsequent trainings as needed for review. Members of volunteer monitoring groups must complete a training as specified by their monitoring group coordinator in order to become "certified volunteer monitors".



Volunteers review the previously used Advanced Monitoring Protocol during a training session. (Sky Swanson)

What materials are available for Chesapeake Bay SAV Watchers?

There are many resources available for *Chesapeake Bay SAV Watchers* participants. All materials can be viewed online at www.chesapeakebaysavwatchers.com and printed as needed.

Methods manual: includes background information on SAV and the *Chesapeake Bay SAV Watchers* Monitoring Program, detailed protocol for the Guide to Submitting Data and Observations, safety information, an updated SAV species guide, and many other references.

instructions: detailed instructions for collecting and submitting data using the *ArcGIS Survey123* app.

Guide to Submitting Data and Observations

1. Open the App Store.
2. Tap the magnifying glass icon in the bottom right corner to open the search bar.
3. Type "ArcGIS Survey123" into the search bar to locate the app. A list of suggested results will appear as you type.
4. Select the ArcGIS Survey123 app from the list to open its App Store page.
5. Tap the "Get" button to download the free app to your device and install it.

In order to contribute data to the Chesapeake Bay SAV Watchers Program, all observers will need access to the survey link or to have downloaded the survey. This can be done using the ArcGIS Survey123 app on a smartphone or online at <https://arcgis/11yWyx0>. This section will review the steps involved in this process.



On a smartphone

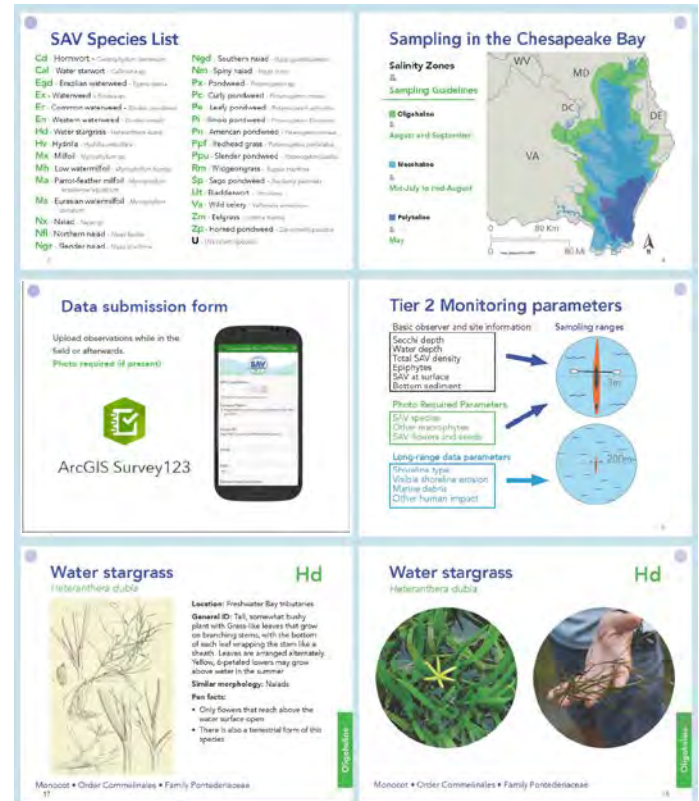
1. Open the ArcGIS Survey123 app and select "While using the app" to allow ArcGIS Survey123 to take pictures and record video. Then select "Allow" for ArcGIS Survey123 to send you notifications.
2. The app will take you to the home page. Select "Continue without signing in" Select "While using the app" to allow access to your device's location.

Volunteers can download a guide that details how they can use *ArcGIS Survey123* to submit data. (Kaitlin Scowen)

Data sheet: volunteers should print this document (double-sided on waterproof paper if possible) and use it to record all field observations.

Data digitization template: Data is automatically formatted when submitted in the survey form. Data is then uploaded to *ArcGIS Online*.

Pocket Field Guide: a pocket-sized SAV species identification guide that includes extra photos of other macrophytes.






The Pocket Field Guide contains a field packing list, protocol reminders, SAV identification resources, and more. (*Suzi Spitzer*)

Video series: covers background information on SAV biology and monitoring. Step-by-step training videos are also available for each data parameter included in the protocol.

Certificate: a printable certificate for certified volunteer monitors.

Contact Information

If you have any further questions about the *Chesapeake Bay SAV Watchers* Monitoring Program, please contact Brooke Landry or Kaitlin Scowen by email at brooke.landry@maryland.gov or kaitlin.scowen@maryland.gov. Brooke is the Chair of the Chesapeake Bay Program's SAV Workgroup. Both Brooke and Kaitlin are SAV Biologists at Maryland's Department of Natural Resources.

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	Group ID _____	General area description _____					

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A printable data sheet for data collection is available on the *Chesapeake Bay SAV Watchers* website. (Suzi Spitzer)

BEST PRACTICES FOR DATA COLLECTION

How should site locations be selected?

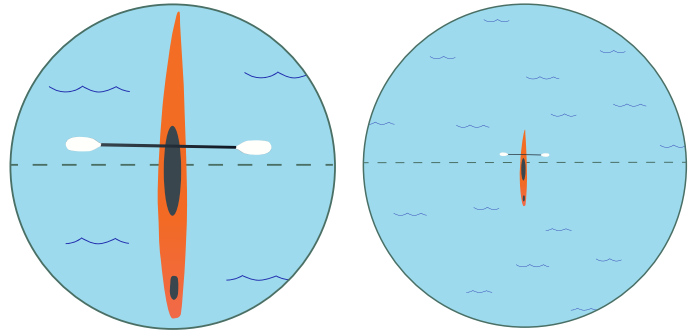
When sampling multiple sites in the same area, it is recommended that individual sites be spaced at least 15 meters apart from each other (about the distance across four lanes on an interstate). Site selection within a monitoring group is left to the discretion of the monitoring group coordinator or leader. When selecting sites, it may be helpful to consult the annual aerial SAV survey map on the VIMS website at <https://www.vims.edu/research/units/programs/sav/access/maps/>. It is particularly valuable when volunteer-collected data can verify the aerial surveys. For example, volunteer-collected data could be used to either confirm the existence of SAV beds that appear on the map, or potentially reveal beds that were not captured in the aerial survey at all. Aerial surveys primarily capture the geographic extent and density of SAV beds but do not reveal other valuable information, such as the species diversity within the beds. Collecting this additional information is extremely important for management purposes. It is also essential to always confirm the accuracy of a site's recorded location. This can be done by double-checking GPS coordinates and recording coordinates in the correct format (see protocol).

What qualifies as a site?

Sampling circle

A sampling site is a circular area with a 3 meter diameter (about the length of a recreational kayak). The GPS coordinates associated with a sampling site represents the center point of a sampling circle. When collecting data at a site, the observer should be positioned at the center of the sampling circle before proceeding to

monitor the area surrounding them (1.5 meters - or about 5 feet - in all directions) for all types of data, excluding the long-range data parameters.



A sampling site with a 3 meter diameter (left) should be used to observe most data parameters. To collect data for long-range data parameters, observers should consider the area within a larger circle with a 200 meter diameter (right). (Dylan Taillie)

Long-range data collection

At each site, observers collect most of the required data by visually inspecting the area within the sampling circle. For some parameters, it is necessary to look beyond the perimeter of the site itself. Long-range data parameters include the following: 1) shoreline type, 2) visible shoreline erosion, 3) marine debris, and 4) other human impact. When collecting these four types of data, observers should expand their sampling circle from a 3 meter diameter to a 200 meter diameter. After establishing this larger circle, begin collecting data for the surrounding area, again, starting from the center of the circle (100 meters in all directions, or about the length of a football field). If a sampling site is not located within 100 meters of a shoreline, indicate this on the data sheet.

When and how often should I sample?

For the purposes of this monitoring program, it is more valuable to sample a greater number of sites once or twice a year rather than frequently sampling a smaller selection of sites. Sampling should be done at least once a year during the summer growing season when the SAV reaches peak biomass and reproductive structures (e.g. seeds and flowers) are visible. Grasses peak earlier in the more southern areas of the Bay and later in the northern regions. Generally, SAV surveys in the southern polyhaline region of the Bay should be conducted in May. In the moderately salty, mesohaline mid-Bay, sampling should occur in July or August when reproductive structures are most abundant in this region. If time and capacity permits, an early spring (April) survey would also be beneficial in the mesohaline to capture the distribution and abundance of horned pondweed. In the freshwater regions of the upper Bay and tributaries, SAV peaks and begins reproducing in August and/or September, therefore sampling should take place within this time frame. The exact timing of peak biomass and reproductive activity varies slightly depending on summer temperatures and precipitation, so these dates should be considered as general guidelines.

What are the best sampling conditions?

To increase data quality and value, it is important to collect data during optimal sampling conditions. When deciding whether or not to go out in the field to sample, there are a few factors to consider. Data collection should be completed when SAV visibility is maximized. Observers should sample at low tide and on a sunny day with little wind, following a period of minimal rainfall.

Rain

Rain increases the turbidity, or murkiness, of the Bay for days, or even weeks, after a precipitation event. When water is cloudy, it is hard to see SAV and even more difficult to accurately estimate SAV density. Sampling should be completed when the water is at its clearest - after a week of dry weather. Sampling should never be done during rainfall or in the days following significant rainfall.



After a rain event, sediment from an upstream source mixes into a river and increases water turbidity. (Will Parson)

Tide

The depth of the water has a large effect on the visibility of SAV. SAV is much easier to see at low tide; so sampling should be completed when the water levels are low. Observers should check the tide chart before planning a sampling trip. Tide charts can be located on the NOAA website (<https://tidesandcurrents.noaa.gov/stations.html?type=Water+Levels>), the MD DNR website (<http://dnr.maryland.gov/Fisheries/Pages/Tide-Finder.aspx>), or by using apps such as [Tide Charts](#) or [Tide Alert \(NOAA\)](#).

Wind

On windy days, it can be difficult (and possibly dangerous) to maintain a steady position on a small boat or kayak in order to accurately monitor a specific site. Wind can also disrupt the surface of the water, decreasing the visibility of SAV below the surface. To safely

and accurately collect data, observers should sample on days with low wind speeds and avoid sampling when small craft advisory warnings have been issued.

Sun

Light also affects the visibility of underwater grasses. Sunlight penetrates the water column and makes grasses easier to see, but too much light can produce a glare on the surface of the water, which can also interfere with sampling. Ideally, observers should sample on sunny days when the sun is not directly overhead.

How should I collect SAV specimens?

When surveying SAV, you will most likely be on a motorboat, in a canoe or kayak, wading in from shore, or observing SAV around your dock. In all cases, you should aim to disturb the SAV bed as little as possible. In order to take good pictures of the species observed, though, you will need to collect some samples. Whenever possible, avoid uprooting SAV. Oftentimes there will be uprooted or broken SAV material floating at the surface. If that's the case, take those samples for your pictures. If you can't find any plants that are already detached, you can grab some either with your hand or by using a rake. Bushy species, like common waterweed or many of the naiads, fragment easily without disturbing the roots. They are simple to collect without causing much disturbance. Other



Volunteers are encouraged to observe SAV without uprooting plants from the sediment (Sky Swanson)

species, like wild celery or widgeongrass, are more likely to come up from the root when collected for sampling; so take care to only pull up one plant of each species for your picture(s). When possible, such as when the leaves are growing to the surface, you can use two hands to break off the upper portion of the plant for your picture to avoid disturbing the roots.

How can I stay safe while sampling?

As with any type of outdoor work or water-based activity, there are some risks associated with monitoring SAV. Therefore, it is important that all volunteers take precautions to keep themselves and others safe during monitoring activities. *Chesapeake Bay SAV Watchers* does not require volunteers to sign any liability waiver forms, but if you are monitoring as part of a group monitoring effort (e.g. for a Riverkeeper monitoring group), they may require you to sign a waiver form. Safety during monitoring activity is the responsibility of both the individual volunteers and volunteer monitoring groups. Below are several recommendations and general precautions that all SAV monitors should follow when conducting any type of volunteer monitoring activity:

- Always alert someone when heading out to monitor. Ensure that someone knows where you are going, when you intend to return, and what to do if you do not return as expected. This is called a Float Plan. There are several example float plans available online. Check out this website for simple instructions on how to create one: <https://www.boaterexam.com/boating-resources/filing-a-float-plan/>.
- Always wear a life jacket.
- Pack a first aid kit, and have a safety plan in place in case of emergency. Share any relevant personal health information, such as any known allergies or heart conditions, with your sampling partner. Know where the nearest medical facility is, and have

emergency contact and medical insurance information on hand just in case.



Always monitor with at least one other person. (Sky Swanson)

- Monitor with at least one partner whenever possible. Follow the “buddy system”!
- Pack plenty of water when you monitor. Never drink water from the Chesapeake Bay or any of its tributaries and streams.
- Dress appropriately for outside work. Wear a hat, sunglasses, water shoes, sunscreen, and insect repellent.
- Do not touch water that you believe may be contaminated (if you see or smell any indication of a sewage spill, oil spill, harmful algal bloom, or fish kill, for example). Do not enter the water after large rain events or if you suspect that the water may be severely polluted. Always wash your hands and shower after monitoring, and avoid water contact if you have open cuts, sores, or wounds.



Avoid contact with contaminated water, such as algal blooms known as mahogany tides. (Alicia Pimental from Flickr)

- Check weather reports before leaving for monitoring. Do not monitor if severe weather is predicted (strong winds or current, lightning, heavy rain, etc.). If you are on the water and a storm blows in before you are able to get back to your point of entry, go to the nearest shoreline or dock to take shelter.
- Familiarize yourself with the monitoring protocol and noted precautions before going out to monitor.
- Access sampling sites by using public access points. Always obtain permission of the landowner when monitoring SAV on private property.

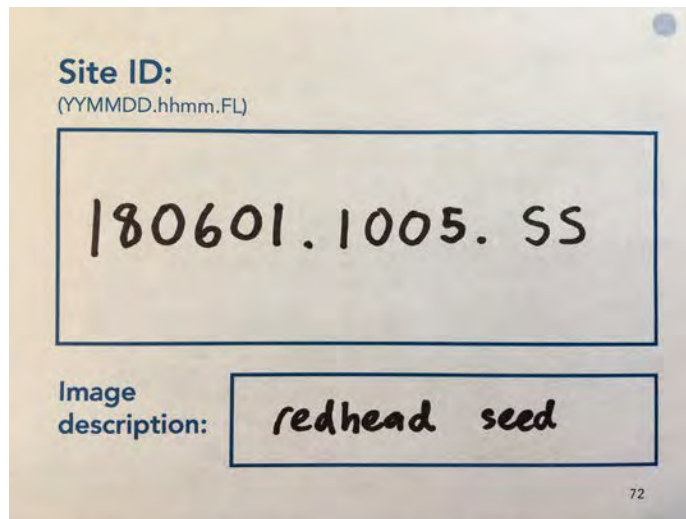
How can I take high-quality photos?

High-quality photos are valuable because they can be used to confirm observations. Providing this method of quality assurance makes data much more likely to be used in a greater variety of contexts, including in scientific reports that inform policy and management decisions. In fact, some data parameters, such as SAV species, density, and flowers or seeds, can only be used by professional scientists if there is also photographic evidence. For this reason, many volunteer monitoring programs, including this one, require observers to submit photographic data along with their recorded observations. Here are some ways to increase the quality of your photos.

Include essential site information in the picture

Observers must include the Site ID (see protocol for formatting instructions) and a brief image description in each photo. An easy way to do this is to fill in the back side of the Pocket Field Guide and include the guide in every photo from a particular site. When the site number and image description are included in the photo, there is less of a need to rely on

only the photo's preserved metadata (photo name, date, etc.) to identify which pictures are associated with a particular sampling site.



A example of the Site ID and image description on the back of the Pocket Field Guide. This information should be included in every photograph. (Suzi Spitzer)

Think about lighting and focus

Whether photographing plant features to identify a species or confirm the presence of flowers or seeds, make sure that the SAV specimen is well lit and the image is in focus. Proper lighting and focus will increase the likelihood that the photo can be a useful quality assurance tool.

Photograph unusual or distinguishing characteristics

Remember, the purpose of taking these photos is so that other volunteers and SAV experts can refer to a photo to confirm a recorded observation. Consider the defining characteristics of particular SAV species, and make sure that someone could potentially use your photo to identify an individual species with reasonable confidence. When removing SAV from the water to set up a photograph, place the specimen against a light-colored surface, such as a clipboard or piece of paper, with the leaves and stems spread out. This will allow others to easily distinguish unique leaf arrangements. If present, include seeds, fruits, and flowers in your photographs. Include close-up shots of the SAV when necessary. For

any data parameters that do not require an image, consider taking a photo when observing anything unusual, rare, or concerning.



A volunteer takes care to spread out the leaves and stems of this slender naiad specimen so the photo can be used to confirm the SAV species identification. ([Will Parson](#) from Flickr)



Photographs should always include any flowers, seeds, or other characteristic structures that can be used to either confirm species identification or learn more about the reproductive success of the SAV bed. (Brooke Landry).



For some bushier SAV species, it may be more effective to photograph the specimen while it is still in the water, rather than trying to spread out the leaves on a flat surface. (MD DNR)

MONITORING PROTOCOL

Overview

Observations with no prior training

Opportunistic observations using the *ArcGIS Survey123* platform

- Basic observer and site information
- SAV species (if possible)

Observations with training

Data collection for an established volunteer monitoring program with training prior to entering the field

- Basic observer and site information
- Secchi depth
- Water depth
- Total SAV density
- SAV species
- Epiphytes
- Other macrophytes
- SAV flowers and seeds
- SAV at surface
- Bottom sediment
- Shoreline type
- Visible shoreline erosion
- Marine debris
- Other human impact

Field packing list

Optional gear

- Binoculars
- Hand lens
- Dry bag
- Waterproof camera
- Mask and snorkel
- Boat
- Life jacket
- Trash bag

Required gear - Observers without training

On-site reporting

- SAV species guide or Pocket Field Guide
- Waterproof phone pouch
- Smartphone equipped with:
 1. The *ArcGIS Survey123* app
 2. GPS location services
 3. Camera

Off-site reporting

- Computer with internet
- *ArcGIS Survey123* website
- Paper/SAV Watcher data sheet
- Pencil
- Watch or clock
- Camera
- GPS-enabled device
- SAV species guide or Pocket Field Guide

Required gear - Observers with training

- Data sheets printed on waterproof or water-resistant paper
- Pencil
- Dry erase marker
- Clipboard
- Sampling protocol and SAV species guide
- Pocket Field Guide
- Watch or clock
- Camera
- Smartphone equipped with GPS location services and the *ArcGIS Survey123* app
- 8" Secchi disk with an attached measuring tape
- Device to classify sediment (boat paddle or pole are adequate)
- Life jacket if monitoring from a boat or paddleboard

Guide to Submitting Data and Observations

Observations with no prior training

Overview:

Record the species of SAV present using the ArcGIS Survey123 platform.

Significance:

SAV species identification provides additional information about the environment and resiliency of the plants that live there. By recording species, changes in SAV can be monitored along with changes in the environment. Knowing how species are changing can guide decisions regarding management and restoration.

Equipment:

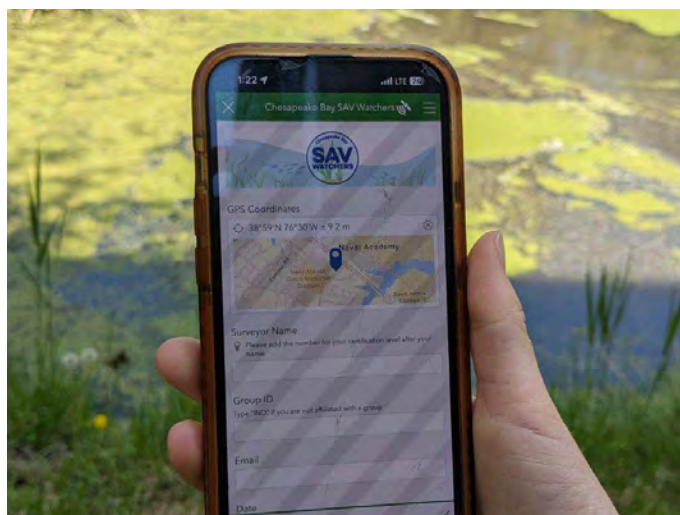
On-site reporting - SAV species guide or Pocket Field Guide, waterproof phone pouch, and a smartphone equipped with the ArcGIS Survey123 app, GPS location services, and a camera.

Off-site reporting - Computer with internet, ArcGIS Survey123 survey website, paper, pencil, watch or clock, camera, GPS-enabled device, and SAV species guide or Pocket Field Guide.

Method:

Non-certified volunteers who participate in the Chesapeake Bay SAV Watchers Program will be asked to submit the following data for each monitoring site: observer name and certification level, GPS location, sampling date, sampling time, and a list of the SAV species observed, in order from most abundant to least abundant. Photos of the observed SAV species must also be submitted as part of any observation. These observations are marked as required on the survey in order to submit the form. All volunteers will use the ArcGIS Survey123 platform to submit data. There are two ways to collect and submit monitoring data using ArcGIS Survey123. The most

straightforward approach is on-site reporting where you submit observations at the monitoring site using a smartphone equipped with the ArcGIS Survey123 app. If a volunteer is uncomfortable doing this, they may rely on off-site reporting, or submitting SAV data to the ArcGIS Survey123 website after the sampling event, using a desktop or laptop computer. Detailed and updated step-by-step instructions on how to use the ArcGIS Survey123 app or website can be found on the Chesapeake Bay SAV Watchers website at www.chesapeakebaysavwatchers.com.



Use the ArcGIS Survey123 app to submit data. (Kaitlin Scowen)

Pro tips:

- If you cannot identify the plant to the species level, identify the genus and make sure to take a clear picture so that the species can be identified by SAV experts.
- The submitted picture should be a close-up shot that highlights plant characteristics for species identification. See the previous section of this manual for more details.
- If multiple species are observed at one site, include all species in your uploaded photo. If you are unable to include all observed species in one photo, you should upload one photo and then include additional photos as comments to your original post.

Observations with training

Overview:

Denote more details about the site where the data was recorded.

Significance:

In order for data to be useful and reliable for Chesapeake Bay data analysts and scientists, information on how and where observations were made must be recorded. Recording basic personal information like the data collector's name and monitoring group can be useful if there are any problems or questions regarding data collection or entry. The sampling time and date are important for bookkeeping and any future data interpretation. For example, SAV abundance depends on other factors such as light and temperature, both of which fluctuate throughout the year. Recording the date addresses some of the annual variation, and recording the time of day accounts for the changing tides. Additionally, observers will measure water depth at all monitoring sites, but that measurement changes as tides go in and out. Depths measured during fieldwork can be standardized with our knowledge of tide schedules. Most importantly, the location of the monitoring site needs to be as precise as possible in order to accurately track both Bay-wide SAV patterns, as well as local-scale changes over time. Finally, the unique Site ID will provide a means to organize all information, including photos, based on the individual sampling event.

Equipment:

Data sheet and pencil, GPS-enabled device, smartphone with the *ArcGIS Survey123* app, watch or clock, camera, spare paper or Pocket Field Guide, and dry erase marker.

Method:

1. Record the following information at the top of the data sheet. This information will be the same for all three sampling sites on the data sheet:
 - a. Observer name, certification level, and monitoring group. This can be done before going to the field.
 - b. Date (DD/MM/YYYY) of sampling.
 - c. General description of area where sampling occurs (e.g. tributary name)
 - d. Time (hh:mm; use 24-hour clock) of high tide and low tide. Use a tide chart to determine tide times.
2. Record the time (hh:mm; use 24-hour clock) at which data collection at a monitoring site begins.
3. Record GPS points.
 - a. Use the Latitude Longitude Coordinate System, and record the location in decimal degrees to six decimal places (DD.DDDDDD, DD.DDDDDD).
 - b. Triple-check coordinates for accuracy!
 - c. For more information on the Latitude Longitude Coordinate System, visit https://maptools.com/tutorials/lat_lon.
4. Record the unique Site ID. The ID helps keep all data organized according to sampling event. The ID includes the sampling date, time, and observer's initials (first, last) and should be recorded using the specified format (YYMMDD.hhmm.FL).
 - a. Ex: 180823.1524.JD signifies a site that was observed on Aug 23, 2018 at 3:24pm by Jane Doe.
 - b. If more than one person is present when monitoring a site, choose one person's initials to use on behalf of the sampling team.

5. Write down the Site ID on the back of the Pocket Field Guide using a dry erase marker (or on a spare piece of paper using a pencil).
6. Record observations for Secchi depth, water depth, SAV density, SAV species, epiphytes, other macrophytes, SAV flowers and seeds, canopy height, bottom sediment description, shoreline type, visible shoreline erosion, marine debris, and other human impacts. See instructions below for parameter-specific instructions.

Pro tips:

- Check that your GPS device is set to measure location using the Latitude Longitude Coordinate System. GPS should be recorded as decimal degrees only, and never as Degrees/Decimal Minutes or Degrees/Minutes/Seconds. If using a handheld GPS unit, consult the device website or instruction manual to adjust settings if necessary.
- GPS points can be retrieved and confirmed using a handheld GPS unit or a standard smartphone. See the Appendix for "How to retrieve a GPS location using phone". You can also use the *ArcGIS Survey123* app to retrieve GPS coordinates.
- GPS points can very easily be written down incorrectly. Observers should triple check the data sheet against the GPS coordinates on their phone or computer and save coordinates digitally whenever possible.

Secchi depth

Overview:

Measure the distance between the water surface and a Secchi disc lowered to the limit of visibility.

Significance:

SAV depends on light for photosynthesis; so aquatic plants are limited to areas where enough light can penetrate the water column and reach the plant. Clear water easily lets light travel through, but suspended sediment, algae, and other materials can reflect and trap light that would otherwise reach plants growing from the bottom. Water that has a greater Secchi depth is more transparent and allows more light to pass through, while water with a smaller, shallower Secchi depth is murkier and blocks light from reaching plants growing on the bottom. Knowing the Secchi depth at a site allows us to determine to what extent the site is suitable for SAV growth and restoration.

Equipment:

8" Secchi disk with an attached measuring tape or pre-marked rope.



This Secchi disk is attached to a line that is marked with pre-measured distances. (Sky Swanson)

Method:

**Note: Measure the Secchi depth before entering the water or taking any other measurements that might disturb bottom sediments or the water column.*

1. Remove sunglasses or snorkeling mask, and turn so you are facing away from the sun.

2. Lower the disk slowly off the shady side of the boat.
3. Continue lowering the disk until the disk just barely disappears from sight. Based on the length of the line that is submerged beneath the surface of the water, note the depth reading.
4. Slowly raise the disk towards the surface of the water until it barely reappears, and note the depth reading.
5. Average the two depth readings to calculate the limit of visibility (index of transparency) and record this calculation to the nearest centimeter.

Pro tips:

- Sometimes the Secchi depth is equivalent to the total water depth of a site (the Secchi disk is still visible even when it is resting on top of the sediment). If this occurs, indicate this by marking "B" for bottom on the data sheet in place of a Secchi depth measurement.
- Make sure that the tape is positioned straight down from the surface. Sometimes the current positions the line at an angle, and influences the measurement.
- If there is wave action at your site, estimate the limit of visibility based on the midway point between the waves' highest part of the crest and lowest part of the trough.
- If dense SAV growth obscures the Secchi disk or prevents the disk from lowering, use a paddle or your hand to gently push SAV plants aside until an accurate, unobstructed Secchi depth reading can be measured.
- If you do not have access to a Secchi disk with a measuring tape, you can also use a Secchi disk attached to a rope. Before monitoring, use electrical tape and either a tape measure or yardstick to mark measurements onto the rope. Include enough markers so that you can measure the depth to the nearest centimeter.

Water depth

Overview:

Measure the water depth from the bottom sediment to the surface of the water.

Significance:

Water depth influences whether or not a habitat is suitable for SAV growth. SAV depends on light for photosynthesis; so plants are limited to areas where enough light can penetrate through the water to reach the bottom. When water is deep, less light reaches the bottom, and plants have a harder time providing enough energy for themselves. However, plants can also be light-limited when water is murky, or turbid. That is why measurements of water depth and Secchi depth complement one another.

Equipment:

8" Secchi disk with an attached measuring tape or pre-marked rope.

Method:

1. Slowly lower the Secchi disk into the water until the disk is touching the bottom, and the line just barely becomes slack.
2. Based on the length of the line that is submerged, record the depth reading in centimeters.

Pro tip:

- When the bottom has been reached, raise and lower the line a few centimeters and use the tension of the measuring tape to confirm the location of the bottom.



To measure water depth, lower the Secchi disk until it just barely rests on the bottom sediment. (Sky Swanson)

Total SAV density

Overview:

Indicate whether or not SAV is present at a site and provide a measure of density.

Significance:

Density is a measurement of how much SAV covers the bottom sediment at a particular site. Highly dense beds generally have more SAV shoots growing per unit of area and/or thicker leafy vegetation coverage when viewed from above. SAV density can serve as an indicator for a meadow's overall health, providing information on how well it can endure storms and how suitable it is for animal habitat. Density can also affect an SAV bed's ability to provide various ecosystem services such as protecting shorelines from erosion and trapping sediment.

Equipment:

None required.

Method:

1. Estimate the average overall percentage of SAV cover. Scan the vicinity to get a better idea of the average coverage for the site.
2. Record the total estimated SAV density category using the following options:

Category 0: Absent

Category 1: < 10% coverage

Category 2: 10% to < 40% coverage

Category 3: 40% to < 70% coverage

Category 4: 70% to \leq 100% coverage

Pro tips:

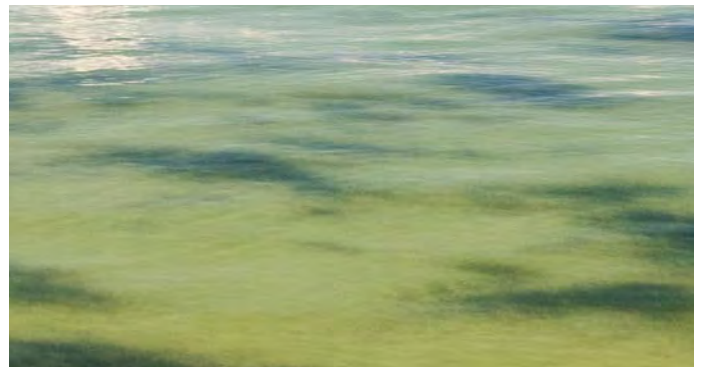
- Normally measuring density requires a quadrat, but to minimize bulky equipment it has been left out of this protocol. The unit of measure will be the sampling site, or the 3 meter sampling circle around your boat.
- SAV density should take into account only SAV that is rooted into the sediment,

rather than uprooted and floating at the surface of the water.

- Density should be estimated at low tide when SAV is most visible.



Category 1: <10% coverage. ([Alicia Pimental](#) from Flickr)



Category 2: 10% to < 40% coverage. ([Alicia Pimental](#) from Flickr)



Category 3: 40% to < 70% coverage. ([Alicia Pimental](#) from Flickr)



Category 4: 70% to \leq 100% coverage. ([Alicia Pimental](#) from Flickr)

SAV species

Overview:

Identify species of SAV present at a site.

Significance:

SAV species identification provides additional information about the environment and resiliency of the plants that live there. The environmental setting, including water clarity, nutrient abundance or limitation, salinity, sediment type, and wave energy, determines whether or not SAV can grow at a site and which species may be present. For example, freshwater species like water stargrass (*Heteranthera dubia*) are unlikely to be found at the mouth of the Chesapeake Bay where the water is typically salty. In this way, the type of SAV is a natural indicator for the condition of the local environment.

As environmental conditions change, so can the species of SAV. When multiple SAV species inhabit an area, it is more likely that at least one of those species will survive changing conditions. Because of this, increased SAV diversity often means increased resilience for a site. When diversity is low, an SAV meadow is more vulnerable to a variety of stressors, such as disease. By recording species over time, changes in SAV can be monitored along with changes in the environment. Knowing how species are changing can guide decisions regarding management and restoration.



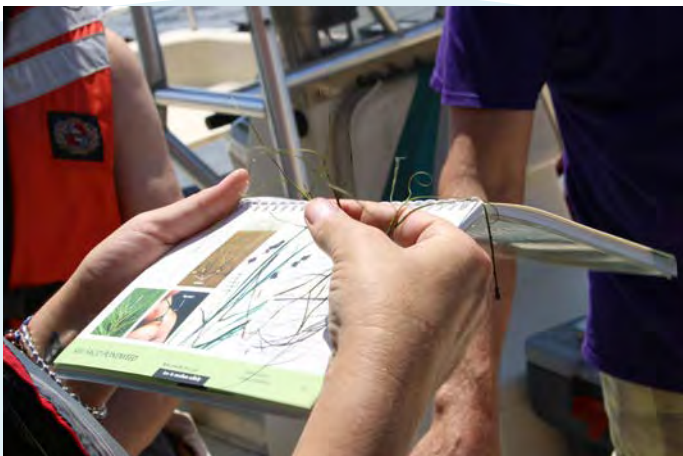
A citizen scientist uses an SAV species guidebook to identify redhead grass (*Potamogeton perfoliatus*) in the Severn River. (Sky Swanson)

Equipment:

Camera, SAV species guide or Pocket Field Guide.

Method:

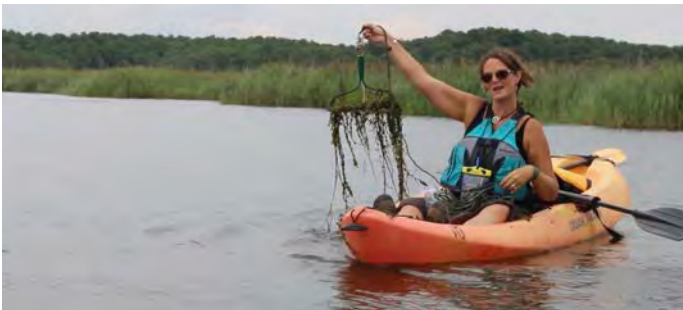
1. Collect enough SAV plants for species identification.
2. Use an SAV guide (the SAV guide in the protocol booklet, Pocket Field Guide, or the ArcGIS Survey123 app) to identify which species of SAV are present at your site. If you cannot identify the plant to the species level, identify the genus, and make sure to take a good, clear picture so that the species can be identified by professional scientists.
3. Record all of the species present at the site, listing them from most abundant to least. Use the species abbreviations provided on the data sheet to record observed species.
4. Take a photo of SAV specimens collected from the site. If flowers or seeds are observed, include them in the photo. Also make sure to include the written Site ID and image description in the photo and note the image number or a brief image description on the data sheet.



Volunteers should use a SAV species guide to identify the species of SAV present at each monitoring site. (Sky Swanson)

Pro tips:

- Pictures should be taken close up, highlighting plant characteristics for species identification. Remove SAV from the water and photograph it against a light-colored surface, such as a clipboard or piece of paper, with the leaves and stems spread out so that leaf arrangement can be distinguished. If present, include seeds, fruits, and flowers in photograph. If multiple species are observed at one site, include all species in your photo or take multiple photos.
- Some SAV genera contain multiple species that look similar (e.g. *Najas gracillima* and *Najas flexilis*, or slender and northern naiads respectively). For these species, if you are having trouble identifying an SAV specimen down to the species level, list only the genera (e.g. *Elodea* sp., *Myriophyllum* sp., *Naiad* sp., and *Potamogeton* sp.).



A throw rake can help retrieve SAV specimens. (Sky Swanson)



A magnifying glass or hand lens can help volunteers differentiate between SAV species that look similar. (Sky Swanson)

Epiphytes

Overview:

Record observations of epiphytes at the monitoring site.

Significance:

Epiphytes are small organisms, often algae, that grow on the surface of SAV leaves and stems. When nutrient concentrations are high, epiphytes can grow dense enough to coat SAV leaves, blocking the light necessary for photosynthesis. Epiphytes compete with SAV for nutrients, light, and space. They often win when nutrients are plentiful. Thus, monitoring epiphytes found in SAV meadows aids in our understanding of SAV status and environmental conditions.

Equipment:

None required.

Method:

1. Using the SAV specimens already collected, scan the leaves for epiphytes.
2. Record the presence or absence of epiphytes by checking the appropriate box on the data sheet. Volunteers should indicate that epiphytes are "Present" when more than 25% of the SAV specimen is covered in epiphytes, and "Absent" when there is less than 25% coverage.
3. (Optional) Add notes regarding color, texture, thickness, etc.



SAV covered with epiphytes (left) (Sky Swanson), compared to SAV without epiphytes. (Will Parson from Flickr)

Other macrophytes

Overview:

Record observations of drift or benthic macroalgae, *Lyngbya*, or emergent plants present at the monitoring site.

Significance:

Macroalgae are macrophytes found in fresh or salty water depending on the species. Macroalgae can be green, brown, or red. They can be found growing anchored to a hard surface, such as a log or a rock, or free-floating in dense mats should they detach. Unattached, free-floating mats of macroalgae, such as *Ulva*, continue to grow as they drift in the water column, and they easily get caught in SAV. When this happens, free-floating macroalgae can block light from reaching the underlying aquatic plants. Macroalgae is a natural part of marine and aquatic ecosystems, but they can grow quickly when large amounts of nutrients are present in the water. If macroalgae is present in abundance, it may be an indication of poor water quality.

Lyngbya is a type of cyanobacteria, or photosynthetic bacteria, that sometimes contains toxins. Under certain conditions, *Lyngbya* can overrun SAV or even block light by forming dense, floating mats on the surface of the water. *Lyngbya* can cause skin irritation for humans, adversely affect wildlife, and disrupt food-web dynamics. Sometimes it can be difficult to differentiate between mats of *Lyngbya* and mats of macroalgae.

Macroalgae and *Lyngbya*, like epiphytes, compete with SAV for nutrients, light, and space and can be an indicator of poor or changing water quality.

Emergent plants are those that are rooted under water but have leaves and stems either floating on the surface of the water, like lily pads, or extending out of the water, like reeds. Emergent plants are common along shorelines and in marshes, but some, like water chestnut

and American lotus, extend into open water and compete with SAV for space, nutrients, and light. In the Chesapeake Bay, water chestnut is an invasive species that is actively managed by state and local agencies and organizations. *Chesapeake Bay SAV Watchers* volunteers will collect data on two types of emergent plants: water chestnut and lily pads.

Please see the appendices for more images and information about other macrophytes.

Equipment:

Camera

Method:

1. Note any macroalgae or *Lyngbya* found at the site or collected during SAV monitoring.
2. If macroalgae or *Lyngbya* are present, estimate density using the four point scale:

Category 0: Absent

Category 1: < 10% coverage

Category 2: 10% to < 40% coverage

Category 3: 40% to < 70% coverage

Category 4: 70% to ≤ 100% coverage

3. Add additional notes on macroalgae identification if known.
4. Note any emergent plants found at the site or collected during SAV monitoring.
5. Record the presence or absence of emergent plants by checking the appropriate box on the data sheet. Add additional notes on emergent plant identification if known.
6. If any macrophytes are observed at the site, take a photo of the specimens. Make sure the written Site ID and image description is included in the photo and note the image number or a brief image description on the data sheet.
7. (Optional) Add notes regarding species, color, or density.

SAV flowers and seeds

Overview:

Indicate whether or not SAV flowers or seeds are present at the monitoring site.

Significance:

SAV reproduce in a number of ways, but one of the most visible is through the production of flowers, seeds, or seed pods that float on or near the surface of the water. Because identifying SAV species can be tricky by looking at the stems and leaves only, SAV flowers and seeds are one of the best ways to identify the species present.



In summer, water stargrass (left) produces yellow star-like flowers that protrude above the water surface. (Will Parson) Redhead grass produces reddish seed heads. (Sky Swanson)

Equipment:

Camera

Method:

1. Scan the stems of growing SAV or any specimens collected.
2. For each observed species, record the presence or absence of SAV flowers or seeds by checking the appropriate box on the data sheet. Add additional notes if necessary.
3. Remember to always take a photo of the flowers or seeds for documentation. Make sure the written Site ID and image description is included in the photo, and note the image number or a brief image description on the data sheet.

SAV at surface

Overview:

Indicate whether or not SAV reaches the surface of the water at the monitoring site.

Significance:

The canopy height of underwater plants is indicative of the species present and the environment in which they grow. Sunlight, nutrient availability, current speed, and water depth can all influence SAV canopy height. The height of the canopy can then, in turn, change the environment; longer leaves and a more complex canopy can slow down currents enough to trap fine particles that sink and get incorporated into the sediment. Taller, more complex SAV meadows also provide habitat for animals seeking shelter from currents and predators. Tall and dense SAV beds can also slow current speeds and water circulation, which can sometimes decrease the amount of dissolved oxygen in the water.

Equipment:

None required.

Method:

1. Scan the site to determine if any SAV has grown to the surface of the water.
2. Record the presence or absence of SAV at the surface by checking the appropriate box on the data sheet.

Pro tip:

- If you observe SAV on the surface, determine if it is attached to a substrate before recording presence or absence. Observers should mark that SAV is present at the surface when the SAV is still rooted in the sediment. Observers should mark that SAV is absent at the surface when SAV is not present or the canopy height is below the surface.

Bottom sediment

Overview:

Indicate the type of sediment found at the site.

Significance:

The bottom of the monitoring site beneath the water column is called the sediment. SAV needs sediment to anchor and stabilize itself in moving water. Different SAV species prefer different types of bottom sediment, ranging from sand to mud. Peat-dominated sediments are also present in areas of the Bay. SAV abundance is generally limited in areas with peat as sediment. In this way, sediment type can help explain why certain species of SAV are present or absent in certain areas, which in turn helps managers and scientists prioritize specific areas of the Bay for SAV restoration.

Equipment:

Paddle, pole, or other long and rigid material.

Method:

1. Position yourself comfortably and securely over the monitoring site.
2. Extend your paddle, or other material, downward and push it through the top few inches of sediment. Take note of how easily the paddle penetrates the bottom sediment.
 - a. If the paddle penetrates the sediment relatively easily, it is soft. Soft sediment in the Chesapeake Bay is likely mud or peat. See the “Pro tips” below for instructions on how to differentiate between types of soft sediment.
 - b. If penetration is slow and requires more effort, the sediment is sandy.
 - c. If you cannot push your paddle into the sediment, it is hard. Hard bottom sediments in the Chesapeake Bay will likely consist of gravel or rock.
3. Repeat these steps two more times in the monitoring site. The most common type

of sediment (mud, sand, peat, or hard) observed at the monitoring site should be the one recorded.

Pro tips:

- If you press on the bottom, and there is some resistance but the sediment does not feel hard, stir the sediment gently with your paddle. If small chunks of dark material float to the surface, the sediment is most likely peat. If the bottom is soft and your paddle penetrates easily, it is most likely mud.
- You can also use your hand to determine if the sediment is muddy, sandy, peat-based, or hard. Be careful not to cut yourself on shells or other materials that may be hidden in the sediment.



Press a paddle into the bottom sediment at a sampling site to collect data on sediment type. (Sky Swanson)



Feeling the sediment with your fingers can also help distinguish between types of sediment. (Suzi Spitzer)

Shoreline type

Overview:

Assess the environment of the nearby shoreline.

Significance:

The type of shoreline nearby can affect the type of bottom sediment, wave energy, water clarity, and amount of nutrients at a site, all of which can in turn influence the presence and growth of SAV. For example, hardened shoreline structures protect shorelines from erosion, yet they can also negatively impact SAV growth by altering wave activity. In this scenario, sediment that would otherwise develop into a habitable substrate for plants to grow gets washed away by tides and currents. The movement of sediments can also cloud the water and cause the water depth to increase, which decreases light availability at the bottom. Many of these issues are avoided at monitoring sites located in calmer environments adjacent to natural shorelines.

Equipment:

None required, binoculars optional.

Method:

1. From the monitoring site, locate the nearest shoreline. Determine whether or not the nearest shoreline is within 100 meters of the monitoring site (about the length of a football field).
2. If the nearest shoreline is more than 100 meters away from the monitoring site, indicate this on the data sheet by writing ">100 m".
3. If the nearest shoreline is within 100 meters, assess the shoreline by panning across, taking note of man-made structures, beach, rock, and vegetation.
4. Record up to three observed shoreline types within 100 meters of the center of the sampling site (sampling circle with a 200 meter diameter) using the list of options on the data sheet, and list them in order from most to least abundant.

Pro tip:

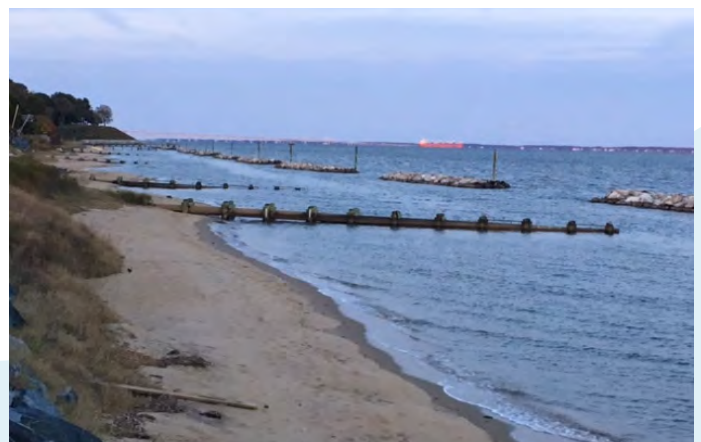
- Review the list of shoreline types (beach, marsh, forest, lawn, bulkhead, on-shore stone, near-shore stone, off-shore stone, soft structure, other) and their pictures in the appendix at the back of this manual before you head out to the field.



An on-shore stone revetment in Talbot county. (Rebecca Swerida)



An exposed sandy beach at Ferry Point Shoreline. (MD DNR)



Large off-shore stone breakwater structures paired with timber groins in Anne Arundel county. (Rebecca Swerida)

Visible shoreline erosion

Overview:

Assess ongoing or recent shoreline erosion.

Significance:

Erosion is a form of habitat degradation where the upper layer of sediment wears away. Not only can erosion have an effect on SAV meadows, but changes in SAV can also cause erosion. The complex canopy of SAV leaves and stems can slow water flow enough to prevent sediment from being washed away and allow suspended sediment particles to sink to the bottom. SAV roots help anchor bottom sediment in place, thus minimizing the risk of sediment erosion. The loss of SAV can mean the loss of bottom sediment stability. Even when SAV is present, sediments can still be washed away if the current moves quickly or forcefully enough. Only coarser sediments remain after an erosion event, and they are less suitable for plant growth and are also a sign of unstable environmental conditions.

Equipment:

None required, camera optional.

Method:

1. Scan the shoreline adjacent to your sample site. Signs of erosion include: exposed tree roots, trees leaning into the water, overhanging or collapsed banks, and steep drops between the shoreline and water surface.
2. Record the presence or absence of erosion within 100 meters of the center of your sampling site (sampling circle with a 200 meter diameter) by checking the appropriate box on the data sheet.
3. If erosion is present, add a description of the erosion in the notes.
4. (Optional) Take a picture of the observed erosion.



Bank erosion can lead to trees overhanging creeks and rivers. ([Hilary Stevens](#) from the IAN Image Library)



Collapsed banks and steep drops between the shoreline and water surface are signs of shoreline erosion. ([Will Parson](#))



An eroding marsh on Poplar Island in Talbot County. ([Alicia Pimental](#) from Flickr)

Marine debris

Overview:

Record observations of non-organic marine debris or litter present at the monitoring site.

Significance:

An occasional glass bottle or wood plank is not uncommon for near-shore Chesapeake Bay sites. However, excessive marine debris can block light, physically damage plants and animals, and introduce hazardous chemicals into the water. Excessive debris may also indicate a high level of human activity, which can influence the local environment, as a whole, in many other ways.

Equipment:

None required, camera optional

Method:

1. Scan across the monitoring site and look for any pieces of debris underwater, on the bottom sediment, floating on the surface of the water, and on nearby shorelines.
2. Record the presence or absence of debris within 100 meters of the center of the sampling site (sampling circle with a 200 meter diameter) by checking the appropriate box on the data sheet..
3. If debris is present, add notes regarding the type and abundance of debris.
4. (Optional) Take a picture of the observed debris.

Pro tip:

- Pack a trash bag with your monitoring supplies so you can collect any marine debris that you see while monitoring. Properly dispose of the debris once back on land.



Volunteers cleaning wood and trash from a marsh shoreline. (Will Parson)



Marine debris includes man-made plastic, glass, and metal containers, such as aluminum cans. (Sky Swanson)



Vehicle tires are a common form of marine debris. (Alicia Pimental from Flickr)

Other human impacts

Overview:

Indicate whether or not other human impacts are present at the monitoring site.

Significance:

SAV meadows can be affected by many forms of human impact. For example, dredging and propeller scarring can disrupt bottom sediment and cut through the roots and rhizomes of a continuous SAV meadow. These types of disturbances reduce overall SAV coverage while also fragmenting the remaining plant communities. Sediment disturbances can be an initiation point for erosion when plants are not present to hold bottom sediment intact. Other types of human impacts include sewage overflows, fish kills, oil streaks, and water discoloration due to pollution or erosion. These visible signs indicate that the ecosystem health is impaired, and could also affect the future growth of SAV, as well as the visibility of SAV for monitoring purposes.



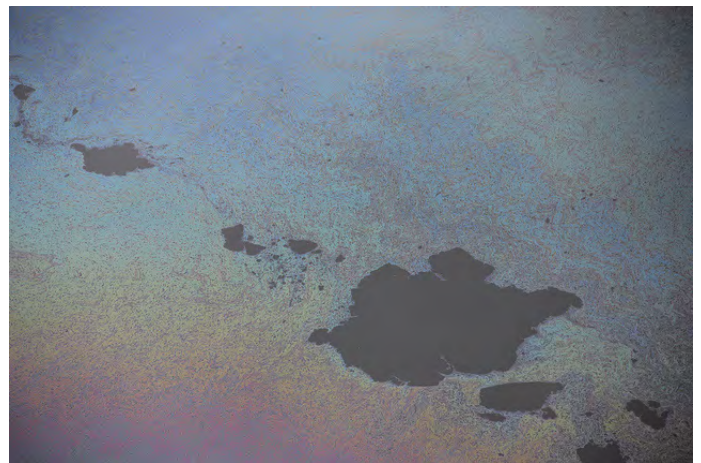
A large fish kill, caused by local pollution. (Sky Swanson)

Equipment:

None required, camera optional.

Method:

1. Position yourself in or above the water where the water surface, sediment, and nearby shoreline can be examined.
2. Scan across the monitoring site, looking for any evidence of human impact.
3. Record the presence or absence of human impact within 100 meters of the center of the sampling site (sampling circle with a 200 meter diameter) by checking the appropriate box on the data sheet.
4. If impact is present, add notes regarding the type and severity.
5. (Optional) Take a picture of the observed human impact.



An oil slick covers the surface of the water in Anne Arundel County. ([Steve Droter](#) from Flickr)

SAV SPECIES GUIDE

Complete species list

Species Code	Common name (Scientific name)	Page
Cd	Hornwort, aka Coontail (<i>Ceratophyllum demersum</i>)	38
Cal	Water starwort (<i>Callitriche</i> sp.)	39
Egd	Brazilian waterweed (<i>Egeria densa</i>)	40
Ex	Unknown waterweed (<i>Elodea</i> sp.)	
Ec	Common waterweed (<i>Elodea canadensis</i>)	41
En	Western waterweed (<i>Elodea nuttallii</i>)	42
Hd	Water stargrass (<i>Heteranthera dubia</i>)	43
Hv	Hydrilla (<i>Hydrilla verticillata</i>)	44
Mx	Unknown milfoil (<i>Myriophyllum</i> sp.)	
Mh	Low watermilfoil (<i>Myriophyllum humile</i>)	45
Ma	Parrot feather milfoil (<i>Myriophyllum brasiliense/aquaticum</i>)	46
Ms	Eurasian watermilfoil (<i>Myriophyllum spicatum</i>)	47
Nx	Unknown naiad (<i>Najas</i> sp.)	
Nfl	Northern naiad (<i>Najas flexilis</i>)	48
Ngr	Slender naiad (<i>Najas gracillima</i>)	49
Ngd	Southern naiad (<i>Najas guadalupensis</i>)	50
Nm	Spiny naiad (<i>Najas minor</i>)	51
Px	Unknown pondweed (<i>Potamogeton</i> sp.)	
Pc	Curly pondweed (<i>Potamogeton crispus</i>)	52
Pe	Leafy pondweed (<i>Potamogeton epihydrus</i>)	53
Pi	Illinois pondweed (<i>Potamogeton illinoensis</i>)	54
Pn	American pondweed (<i>Potamogeton nodosus</i>)	55
Ppf	Redhead grass (<i>Potamogeton perfoliatus</i>)	56
Ppu	Slender pondweed (<i>Potamogeton pusillus</i>)	57
Rm	Widgeongrass (<i>Ruppia maritima</i>)	58
Sp	Sago pondweed (<i>Stuckenia pectinata</i>)	59
Ut	Bladderwort (<i>Utricularia</i>)	60
Va	Wild celery (<i>Vallisneria americana</i>)	61
Zm	Eelgrass (<i>Zostera marina</i>)	62
Zp	Horned pondweed (<i>Zannichellia palustris</i>)	63
U	Unknown species	

Hornwort/Coontail

Ceratophyllum demersum — Cd

Classification:

Neither monocot nor eudicot

Order:

Ceratophyllales

Family:

Ceratophyllaceae

Salinity Range:

Oligohaline

Best Time to Survey:

August/September

Location:

Found in freshwater tributaries of the Chesapeake Bay

General characteristics:

Though it lacks true roots, hornwort may be observed attached to the sediment by a holdfast-type structure or floating freely below the water surface. Stems grow up to 3 m long. Brittle, stiff leaves grow in whorls of 9 or 10. Whorls are denser toward the end of the stem. Leaves fork into linear, flat segments. Fine teeth grow on one side of the leaf margin.

May be confused with:

Eurasian watermilfoil, but Eurasian watermilfoil has pinnate leaves and roots.

Fun facts:

- Recent genetic evidence shows that Ceratophyllales belongs to neither the monocots nor the eudicots; instead, it is a "sister group" to the eudicots
- Most often found in slow-moving waters
- Found in all 50 states



Water starwort

Callitriche sp. — Cal

Classification:

Eudicot

Order:

Lamiales

Family:

Plantaginaceae

Salinity Range:

Oligohaline

Best Time to Survey:

August/September

Location:

Found in fresh waters throughout the Chesapeake Bay

General characteristics:

Egg-shaped leaves are bright green and grow about 2 cm long and up to 8 mm wide, and may be observed at or just above the surface growing in rosettes that resemble small green flowers. Below the surface, each joint of the stem has two leaves that grow opposite one another.

May be confused with:

Common waterweed, but common waterweed leaves grow in whorls of 3.

Fun facts:

- Four species, including *C. stagnalis* and *C. heterophylla*, grow in the Chesapeake Bay
- Food source for ducks
- Provides habitat for insects



Brazilian waterweed

Egeria densa — Egd

Classification:

Monocot

Order:

Alismatales

Family:

Hydrocharitaceae

Salinity Range:

Oligohaline

Best Time to Survey:

August/September

Location:

Not common in the Chesapeake Bay; may be found in fresh waters

General characteristics:

Forms thick mats at the surface of the water. Stems are highly branched. Leaves form in whorls of 4 to 8, and are densest near the top of the stem. Leaves are dark or bright green, serrated, long, and narrow (up to 2.5 cm long and 0.75 cm wide). Small white flowers form in the spring and fall.

May be confused with:

Hydrilla, common waterweed

Fun facts:

- South American species
- Introduced to US waters by aquarium owners emptying their aquaria in rivers and ponds
- Commonly referred to as *Anacharis* in the aquarium trade



Common waterweed

Elodea canadensis — Ec

Classification:

Monocot

Order:

Alismatales

Family:

Hydrocharitaceae

Salinity Range:

Oligohaline

Best Time to Survey:

August/September

Location:

Found in the upper freshwater reaches of Bay tributaries, occasionally in saltier waters where freshwater springs are found.

General characteristics:

Oval leaves grow directly on thin, branched stems (no leaf stalks). Leaves grow in whorls, with 3 per node. Tips of leaves are blunt and margins have very fine teeth that are only visible using a hand lens. Leaves are densest toward stem tip.

May be confused with:

Hydrilla, but *Hydrilla* has visibly toothed leaf margins. Water starwort, but water starwort has paired leaves. Other waterweeds.

Fun facts:

- Food source for beavers, muskrats, and ducks
- Can grow in deep or shallow waters
- Habitat for invertebrates, small fishes, and amphibians



Western waterweed

Elodea nuttallii — En

Classification:

Monocot

Order:

Alismatales

Family:

Hydrocharitaceae

Salinity Range:

Oligohaline

Best Time to Survey:

August/September

Location:

Found in fresh waters and upper reaches of Bay tributaries

General characteristics:

Long, slender, branched stems grow up to 1 meter long. Whorled leaves (in 3s or 4s) are evenly spaced along stem. Leaves are short (up to 16 mm, narrow (up to 1.5 mm, and pale green. Flowers are white.

May be confused with:

Hydrilla, other waterweeds

Fun facts:

- Native to North America
- Invasive in Europe and Asia



Water stargrass

Heteranthera dubia — Hd

Classification:

Monocot

Order:

Commelinales

Family:

Pontederiaceae

Salinity Range:

Oligohaline

Best Time to Survey:

August/September

Location:

Found in freshwater Bay tributaries

General characteristics:

Tall, somewhat bushy plant with grass-like leaves that grow on branching stems. The bottom of each leaf wraps around the stem like a sheath. Leaves are arranged alternately. Yellow, 6-petaled flowers may grow above water in the summer.

May be confused with:

Naiads

Fun facts:

- Flowers only open above the surface of the water
- There is also a terrestrial form of this species



Hydrilla

Hydrilla verticillata — Hv

Classification:

Monocot

Order:

Alismatales

Family:

Hydrocharitaceae

Salinity Range:

Oligohaline

Best Time to Survey:

August/September

Location:

Fresh and mildly brackish waters of the Bay, in areas with muddy substrate

General characteristics:

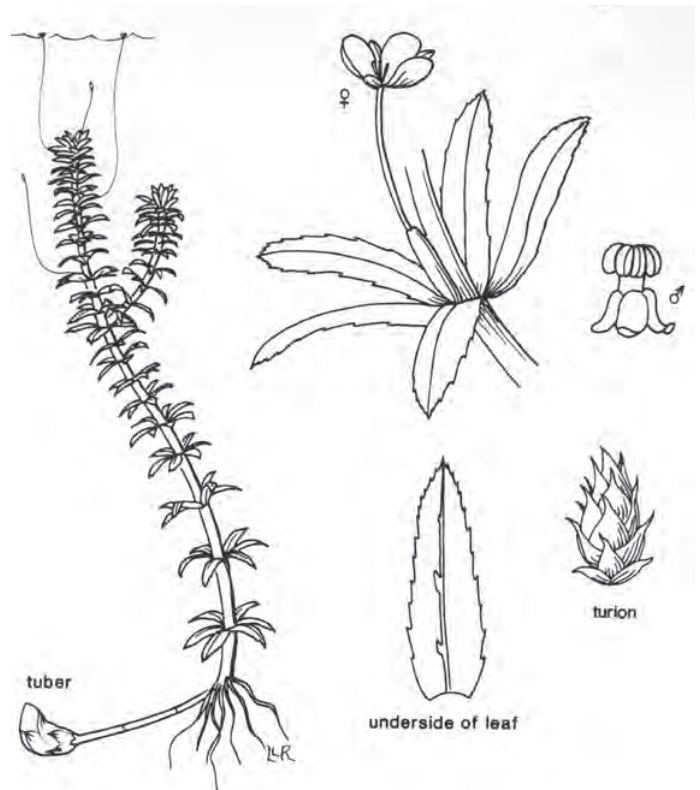
Stems are long and branching. Leaves grow in whorls of 3-5, but most frequently 5, and can be straight, lance-shaped, or very small. Leaves are linear and serrated. Flowers are white and very small.

May be confused with:

Waterweeds, but can be differentiated from waterweeds by the visibly serrated leaves.

Fun facts:

- Non-native to the Chesapeake Bay
- Can live in lower light conditions than other SAV species
- Habitat for fish and food source for migratory birds



Low watermilfoil

Myriophyllum humile — Mh

Classification:

Eudicot

Order:

Saxifragales

Family:

Haloragaceae

Salinity Range:

Oligohaline

Best Time to Survey:

August/September

Location:

Not common in the Chesapeake Bay; may be found in freshwater coastal ponds, lakes, and reservoirs along the shoreline

General characteristics:

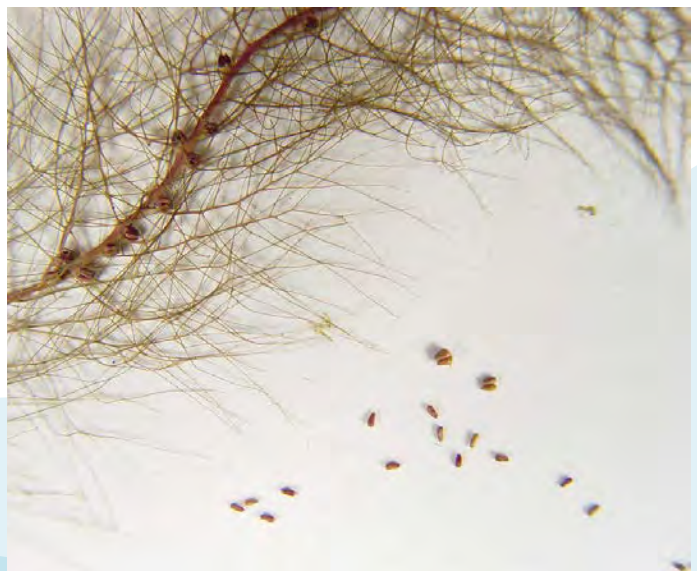
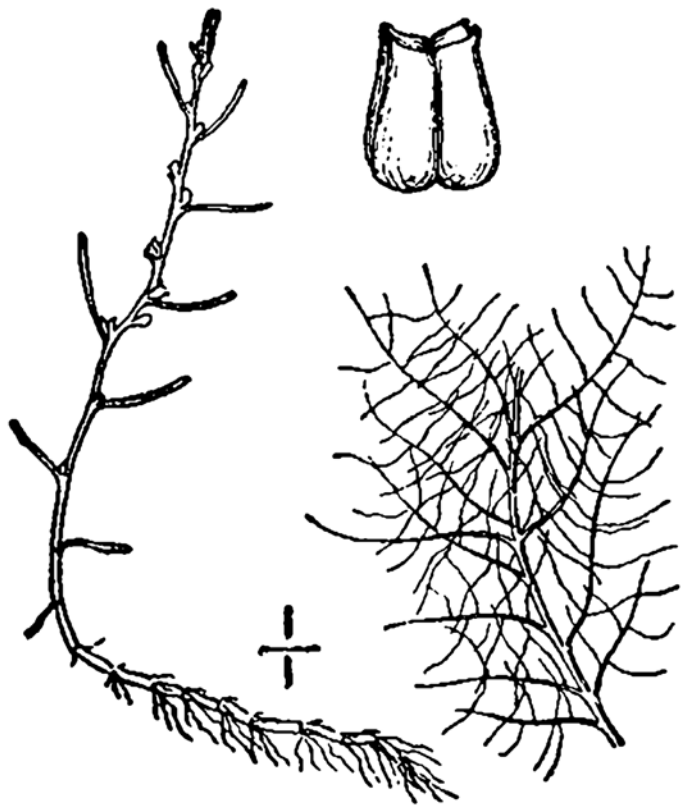
Morphology is extremely variable depending on water level. Leaves are very fine and grow sub-oppositely or scattered along stems. Each leaf has up to 20 hair-like segments (up to 10 per side) that make this plant appear fuzzy.

May be confused with:

Eurasian watermilfoil

Fun facts:

- Rare in the Chesapeake Bay



Parrot feather milfoil

Myriophyllum brasiliense (or *aquaticum*) — Ma

Classification:

Eudicot

Order:

Saxifragales

Family:

Haloragaceae

Salinity Range:

Oligohaline

Best Time to Survey:

August/September

Location:

Found in fresh waters of the Chesapeake Bay

General characteristics:

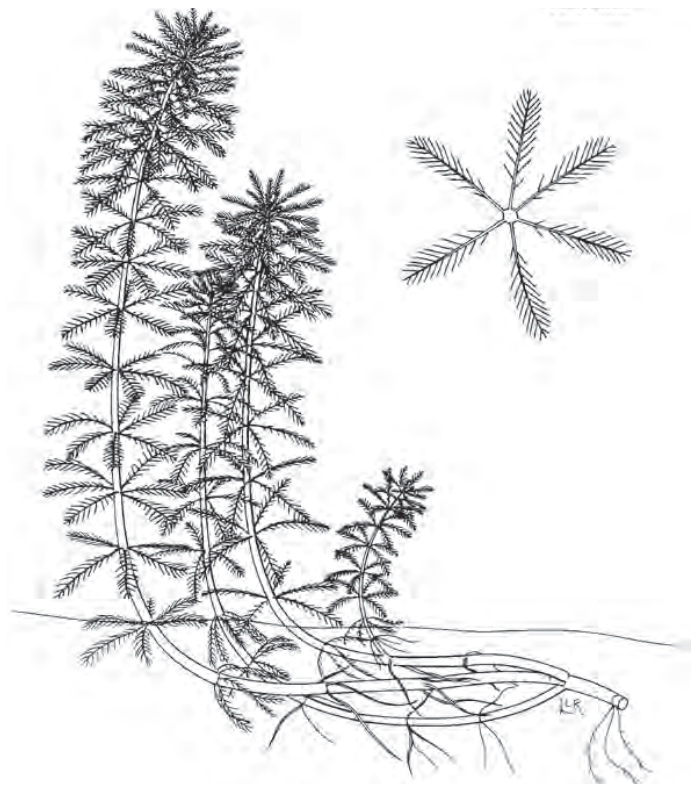
Stems are stout; pinnate leaves grow in whorls of 5. Each side of the leaf has up to 25 protrusions. May be observed growing along the shoreline submerged and exposed. Maintains structure out of the water and can survive growing terrestrially along shoreline.

May be confused with:

Eurasian watermilfoil, but Eurasian watermilfoil has whorls of 4 leaves. Hornwort, which has leaves in whorls of 9-10.

Fun facts:

- Native to the Amazon
- Brought to the U.S. as an aquarium plant



Eurasian watermilfoil

Myriophyllum spicatum — Ms

Classification:

Eudicot

Order:

Saxifragales

Family:

Haloragaceae

Salinity Range:

Oligohaline

Best Time to Survey:

August/September

Location:

Widely distributed in fresh and mildly brackish waters of the Bay and its tributaries

General characteristics:

Delicate leaves resemble feathers and grow in whorls of 4 (usually or 5). Leaves are pinnate and lose their shape when removed from the water. In the summer, reddish flowers grow in spikes above the water.

May be confused with:

Parrot feather milfoil, but parrot feather milfoil has whorls of 4 leaves. Hornwort, which has whorls of 9-10 leaves.

Fun facts:

- An introduced species in the Chesapeake Bay
- Provides habitat for insects and aquatic species



Northern naiad

Najas flexilis — Nfl

Classification:

Monocot

Order:

Alismatales

Family:

Hydrocharitaceae

Salinity Range:

Oligohaline

Best Time to Survey:

August/September

Location:

Rivers and fresh Bay waters, in areas with sandy substrate

General characteristics:

Narrow leaves are slightly broader at the base and grow up to 6 mm long. Leaves are opposite or in whorls, and curve out from the stem. Stem is slender and branching.

May be confused with:

Slender, southern, and spiny naiads; they are difficult to distinguish from one another without a hand lens

Fun facts:

- Also called “nodding waternymph”
- Sensitive to pollution
- Food source for water birds



Slender naiad

Najas gracillima — Ngr

Classification:

Monocot

Order:

Alismatales

Family:

Hydrocharitaceae

Salinity Range:

Oligohaline

Best Time to Survey:

August/September

Location:

Rivers and fresh Bay waters, in areas with sandy substrate

General characteristics:

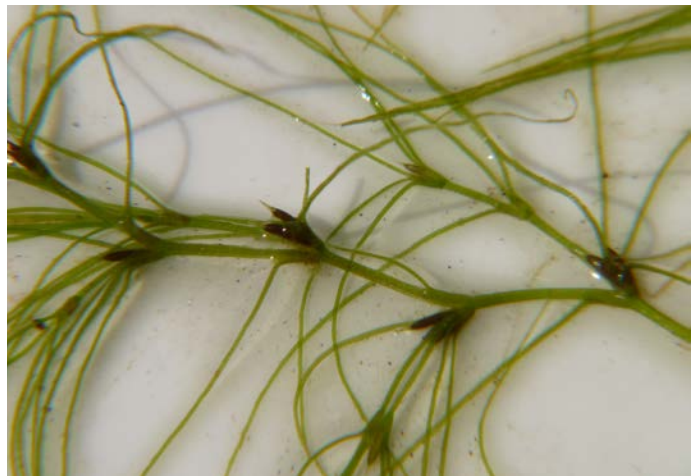
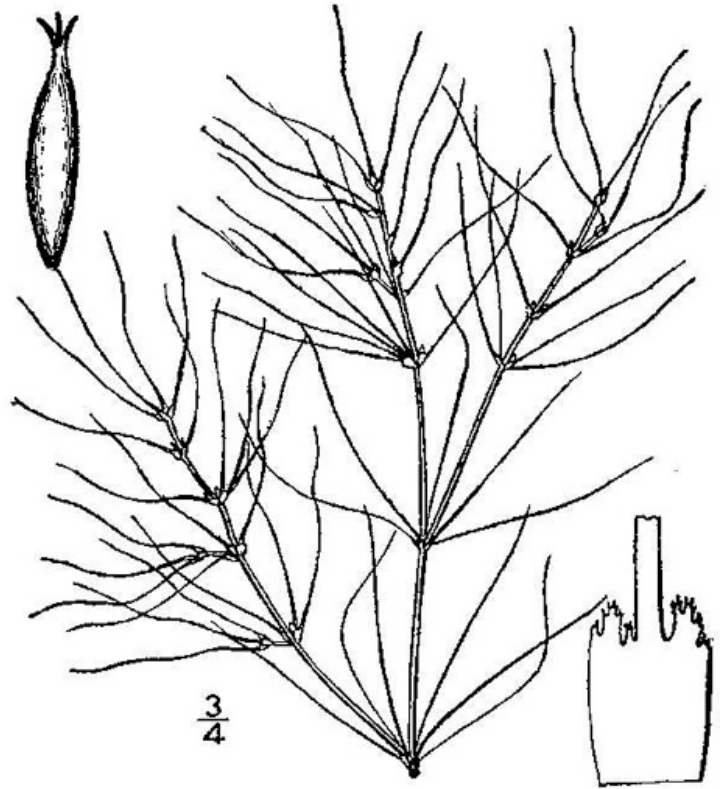
Leaves are narrower than in southern and northern naiads. Tiny teeth are very difficult to see on the leaf edges. Leaves are opposite or whorled and grow up to 28 mm in length. Leaves grow more densely near the top of the slender, branching stem.

May be confused with:

Northern, southern, and spiny naiads; they are difficult to distinguish from one another without a hand lens

Fun facts:

- Also called “thread-like waternymph”



Southern naiad

Najas guadalupensis — Ngd

Classification:

Monocot

Order:

Alismatales

Family:

Hydrocharitaceae

Salinity Range:

Oligohaline

Best Time to Survey:

August/September

Location:

Rivers and fresh Bay waters, in areas with sandy substrate

General characteristics:

Narrow, flat, straight leaves grow up to 33 mm long. Leaves are opposite or in whorls on slender, branching stems

May be confused with:

Northern, slender, and spiny naiads; they are difficult to distinguish from one another without a hand lens

Fun facts:

- Found across the Americas, and considered a weed in some areas
- Food source for water birds and fish
- Also called "bushy pondweed"



Spiny naiad

Najas minor — Nm

Classification:

Monocot

Order:

Alismatales

Family:

Hydrocharitaceae

Salinity Range:

Oligohaline

Best Time to Survey:

August/September

Location:

Rivers and fresh Bay waters, in areas with sandy substrate

General characteristics:

Leaves narrower than in southern and northern naiads. Tiny teeth on leaf edges are visible to the naked eye. Stiff, recurved leaves grow opposite or whorled on slender, branching stems.

May be confused with:

Northern, slender, and southern naiads; they are difficult to distinguish from one another without a hand lens

Fun facts:

- Also called "brittle waternymph"
- Introduced species from Europe



Curly pondweed

Potamogeton crispus — Pc

Classification:

Monocot

Order:

Alismatales

Family:

Potamogetonaceae

Salinity Range:

Oligohaline

Best Time to Survey:

August/September

Location:

Found in fresh and slightly brackish waters of the Bay

General characteristics:

Stems are round and branching, with alternate leaves that may grow opposite near water surface. Leaves are wavy with distinct mid-vein and may appear reddish-brown as summer progresses.

May be confused with:

Redhead grass; other pondweeds

Fun facts:

- Introduced to the Chesapeake Bay from Europe in the 1800's
- Leaves appear crimped



Leafy pondweed

Potamogeton epihydrus — Pe

Classification:

Monocot

Order:

Alismatales

Family:

Potamogetonaceae

Salinity Range:

Oligohaline

Best Time to Survey:

August/September

Location:

Found in slow moving, freshwater less than 2 m deep; not common in Chesapeake Bay

General characteristics:

Has both floating and submerged leaves. Leaves are bright green with a light-colored stripe down the center. Floating leaves are paddle-like. Stems are flat and grow up to 18 cm long. Flowers are small and brownish green.

May be confused with:

Other pondweeds

Fun facts:

- Eaten by waterfowl
- Provides habitat for aquatic animals



Illinois pondweed

Potamogeton illinoensis — Pi

Classification:

Monocot

Order:

Alismatales

Family:

Potamogetonaceae

Salinity Range:

Oligohaline

Best Time to Survey:

August/September

Location:

Rare in the Chesapeake Bay, may be found in freshwater areas

General characteristics:

Long stems support ellipse-shaped leaves. Leaves grow submerged and floating. Submerged leaves are longer than floating ones, and have pointed tips. Floating leaves are paddle-like. Stems are long, cylindrical, slim, and branching. Small green flowers grow on spikes.

May be confused with:

Other pondweeds

Fun facts:

- Also called "shining pondweed"



American pondweed

Potamogeton nodosus — Pn

Classification:

Monocot

Order:

Alismatales

Family:

Potamogetonaceae

Salinity Range:

Oligohaline

Best Time to Survey:

August/September

Location:

Rivers, ponds, tidal fresh and brackish waters of the Chesapeake Bay

General characteristics:

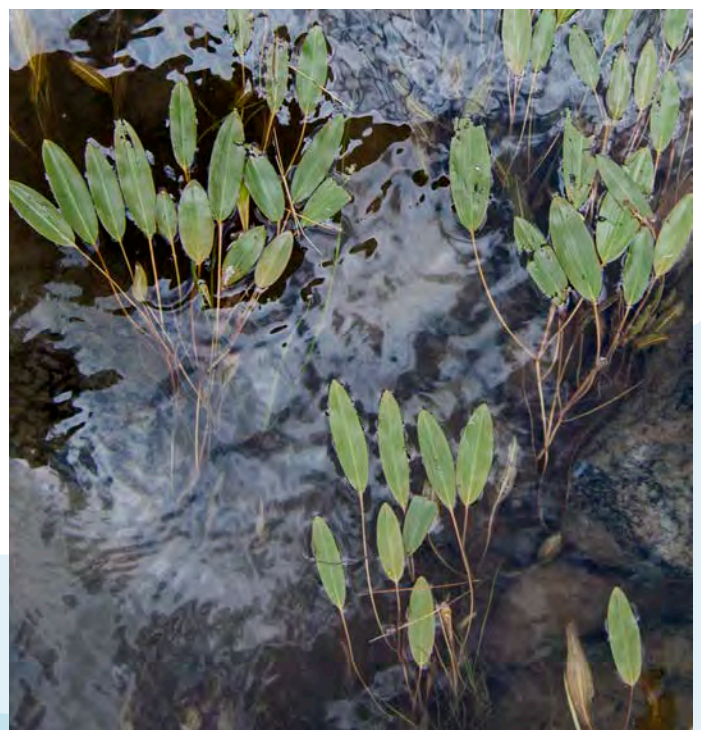
Floating leaves may appear dense at the surface. Stems can be up to 2 m long. Floating leaves are oval and are 10-18 cm long and up to 5 cm across. Underwater leaves are sparse, and are smaller and blade-like. Flower stalks grow above water.

May be confused with:

Other pondweeds

Fun facts:

- Also called "longleaf pondweed"
- Food source and shelter for turtles, fishes, ducks, and invertebrates
- Has submerged and floating leaves



Redhead grass

Potamogeton perfoliatus — Ppf

Classification:

Monocot

Order:

Alismatales

Family:

Potamogetonaceae

Salinity Range:

Oligohaline & (usually) Mesohaline

Best Time to Survey:

July - September

Location:

Brackish waters with muddy substrate and slow currents

General characteristics:

Flat, oval leaves have several highly visible veins and are arranged alternately along the stem, occasionally opposite near the surface. Leaf bases attach directly to and wrap around the stem. Leaves are up to 7 cm long and 4 cm across, and have curled edges. Stems may be whitish or reddish, and branch near the top.

May be confused with:

Young individuals look similar to curly pondweed.

Fun facts:

- An important food source for various other waterfowl
- Named for the redhead ducks that consume it



Slender pondweed

Potamogeton pusillus — Ppu

Classification:

Monocot

Order:

Alismatales

Family:

Potamogetonaceae

Salinity Range:

Oligohaline

Best Time to Survey:

August/September

Location:

Upper and middle Bay and fresh to slightly brackish tributaries

General characteristics:

Long, thin, grass-like leaves have pointed tips and may be purplish in color. Leaves are arranged alternately and have prominent mid-veins. Stems are slender and branching. Flowers grow in whorls on spikes.

May be confused with:

Sago pondweed, horned pondweed, and widgeongrass

Fun facts:

- Also called "small pondweed"
- Eaten by waterfowl



Widgeongrass

Ruppia maritima — Rm

Classification:

Monocot

Order:

Alismatales

Family:

Ruppiaceae

Salinity Range:

Mesohaline and Polyhaline, widely distributed in Bay

Best Time to Survey:

June/July

Location:

Middle to lower Bay throughout brackish and salty tributaries and mainstem

General characteristics:

Long, narrow, threadlike leaves grow alternately on narrow stems. A sheath grows at the base of each leaf. Leaves grow up to 10 cm long and 0.5 mm wide. During the mid to late summer, flower stalks grow and branch upwards with distinct flowers and drupelets.

May be confused with:

Horned and sago pondweed (when not flowering)

Fun facts:

- May be found growing with eelgrass
- Important food source for ducks, geese, and other waterfowl



Sago pondweed

Stuckenia pectinata — Sp

Classification:

Monocot

Order:

Alismatales

Family:

Potamogetonaceae

Salinity Range:

Mesohaline

Best Time to Survey:

July/August

Location:

Fresh to brackish waters throughout the Chesapeake Bay

General characteristics:

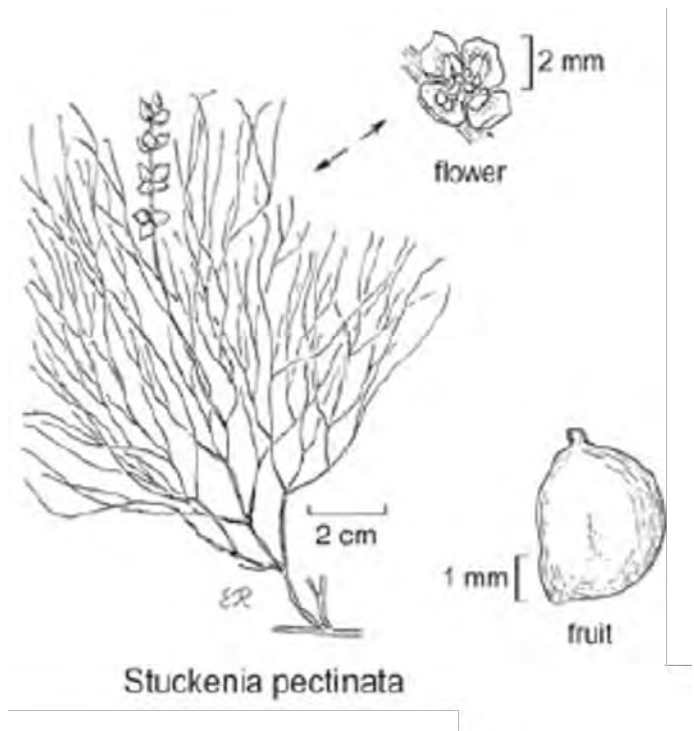
Stems are slender and branching. Leaves are arranged alternately, and are long, threadlike, and tapered to a point. The basal sheath may be pointed. Stems and leaves may appear fan-like. Seed clusters may appear above the water surface and resemble grape clusters.

May be confused with:

Horned pondweed, which has opposite or whorled leaves. Widgeongrass, which does not have clustered leaves.

Fun facts:

- This species was formerly classified as *Potamogeton pectinatus*
- Inhabits the Americas, Europe, Africa, and Asia
- Easiest to differentiate from widgeongrass when seeds are present



Bladderwort

Utricularia sp. — Ut

Classification:

Eudicot

Order:

Lamiales

Family:

Lentibulariaceae

Salinity Range:

Oligohaline

Best Time to Survey:

August/September

Location:

Found in freshwater ponds and ditches

General characteristics:

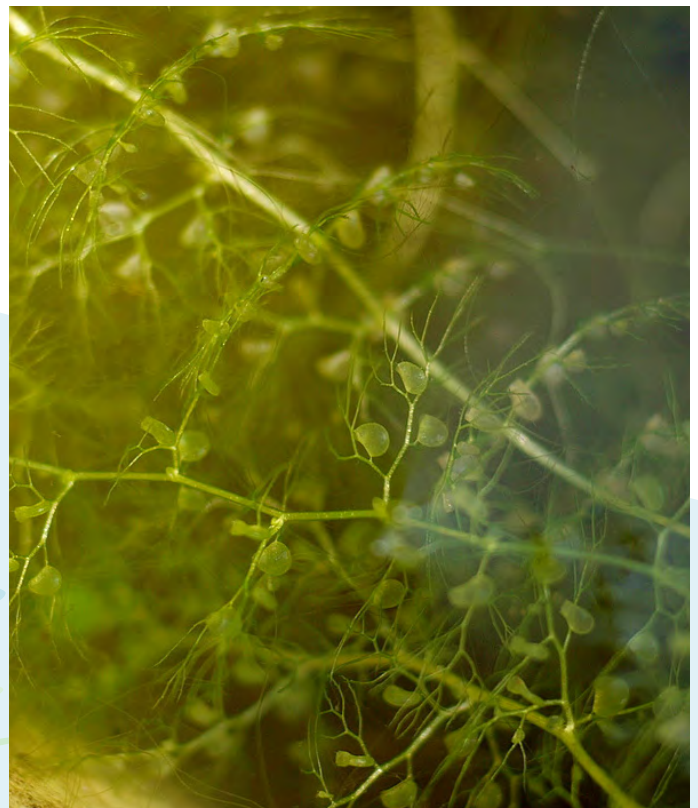
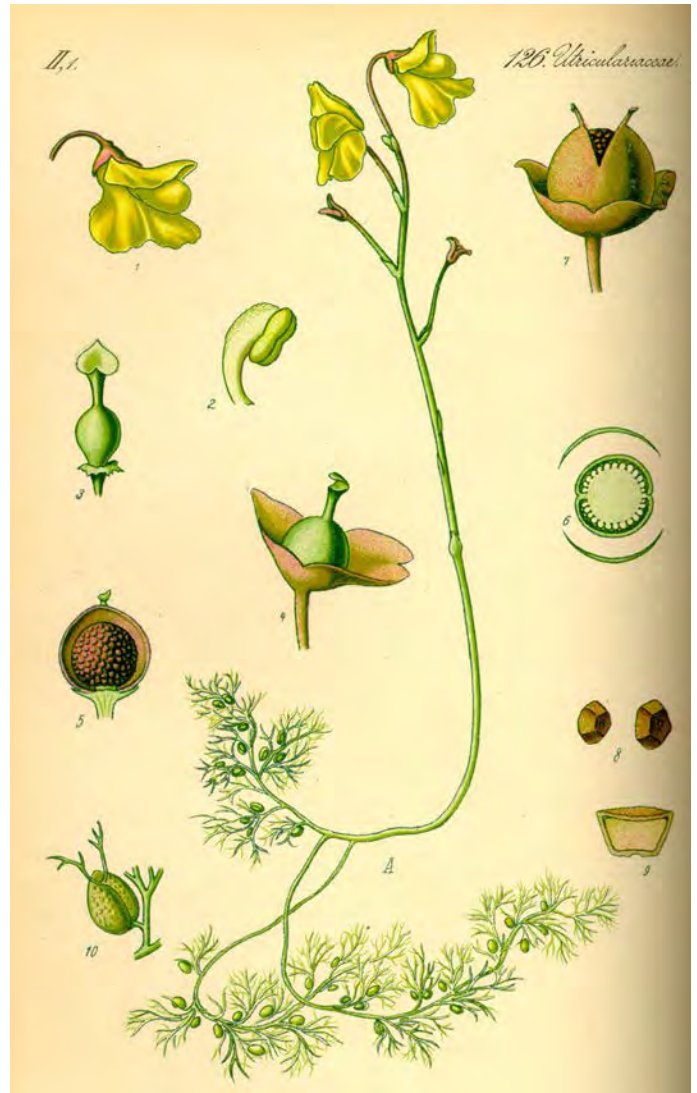
Typically found floating, with stems and leaves submerged. Stems are branching and grow horizontally. Leaves are alternate, stem-like, linear, and may grow oppositely or whorled. Bladders grow on stems and leaves. True roots are absent. Flowers grow on leafless stems when present.

May be confused with:

Not applicable

Fun facts:

- Several species live in the Chesapeake Bay
- Are carnivorous; trap and digest organisms in bladders
- Free-floating and rootless
- Also called "ditch grass"



Wild celery

Vallisneria americana — Va

Classification:

Monocot

Order:

Alismatales

Family:

Hydrocharitaceae

Salinity Range:

Oligohaline

Best Time to Survey:

August/September

Location:

Fresh to slightly brackish tidal waters of the Bay

General characteristics:

Ribbon-like leaves grow in clusters from the base of the plant. Leaves are long and flat with blunt, rounded tips and a light green mid-vein. They grow up to 1.5 m long and 1 cm wide.

May be confused with:

Eelgrass, but eelgrass has narrower leaves and grows in the polyhaline portion of the Bay, so the two would not be co-located.

Fun facts:

- Provides food for migratory and overwintering birds



Eelgrass

Zostera marina — Zm

Classification:

Monocot

Order:

Alismatales

Family:

Zosteraceae

Salinity Range:

Polyhaline

Best Time to Survey:

May

Location:

Saltier waters of the Bay

General characteristics:

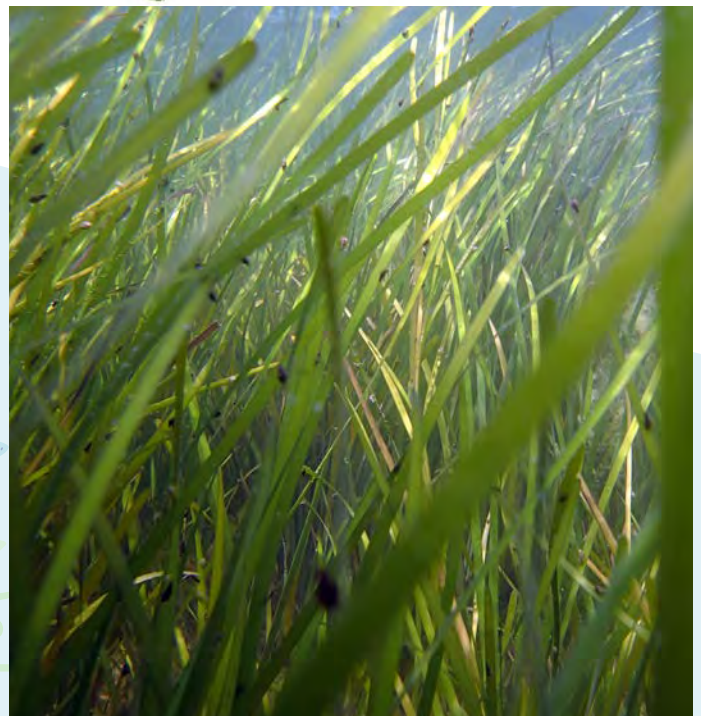
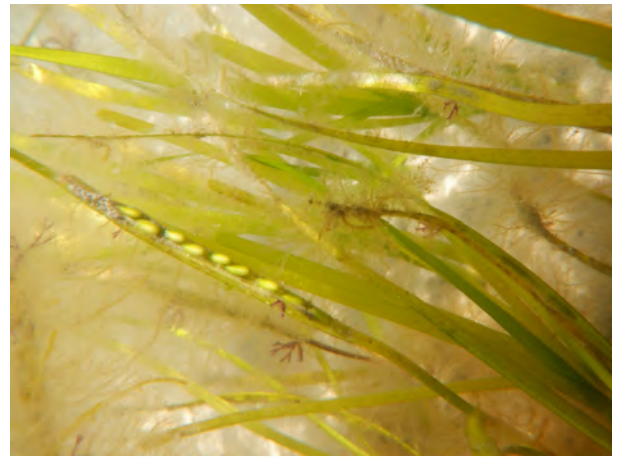
Eelgrass shoots typically consist of 3-5 strap-like leaves enclosed in a basal leaf sheath. Leaves can grow to be 4 feet long, but vary in size depending on the plant's location. Eelgrass has thick, creeping rhizomes with many roots and nodes.

May be confused with:

Wild celery, but wild celery has broader leaves and grows in the tidal fresh and oligohaline areas of the Bay, so the two would not be co-located.

Fun facts:

- Eelgrass beds provide refuge for many species including seahorses, pipefishes, juvenile fishes, blue crabs, and scallops
- May also be referred to as "seagrass"
- It prefers cold water



Horned pondweed

Zannichellia palustris — Zp

Classification:

Monocot

Order:

Alismatales

Family:

Potamogetonaceae

Salinity Range:

All zones

Best Time to Survey:

April/May

Location:

Widely distributed in the Bay, most abundant in the Mesohaline mid-Bay

General characteristics:

Stems are slender and branching. Long, linear, threadlike leaves are arranged oppositely or in whorls. Leaf tips are pointed and the basal sheath of the leaves is thin. This plant can be distinguished by its horn-like seeds that appear in pairs or sometimes in a set of 4.

May be confused with:

Sago pondweed; but sago pondweed has clustered leaves. Widgeongrass; but widgeongrass has alternate leaves.

Fun facts:

- Multiple variations of this species exist; several are shown on this page
- Two forms occur in the Bay: one grows upwards, the other grows along the bottom with stems and roots together
- It dies back and drops seeds in June. Its early seasonality and northern range exclude it from VIMS aerial surveys



APPENDICES

Leaf arrangement terminology

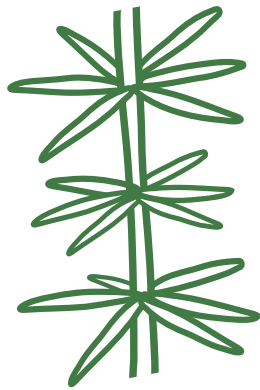
These four diagrams introduce you to terminology that is used throughout the SAV species guide to denote leaf arrangement. *Note: Do not determine leaf arrangement based on where the stem divides, as this will likely reflect an atypical arrangement from the majority of the plant.*

Basal



Ex: Val and Zostera

Whorled



Ex: Coontail, Hydrilla, Milfoil

Alternate



Ex: Potamogetons

Opposite



Ex: Naiads

Harmful algal blooms

What are they?

Certain algae species can produce toxins dangerous to humans and aquatic species. When these species reproduce very quickly, or “bloom,” they can form a harmful algal bloom, or “HAB”. HABs may be red, green, or brown in color, and may be made up of rhodophytes (red algae) or chlorophytes (green algae).

Are HABs harmful to SAV?

HABs can block sunlight from reaching SAV species by shading them and reducing water clarity. They can also reduce the amount of oxygen present in water, harming both SAV and the species it supports.

How do I identify HABs?

It is difficult to distinguish a HAB from a non-harmful one, so it is best not to sample in areas with an algal bloom. A HAB may be present if you see floating scum, dots, clumps, stripes, or thick mats on the surface of the water. The water may appear green, blue, red, yellow, or brown.



Warning

Harmful Algal Blooms, or HABs, may produce toxins harmful to human and animal health. If you suspect a HAB, do not sample. Please report suspicious algal blooms to the Chesapeake Bay Safety and Environmental Hotline at (877) 224-7229.

Guide to other macrophytes

Emergent plants

Emergent plants are rooted under water, but have leaves and stems that extend out of or float on top of the water.

Water chestnut (*Trapa natans*)

Where is it found?

Upper Chesapeake Bay tributaries and Potomac

What is it?

Water chestnut is an invasive floating aquatic plant that is actively managed in the Chesapeake Bay. Triangle-shaped leaves form rosettes that float on the surface of the water. The plant itself is bulky but the flowers are small and white.

Is it harmful to SAV?

Water chestnut can block sunlight from reaching SAV, and competes with SAV for space. If you see water chestnut while sampling SAV, alert MD DNR at (410) 260-8634

Lily pads

There are three genera in the Chesapeake Bay: *Nuphar*, *Nymphoides*, and *Nelumbo*

Where is it found?

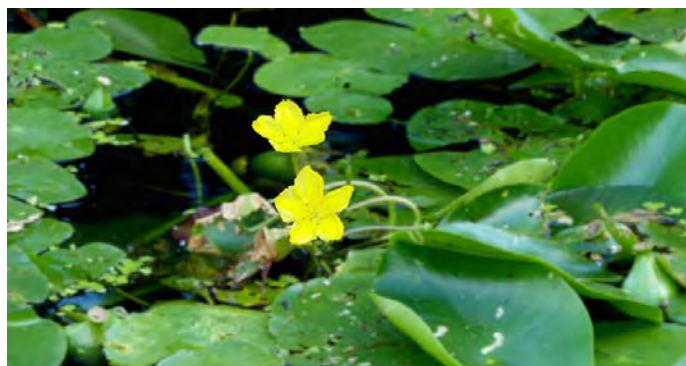
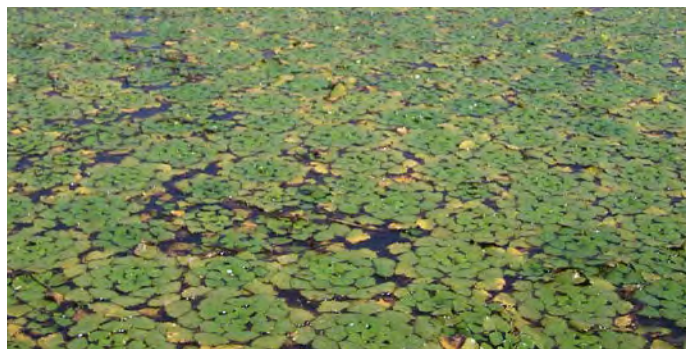
Fresh waters in the Chesapeake Bay watershed

What is it?

Lily pads are native to the Chesapeake Bay. They have large round leaves that float on the water surface.

Is it harmful to SAV?

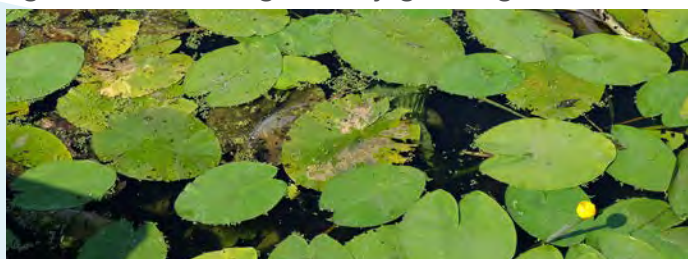
Lily pads, including American lotus, compete with SAV for space and nutrients, and block light from reaching SAV by growing above it.



Nymphoides



N. lutea (American lotus)



Nuphar

Macroalgae

Green freshwater algae

What species are commonly found in the Bay?

Chara vulgaris (muskgrass)

Nitella flexilis (stonewort)

What is it?

Green freshwater algae can resemble vascular plants and may be mistaken for SAV. These species have what appear to be stems and leaves, with whorls of what appear to be branches. They may attach to the substrate, but do not have roots. *Chara* and *Nitella* may be distinguished from one another based on their branches; those on *Chara* have ridges, while those on *Nitella* are smooth.



Chara



Nitella

Green saltwater algae

What species are commonly found in the Bay?

Ulva lactuca (sea lettuce)

Enteromorpha (turf green seaweed)

What is it?

Green saltwater algae are usually bright green in color. Sea lettuce resembles green sheets of cellophane. Turf green seaweed is similar to sea lettuce, but grows in a tubular morphology. Both may be found attached to the substrate by holdfasts, but are more often observed in mats or clumps rolling around with the tide. Though it is a normal part of the ecosystem, excess nutrients in the water column often lead to blooms of green saltwater algae.



Ulva lactuca



Enteromorpha

Red saltwater algae

What species are commonly found in the Bay?

Agardhiella sp.

Gracilaria sp.

What is it?

Appears red and highly branched, resembling some SAV species. Distinguishable from SAV by color and lack of roots.



Agardhiella



Gracilaria

Brown saltwater algae

What species are commonly found in the Bay?

Ascophyllum nodosum (knotted wrack)

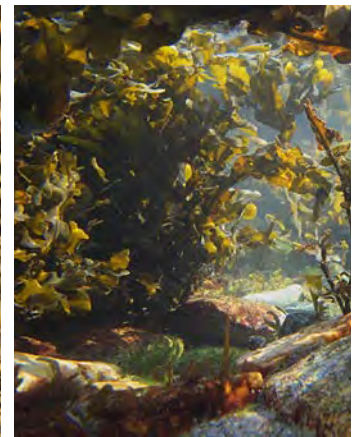
Fucus sp. (bladder wrack)

What is it?

Characterized by long, branching fronds with air bladders. *Ascophyllum* fronds have rounded tips.



Ascophyllum



Fucus

Lyngbya

What is it?

Lyngbya is a genus of freshwater cyanobacteria that grows in strands that clump together and form mats. During the summer, some species of *Lyngbya* have been found in the northern Chesapeake Bay covering SAV beds and caught in fishing gear. *Lyngbya* occurs naturally, but under certain conditions may “bloom”.

Is *Lyngbya* harmful to SAV?

Lyngbya may overgrow SAV beds, blocking sunlight and inhibiting photosynthesis. *Lyngbya* also competes with SAV for nutrients.

Warning

Lyngbya can be harmful to human and animal health, as associated toxins may cause skin and gastrointestinal inflammation. Avoid direct contact with *Lyngbya* and wash your skin with soap if contact occurs.



Affiliated species

Epiphytes

What are they?

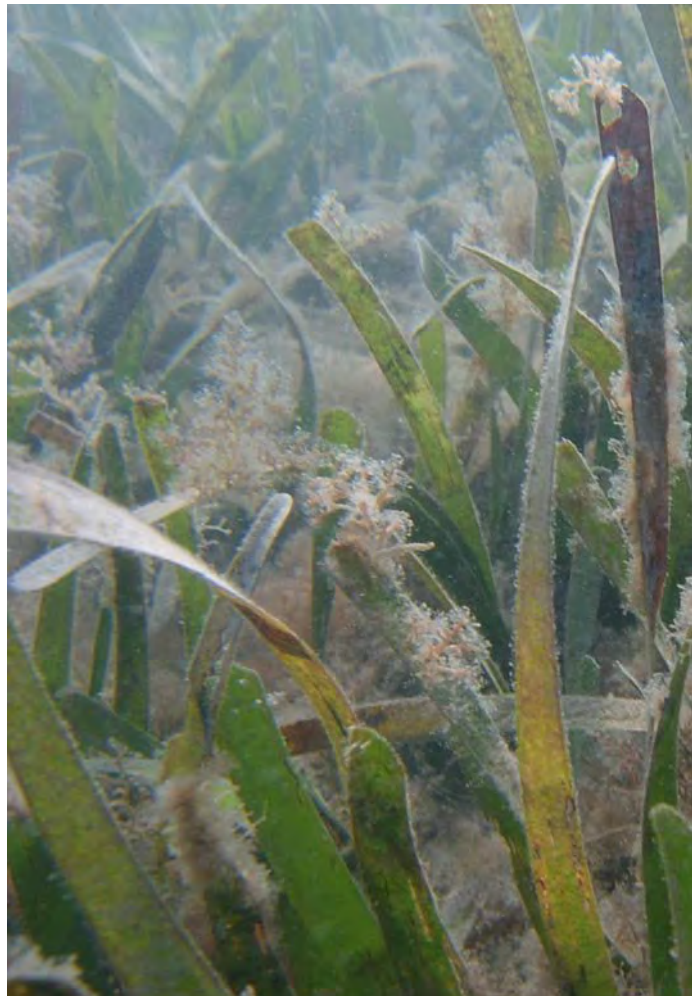
Epiphytes are plants or algae that grow on the surface of other plant species, like SAV.

Are epiphytes harmful to SAV?

Epiphytes are not parasitic, meaning they do not feed on their host plants, and they do not always impact SAV negatively. Epiphytes can become overgrown, however, when nutrient concentrations are too high. When this happens, epiphytes can cover so much of their host SAV plant that they block sunlight from reaching the SAV leaves, inhibiting photosynthesis.

How do I identify epiphytes?

There are many species of epiphytes in the Chesapeake Bay, and they are difficult to distinguish from one another. Look for them on the leaves and stems of SAV. When examining SAV for epiphytes, you may also see epifauna, or small animals that live on SAV.



Animal species

What are they?

Many animal species seek refuge in SAV beds and may cling to SAV stems, roots, or leaves.

Are they harmful to SAV?

While some animal species may consume SAV, they are a natural part of a healthy SAV system.

What species can I find?

You may find snails and barnacles clinging to SAV. You may also find benthic invertebrates, such as isopods or amphipods, larval or juvenile fishes, and commercially important species such as blue crabs. Other invertebrates that use SAV as habitat include clams and scallops. Large predators including adult fishes and sea birds may also be found in and around SAV beds. Other fishes that can be found there are mummichogs, seahorses, and pipefish.



Scallops



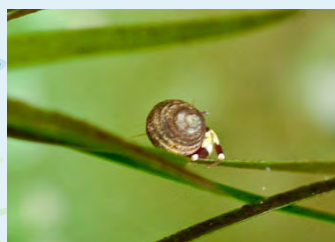
Seahorses



Mummichog (fish)



Amphipods



Snails



Crustaceans

Shoreline types guide

When collecting data on shoreline type, volunteers should first locate the shoreline that is closest to the monitoring site. The nearest shoreline is most impactful to the SAV at that particular location. Volunteers should then record up to three observed shoreline types within 100 meters of the center of the sampling site, listing them in order from most abundant to least abundant.

Only coastal land that is directly adjacent to the water should be recorded as shoreline. For example, if a bulkhead at the edge of the water has partitioned a forest from direct contact with a tributary, then the shoreline should be classified as a bulkhead because the bulkhead stands between the forest and the water. Similarly, if a near-shore stone structure is positioned parallel to a marsh landscape, the shoreline should be classified as near-shore stone because that structure is closest to the SAV bed. If, in these two cases, there are portions of the natural forested shoreline that are not reinforced with a bulkhead, or portions of the marsh shoreline that are not protected by near-shore stone structures, both types of shorelines should be recorded. If there are multiple shoreline types present at a monitoring site, mentally calculate which percentage of the total shoreline can be classified as each type, and record the shoreline types in order from highest estimated percentage to lowest.

Finally, many of these shorelines can be tricky to distinguish depending on the tide. For example, small “beach” areas can appear along shorelines at low tide. In cases like these, shorelines should not be classified as beaches because in order for a shoreline to qualify as a beach, there must be a substantial stretch of sand exposed at high tide. Similarly, a stone structure positioned at the edge of a marshy area could appear at first to be an on-shore

stone structure when observed at low tide, but if the structure is inundated at high tide and allows tidal flow between the flooded marsh landscape and the body of water, it should be classified as a near-shore stone structure. Differentiating between shoreline types based on their appearances and functions at different tide levels is critical as a volunteer monitor.

Participants in the *Chesapeake Bay SAV Watchers* Monitoring Program will collect data on nine types of shorelines. If another type of shoreline is observed, monitors should record the shoreline type as “other”. In these cases, volunteers are encouraged to take a picture of the unusual shoreline type and note any additional observations on their data sheet. If the monitoring site is located more than 100 meters away from the nearest shoreline, such as in the Susquehanna Flats, observers should record the shoreline type as “> 100 m”. The nine major shoreline types are listed and described in the following pages.

Beach

A beach shoreline consists of a sandy slope. Beaches are sometimes vegetated and often border a variety of habitats such as forest, marsh, and lawns. If a substantial distance of sandy beach remains exposed at high tide, the shoreline should be categorized as a beach. Sandy shores completely submerged at high tide do not qualify as beaches.



Exposed sandy beach at Ferry Point Shoreline. (MD DNR)

Marsh

Marsh habitats are specially adapted to daily flooding that stems from the ebb and flow of the tide. In the Chesapeake Bay, marshes are mainly characterized by dense mud, peat, and grassy vegetation. In fresher areas, the vegetation consists of grasses such as wild rice (*Zizania aquatica*), and broad-leafed emergent species like arrow arum (*Peltandra virginica*) and pickerelweed (*Pontederia cordata*). In brackish and saltier waters, cattails (*Typha sp.*) and *Spartina* grasses are common. Invasive *Phragmites* reeds are also present in marshes throughout the Chesapeake Bay. Many shoreline modification techniques incorporate marsh habitat in their designs, but only a natural marsh without man-made structures should be classified as a 'marsh' when monitoring.



Jug Bay freshwater marsh. (Rebecca Swerida)



Phragmites marsh. (Chesapeake Bay Program)



Saltwater marsh and mudflat at Monie Bay. (Rebecca Swerida)

Forest

A forest shoreline is vegetated by shrubs and trees as opposed to grasses. Forested shorelines may be in the process of transitioning to marsh or beach. If the majority of trees are still living and appear to be the dominant species over marsh grasses, then the shoreline should be categorized as forested. If very little beach remains exposed at an average high tide, the shoreline should be categorized as forested.



Forested freshwater shoreline. (Chesapeake Bay Program)



Forested shoreline in Prince George's County. (Rebecca Swerida)



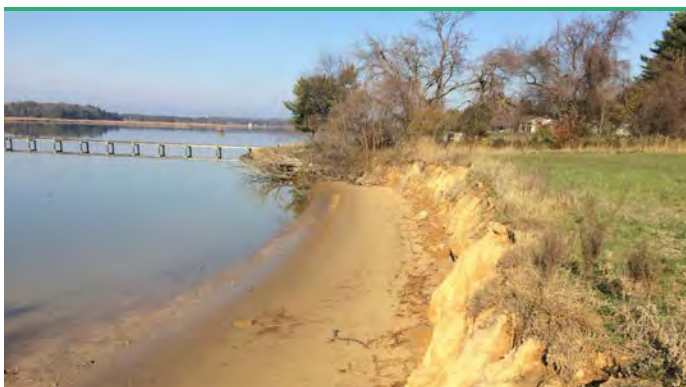
Forested shoreline with only a small fringe marsh at Otter Point Creek. (Rebecca Swerida)

Lawn

A lawn shoreline consists of any manicured, human-maintained landscape, turf grass lawns being one of the most common features. An area containing decorative gardening would also be considered a lawn. A shoreline should only be classified as a lawn if the grass is bordering the water's edge - not when other shoreline structures, such as marsh grasses or on-shore stones, are located between the water and the lawn. In some cases, lawn shorelines may have a small amount of natural vegetation or sandy beach at their edge. The key characteristic of a lawn as it impacts SAV habitat is that it does not retain water or excess nutrients from stormwater runoff.



Lawn shoreline in Talbot County despite sparse emergent marsh grasses and a mowed marsh edge. (Rebecca Swerida)



Lawn shoreline in Queen Anne's County. Note that the shoreline erosion and sandy beach area are only exposed at low tide here. (Rebecca Swerida)

Bulkhead

A bulkhead is a vertical wall built at the edge of a shoreline. Bulkheads are often made from timber, metal, or vinyl. Sometimes, sediment accumulates at the base of the bulkhead, and a small beach or marsh area develops in front of a bulkhead. If waves cover the beach or marsh and hit the bulkhead regularly, the shoreline should be classified as a bulkhead. Bulkheads are also sometimes paired with other shoreline structures such as groins or breakwaters. The shoreline should be categorized as a bulkhead if waves crash directly against the bulkhead.



Timber bulkhead with base sediment accumulation visible at low tide in Talbot County. (Rebecca Swerida)



A deteriorating concrete bulkhead in Harford County. (Rebecca Swerida)



A high, vinyl bulkhead. (MD DNR)

On-shore stone

On-shore stone structures run parallel to the shoreline. Most often, on-shore stone consists of stone revetment or riprap. There is often some vegetation on the landward side of the structure and sediment build-up in the water at the base of the structure. Groins or headland spur breakwaters - stone structures that run perpendicular to the shoreline and leave the shores mostly exposed to the water - should not be in this category. On-shore stone shorelines can be distinguished from near-shore and off-shore stone shorelines in that on-shore stone is positioned directly at the water's edge at high tide, and some stones remain exposed even when the water is at its highest point.



Although some sparse marsh grass is in front of the on shore stone and some lawn and trees are behind, the stone is the most significant factor for SAV habitat. (Rebecca Swerida)



Rubble and loosely placed on-shore stone. (Rebecca Swerida)

Near-shore stone

Near-shore stone structures run parallel to the shoreline and are usually placed about 10 meters out towards the water from the high tide line. A stone sill is the most common type of near-shore stone structure. Near-shore stone structures allow tidal flow and wildlife to transition between the open water and protected areas near the shoreline. Near-shore stone structures regularly have water on both sides of the rocks, whereas water remains only on one side of on-shore structures. Furthermore, unlike off-shore stone structures, near-shore stone structures are also easily accessible from land.



A non-segmented stone sill protecting a marsh habitat. (MD DNR)



Near-shore stone sills in Baltimore County. (Rebecca Swerida)

Off-shore stone

Off-shore stone shorelines will most often consist of breakwater structures that are located further away from shore - about 15 to 30 meters out towards the water from the high tide line. Off-shore stone structures protect beaches and other shorelines by reducing wave action and erosion. Unlike near-shore stone structures, off-shore stone structures are not easily accessible from the shoreline. Breakwater structures are also much larger and taller than near-shore structures. At times, a shallow or exposed sand bar will form, connecting the breakwater structure to the land and forming 'pocket beaches' as a result.



Large off-shore stone breakwaters structures are sometimes connected to shore by tombolos of sand at very low tides. (Virginia Institute of Marine Science)

Soft structure

Soft structures most often consist of coir sills that use natural coconut fiber 'coir logs' in place of stone structures. These structures are used in shoreline restoration projects to stabilize sediment along a shoreline in order for plants to eventually establish themselves and develop a root mat. The coir logs naturally break down over a few years as the plant population grows more stable.



A newly placed coir log protecting a freshwater marsh. (MD DNR)

Multiple shorelines in a row

Sometimes volunteers may find that there are multiple shoreline types positioned along the nearest shoreline. In these cases, volunteers should record up to three types of shorelines that are most prominent, listing them in order from most to least coverage.



Timber bulkhead to the left of on-shore stone. (Rebecca Swerida)



From left to right a lawn, then marsh, then forest shoreline. (Rebecca Swerida)

Other

Other shoreline types include groin and spur structures that run perpendicular to the shoreline. Groins are sand containment structures that are composed of large stones or timber. Breakwater spur structures create a crescent shaped beach or 'crab claw' shoreline. To restore shorelines, sometimes marsh or beach grasses are planted behind the structures. Another alternate shoreline type is a constructed cobble beach, which uses strategically placed small stones paired with marsh planting to stabilize a shoreline. In some areas, shorelines are stabilized using oyster reefs or castles, which are positioned parallel to the shore. Finally, there are many unique shoreline configurations that cannot be described by the specified categories.



Stone groin structures in Anne Arundel County.
(Rebecca Swerida)



Headland breakwater spur in Anne Arundel County.
(Rebecca Swerida)



Cobble beach living shoreline at Conquest Beach.
(Rebecca Swerida)



Artificial oyster reefs can protect the shoreline from erosion.
(U.S. Fish and Wildlife Service)



A very complex shoreline in St. Mary's County contains several failed shoreline control structures and cannot be effectively categorized. (Rebecca Swerida)

Printing instructions

Chesapeake Bay SAV Watchers Monitoring Program participants can view and download all of the program materials from the program website at www.chesapeakebaysavwatchers.com. The following section contains printing instructions for several program materials.

Methods Manual

Print double-sided and select the "Flip pages on long edge" option on the Print menu. Print on standard printer paper and store pages in a 3-ring binder.

Guide to Submitting Data and Observations

Print double-sided and select the "Flip pages on long edge" option on the Print menu. Print on standard printer paper and staple the pages together.

Certificate

Select "Fit" on the print menu to print the certificate. We recommend that you print the certificate on cardstock and use a dark pen or thin-tipped marker to fill out the information.

Data sheet

Print double-sided on Rite in the Rain paper, which can be purchased online at <https://www.riteintherain.com/copier-paper-500-white-20-bond-8-1-2-x-11>. When printing on *Rite in the Rain* paper, use a copier or laser printer. Do not use an ink-jet printer. Be sure to use a pencil to record your observations in the field.

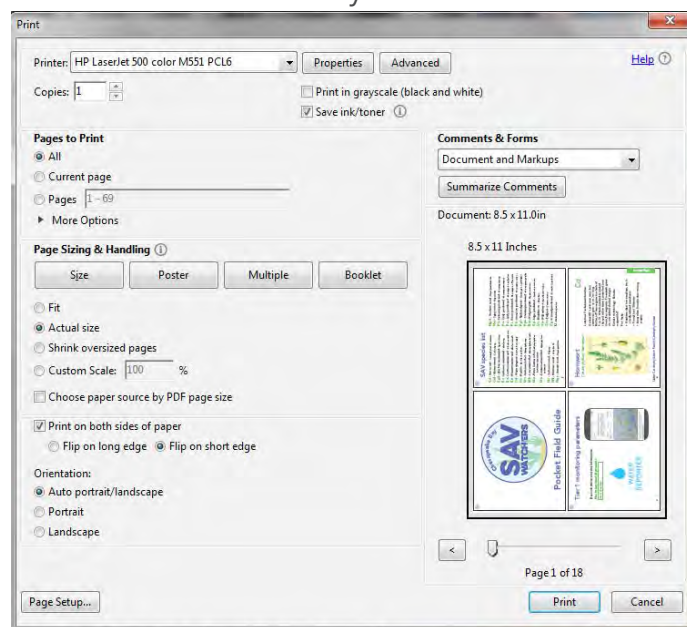
Pocket Field Guide

Volunteers can choose what type of paper to use when printing the Pocket Field Guide. The first recommended option is to print on *Rite in the Rain* 8.5 x 11" cardstock paper, which can be purchased online at <https://www.riteintherain.com/card-stock#HW8511>. When printing on *Rite in the Rain* paper, use a copier or laser printer. Do not use an ink-jet printer. Print double-sided and select the "Actual size" and "Flip on short edge" options on the Print menu to ensure that the

cards print in the correct orientation. Once printed, cut the pages to size and hole punch each card using the provided circle guide. Use packing tape to cover the Site ID and image description boxes on the last card. This layer of plastic will allow you to write on this page with a dry erase marker while monitoring.

The second recommended option for printing the Pocket Field Guide is to print on standard 8.5 x 11" cardstock paper. Print double-sided and select the "Actual size" and "Flip on short edge" options on the Print menu to ensure that the cards print in the correct orientation. Once printed, cut the pages to size and then work with a printing company to laminate each card individually. After the cards are laminated, hole punch each card using the provided circle guide.

Store all the cards on a medium-sized book ring, which you can purchase from Amazon by searching for "medium-sized book ring". We recommend also attaching a carabiner onto the ring so that your Pocket Field Guide can easily be clipped and unclipped to your life jacket or another location for easy access.



The Pocket Field Guide will print four cards on one page. The cards will be approximately 4 x 5 inches, or about the size of a large index card. (Suzi Spitzer)

Submitting data

All photos and data points should be submitted to the *ArcGIS Survey123* before the end of the sampling season by uploading files to through the Chesapeake Bay SAV Watchers survey on a mobile device or computer. Please email Brooke Landry at brooke.landry@maryland.gov or Kaitlin Scowen kaitlin.scowen@maryland.gov if you have any issues submitting data.

How to retrieve a GPS location using a smartphone

Google maps

Retrieve coordinates of current location

1. Press the circle icon with the triangle in it in the bottom right corner to center on your current location.
2. Zoom in to your current location (blue dot with white circle edge) until you cannot zoom in any further.
3. Press and hold your finger on the screen directly on top of your blue locator dot until a red bubble pin appears and the words "Dropped Pin" appear in the location search bar.
4. Press the white "Dropped Pin" menu at the bottom of the screen and scroll down until the GPS coordinates appear.
5. Write down the coordinates very carefully and double-check each number.

Add a location as a recurring site

1. Press the "Add Label" button (flag icon) in the "Dropped Pin" menu.
2. Type in a site name that will help differentiate this location from others you might save.
3. Press "Done" in the top right corner.
4. Press the "Save" button (bookmark icon) in the "Dropped Pin" menu.
5. Press the "Favorites" (heart icon) button or specialized SAV locations list (must create this- see below).

Create a specialized list

1. Press the "Save" button (bookmark icon) in the "Dropped Pin" menu (above).
2. Press "New list" (plus icon) at the bottom of the menu.
3. Type in a list name (e.g. My SAV sites, SAV monitoring locations, etc.).
4. Press "Create". Your existing pin will automatically be saved into the new SAV list.
5. Double-check that the pin was added to the list. On the "Dropped Pin" menu, under the section "Saved in your lists," your SAV list name should appear next to a blue list icon.

Navigate to a recurring site (that was previously marked)

1. Press the menu icon (three horizontal lines) at the top left of the screen.
2. Press "Your places".
3. Scroll in the "Label" menu until you find your labeled location OR use the "Saved" menu to access your "Favorites" list or a specialized SAV list (if you created one).
4. Press your labeled location on the menu.
5. Press the blue "Directions" button in the bottom right corner.
6. Press the blue "Start" button and follow the app's directions until the white box at the bottom of the screen says "You made it to (location name)".
7. Press the red "Exit" button at the bottom of the screen.
8. Exit the "Dropped Pin" location menu by swiping it towards the bottom of the screen.
9. Zoom in to your current location (blue dot with white circle edge) until you cannot zoom in any further.
10. Adjust your location until your blue dot is as centered as possible on top of your red marked location bubble.

Apple maps

Retrieve coordinates of current location

1. Press the arrow icon in the top right corner to center on your current location.
2. Press the information icon (i in a circle) in the top right corner to open the "Maps Settings" menu.
3. Press "Mark my location" to open the "Marked Location" menu and scroll down until the GPS coordinates appear.
4. Write down the coordinates very carefully and double-check each number.

Add this location as a recurring site

1. Press the "Favorite" (heart icon) button in the Marked Location menu (see above).
2. Type in a site name that will help differentiate this location from others you might save.
3. Press "Save".

Navigate to a recurring site (that was previously marked)

1. Press the navigation box at the bottom of the screen to search for a place or address.
2. Scroll to the bottom of the box until you see the "Favorites" section.
3. Press the "Favorites" section and scroll in this menu to your desired site.
4. Press the site name and then press the large blue "Directions" box.
5. Press the green "Go" button and follow the app's directions until the black box at the top of the screen says "Arrived".
6. Press the big red "End Route" button at the bottom of the screen.
7. Exit the "Marked Location" menu by pressing the small gray "x" icon at the top right of the menu box.

8. Zoom in to your current location (blue dot with white circle edge) until you cannot zoom in any further.
9. Adjust your location until your blue dot is as centered as possible on top of your red marked location bubble.

Contact list

To report suspicious algal blooms, call the Chesapeake Bay Safety and Environmental Hotline at (877) 224-7229.

To report a stranded marine mammal or sea turtle, call the Maryland Marine Mammal and Sea Turtle Stranding Response Program at 1-800-628-9944.

For a natural resources emergency or to request assistance, call the Maryland Department of Natural Resources at 1-800-628-9944 or (410) 260-8888.

To report a fishing or wildlife violation, contact Maryland Wildlife Crimestoppers at (443) 433-4112 or email mwc.dnr@maryland.gov.

SAV and other species photo attributions

Several of the images in the SAV species guide and appendices sections are sourced from the Pocket Field Guide. Please find photo attributions below.

38 - Chesapeake Bay Program (CBP) Andreas Rockstein, Jon Sullivan

39 - Dr. Mary Gillham Archive Project, Richard Place

40 - CBP, T. Pennington

41 - Andreas Rockstein, Merike Linnamägi

42 - Christian_Fischer, Radio Tonleg

43 - Fritzflohreynolds, jillllybean

44 - USFWS, Darkmax

45 - Donald Cameron

46 - André Karwath, Evelyn Simak

47 - burita2012

48 - Robert H. Mohlenbrock, SERNEC

49 - Donald Cameron, Show Ryu, Britton, N.L., and A. Brown

50 - Robert H. Mohlenbrock

51 - Robert H. Mohlenbrock, MD DNR, Ernst Gilg and Karl Schumann

52 - Kristian Peters

53 - Britton & Brown, Edward G. Voss

54 - Dick Culbert, Na. J. Pilla, Fernando Arcas

55- jillllybean

56 - Kristian Peters, Natural Resources Wales 57 - all by ChristianFisher2

58 - Brooke Landry, Tim Carruthers

59 - CBP, Brooke Landry, Mike Norman

60 - Himeji Science Museum

61 - Annie Carew, DNR

62 - Jon Lefcheck, Jessie Jarvis

63 - CBP

64 - Ohio Sea Grant

65 - MD DNR, Allen Gathman, DennisM2, Carnat Joel

66 - Mary Kleim, Texas AquaPlant, Katia Schulz, Ria Tan

67 - MD DNR, Wikimedia Commons, Bob Peterson, Peter Southwood, Henry Hemming, Ansgar Gruber

68 - Mark Rodrique, Luke McGuff, CBP, Hans Hillewaert, CBP, NOAA's National Ocean Sciences, Georgia DNR

Recommended references

Web resources

Chesapeake Plants: Bay Grasses

Chesapeake Bay Foundation

<https://www.cbf.org/about-the-bay/chesapeake-plants/bay-grasses.html>

How We're Organized: SAV Workgroup

Chesapeake Bay Program

https://www.chesapeakebay.net/who/group/submerged_aquatic_vegetation_workgroup

State of the Chesapeake: Underwater Grasses

Chesapeake Bay Program

https://www.chesapeakebay.net/state/underwater_grasses

Vital Habitats: SAV

Chesapeake Progress

<https://www.chesapeakeprogress.com/abundant-life/sav>

Eyes on the Bay: Bay Grasses

Maryland Department of Natural Resources

<http://eyesonthebay.dnr.maryland.gov/sav/aboutSAV.cfm>

Chesapeake Bay Report Card: Health (by indicator or region)

University of Maryland Center for Environmental Science, Integration and Application Network

<https://ecoreportcard.org/report-cards/chesapeake-bay/health/>

Chesapeake Bay and Delmarva Coastal Bays SAV Bibliography

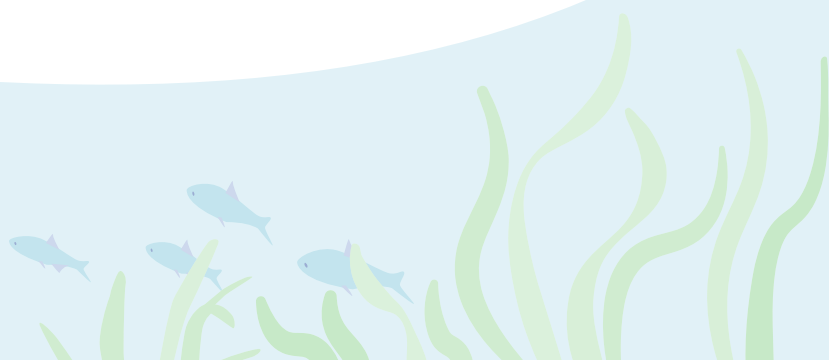
Virginia Institute of Marine Science

https://www.vims.edu/research/units/programs/sav/_pubs/sav_biblio/index.php

SAV in Chesapeake Bay and Coastal Bays

Virginia Institute of Marine Science

<https://www.vims.edu/research/units/programs/sav/index.php>



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Greiner, J. T., McGlathery, K. J., Gunnell, J., & McKee, B. A. (2013). "Seagrass restoration enhances 'blue carbon' sequestration in coastal waters." *PloS One*, 8(8), e72469.

Lefcheck, J. S., Orth, R. J., Dennison, W. C., Wilcox, D. J., Murphy, R. R., Keisman, J., Gurbisz, C., Hannam, M., Landry, J. B., Moore, K., Patrick, C. J., Testa, J., Weller, D. E., & Batiuk, R. A. (2018). "Long-term nutrient reductions lead to the unprecedented recovery of a temperate coastal region." *Proceedings of the National Academy of Sciences*, 115(14), pp. 3658–3662.

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Moore, K. A., Wilcox, D. J., & Orth, R. J. (2000). "Analysis of the abundance of submersed aquatic vegetation communities in the Chesapeake Bay." *Estuaries*, 23(1), pp. 115–127.

Orth, R. J., Carruthers, T. J., Dennison, W. C., Duarte, C. M., Fourqurean, J. W., Heck, K. L., Hughes, A. R., Kendrick, G. A., Kenworthy, W. J., Olyarnik, S., Short, F. T., Waycott, M., & Williams, S. L. (2006). "A global crisis for seagrass ecosystems." *Bioscience*, 56(12), pp. 987–996.

Orth, R. J., Dennison, W. C., Lefcheck, J. S., Gurbisz, C., Hannam, M., Keisman, J., Landry, J. B., Moore, K. A., Murphy, R. R., Patrick, C. J., Testa, J., Weller, D. E., & Wilcox, D. J. (2017). "Submersed aquatic vegetation in Chesapeake Bay: Sentinel species in a changing world." *Bioscience*, 67(8), pp. 698–712.

Orth, R. J., Williams, M. R., Marion, S. R., Wilcox, D. J., Carruthers, T. J., Moore, K. A., Kemp, W. M., Dennison, W. C., Rybicki, N., Bergstrom, P., & Batiuk, R. A. (2010). "Long-term trends in submersed aquatic vegetation (SAV) in Chesapeake Bay, USA, related to water quality." *Estuaries and Coasts*, 33(5), pp. 1144–1163.

Waycott, M., Duarte, C. M., Carruthers, T. J., Orth, R. J., Dennison, W. C., Olyarnik, S., Calladine, A., Fourqueen, J. W., Heck Jr., K. L., Hughes, A. R., Kendrick, G. A., Kenworthy, W. J., Short, F. T., & Williams, S. L. (2009). "Accelerating loss of seagrasses across the globe threatens coastal ecosystems." *Proceedings of the National Academy of Sciences*, 106(30), pp. 12377–12381.



A diverse and dense bed of SAV grows to the surface of the water. (MD DNR)

Acknowledgments

The core team for this project was Brooke Landry (Maryland Department of Natural Resources), and Suzi Spitzer, Dr. Katie May Laumann, and Sky Swanson (University of Maryland Center for Environmental Science, Integration and Application Network). We would like to thank many individuals and groups for their various contributions to this project.

This project would not have been possible without the input and support from Chesapeake Bay volunteer monitors, monitoring group coordinators, and Riverkeepers. Participants of the pilot project included ShoreRivers, the Severn River Association, the James River Association, and the Havre de Grace Maritime Museum Environmental Center. Many volunteers and Riverkeepers also invited our core team to accompany them in the field, attended an in-person workshop to field-test the protocol, and/or provided other feedback that helped inform the development of this program. These individuals include Chuck Foster and Greg DeCowsky (Friends of the Bohemia), Bruce Russell, Logan Poore, and Sarah Shpak (Havre de Grace Maritime Museum Environmental Center), Lise and Jim Crafton (Magothy River Association), Tom Guay and Beverly DiPietropaolo (Severn River Association), Laura Wood and Rebecca Murphy (ShoreRivers), and Tom Milke (West & Rhode Riverkeeper).

This project also benefited greatly from the help of SAV experts and other environmental professionals. The Chesapeake Bay Program SAV Workgroup, especially Dr. William C. Dennison (University of Maryland Center for Environmental Science) and Dr. Robert J. Orth (Virginia Institute of Marine Science), provided expert advice on the SAV monitoring protocol. Rebecca Swerida (Maryland Department of Natural Resources) provided consultation, text, and images for the shoreline types section of the appendix. The Chesapeake Bay Program Habitat Goal Implementation Team offered continued support for this effort. Dave Wilcox (Virginia Institute of Marine Science) provided consultation for the data management aspects of the project.

Finally, many individuals contributed to creating the final materials associated with this project. Kaitlin Scowen designed an ArcGIS Survey123 survey that is intuitive and accessible to users of all levels of expertise. Erin Hofmann and R. John Dawes (Chesapeake Commons) made customized changes to the *Water Reporter* app so that it would better fit our data collection needs for the previously used Introductory Monitoring Program. Dylan Taillie, Emily Nastase, and Nathan Miller (UMCES-IAN) assisted with layout, graphic design, and copy editing of project materials. Will Parson (Chesapeake Bay Program) provided images and video clips. Jamie Currie (UMCES-IAN) assisted with filming and photographing several field trips and workshops. Dr. Jason Howard (UMCES-IAN) was involved in the initial stages of the protocol co-development process.

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Chesapeake Bay Program

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