

Survey of Aquatic Invasive Species in Maryland Lakes

Report of Survey Activity and Results
January 2018

Prepared For
Maryland State Legislature
Maryland Department of Natural Resources
Maryland Park Service
Maryland Fishing and Boating Service

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Tidewater Ecosystem Assessment

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Executive Summary

Biologists from DNR's Resource Assessment Service conducted the first Aquatic Invasive Species survey in all sixteen state -owned lakes in the summer of 2016. Surveys were conducted from kayaks, canoes and motor boats to assess the aquatic macrophyte communities in each lake. The purpose of the survey was to assess the current condition of the state lakes and assist in making management decisions related to aquatic invasive species. Overall, twenty-nine species of submerged aquatic vegetation and six species of floating or emergent plants were observed. Invasive species were found in eleven of the sixteen reservoirs. The report includes a list of recommendations that can be implemented at each lake, with specific recommendations for Deep Creek Lake and some smaller lakes with extensive invasive species populations.

Report

An Aquatic Invasive Species (AIS) is a non-native species whose introduction may cause harm economically, environmentally, or to human health. AIS can cause profound economic and ecological loss, such as decreased biodiversity and food availability and competition with native species. Invasive submerged aquatic vegetation (SAV) can outcompete native species, create navigational hazards, alter water chemistry and drastically reduce boating, fishing and recreational opportunities.

House Bill 860, which passed in the Maryland General Assembly during the 2015 legislative session, was signed into law by the Governor, and created an AIS Workgroup. The purpose of the workgroup was to make recommendations on reducing the spread of aquatic invasive species from vessels placed in state-owned and managed lakes. As a result of the workgroup's final recommendations, the following actions have been taken:

- AIS prevention signs were posted at the State Park boat launch, private launches and marinas to remind boaters to properly clean their vessels.
- Maryland Park Service created a launch steward program at Deep Creek Lake (DCL) to provide voluntary boat inspections and will continue this program in 2017.
- DNR has created an on-line instructional video to educate boaters on the proper way to Clean, Drain and Dry their vessels.
- Resource Assessment Services (RAS) biologists have worked with the DCL Property Owners Association to place signs that reinforce the 'Clean, Drain and Dry' message along Route 219, the main road that runs through the lake.
- RAS staff provide training to lake managers, marina owners and rental shops and staff on proper vessel inspection.
- DNR has an Aquatic Nuisance Species Plan that was approved by the Aquatic Nuisance Species Task Force, allowing the Department to apply for federal funds for AIS control.

- AIS disposal stations are being constructed at most of the state parks, which together with voluntary questionnaires will provide information on boat traffic at other state-owned lakes.

Another outcome of the HB860 Workgroup was the passage of the State Lakes Invasive Species Act of 2017, which makes it illegal for the owner of a vessel to launch in Maryland waters unless the owner has cleaned the vessel and removed all visible organic material. A vessel owner who violates this requirement could be subject to natural resource fines of up to \$2,500 for introducing AIS to Maryland waters. To improve the effectiveness of enforcement, Resource Assessment Service (RAS) staff worked with the Natural Resources Police (NRP) to educate officers on the act and coordinate a response if boaters were not in compliance with the regulation.

Additionally the Work Group recommended establishing a baseline understanding of AIS presence and abundance by surveying each of the sixteen state -owned lakes (reservoirs). Fourteen of the reservoirs are part of the Chesapeake Bay watershed and two drain to the Ohio River watershed. These lakes are managed by three different DNR units. Maryland Park Service manages ten lakes, Wildlife and Heritage Service manages two lakes and Fisheries Service manages four lakes. No comprehensive surveys of invasive species in these reservoirs had been performed so in order to establish a baseline, RAS biologists visited each of the state lakes in the summer and fall of 2016. Park managers indicated that many of the lakes had SAV populations, but little was known about the abundance or species composition of AIS.

Surveys were conducted from kayaks, canoes and motor boats to assess the aquatic macrophyte communities at each lake. Protocols developed by the Maryland Biological Stream Survey were used to collect information about the aquatic mollusk community. Aquatic plant inspections were conducted in a continuous band along the shoreline, with throwing devices designed to collect vegetation used to sample grasses not visible in the water column.

The surveys focused primarily on searching for invasive SAV and mussels. For some reservoirs, water samples were collected to evaluate non-native algae as well. In addition to establishing a baseline, the survey was intended to determine the extent to which invasive SAV and mussel populations are present in Maryland reservoirs and to provide managers with a clear understanding of AIS threats to help make management decisions related to AIS in their respective reservoirs.

Overall, twenty-nine species of SAV and six species of floating or emergent plants were observed. For the purpose of this report, we considered a species to be invasive if it did not evolve within the state and if it has historically caused economic, ecological, or environmental harm. The following species fitting this definition were observed: Brazilian waterweed (*Egeria densa*), curly pondweed (*Potamogeton crispus*), Eurasian watermilfoil (*Myriophyllum spicatum*), hydrilla (*Hydrilla verticillata*), the floating macrophytes water lettuce (*Pistia stratiotes*) and water hyacinth (*Eichhornia crassipes*). These invasive species were found in eleven of the sixteen reservoirs.

Maryland DNR is charged with the protection of all Maryland waters as well as the Chesapeake Bay and is working to prevent the spread of AIS. Boats trailered between water bodies are believed to be the mechanism by which most AIS are introduced to new water bodies. Every state-owned reservoir except Clopper Lake has at least one boat ramp designed to allow the launching of trailered boats. While boat ramps facilitate the recreational use of lakes, they simultaneously facilitate the introduction of invasive species. To help offset this, substantial effort has been put into increasing education and outreach to the boating community. Signs that educate boaters on proper cleaning have been placed at most National Park Service, state and county boat launches.

This report provides a picture of each boat ramp and a summary of the data collected, from smallest water body to largest. Table 1 is summary of all the species found during the survey. As part of the 2016 DNR lake study for submerged vegetation, eight lakes were sampled for phytoplankton. The purpose was to establish baseline data on phytoplankton communities and to determine if any harmful algae, especially potentially toxic cyanobacteria, were present. The phytoplankton synopsis, results and recommendations are in Appendix A.

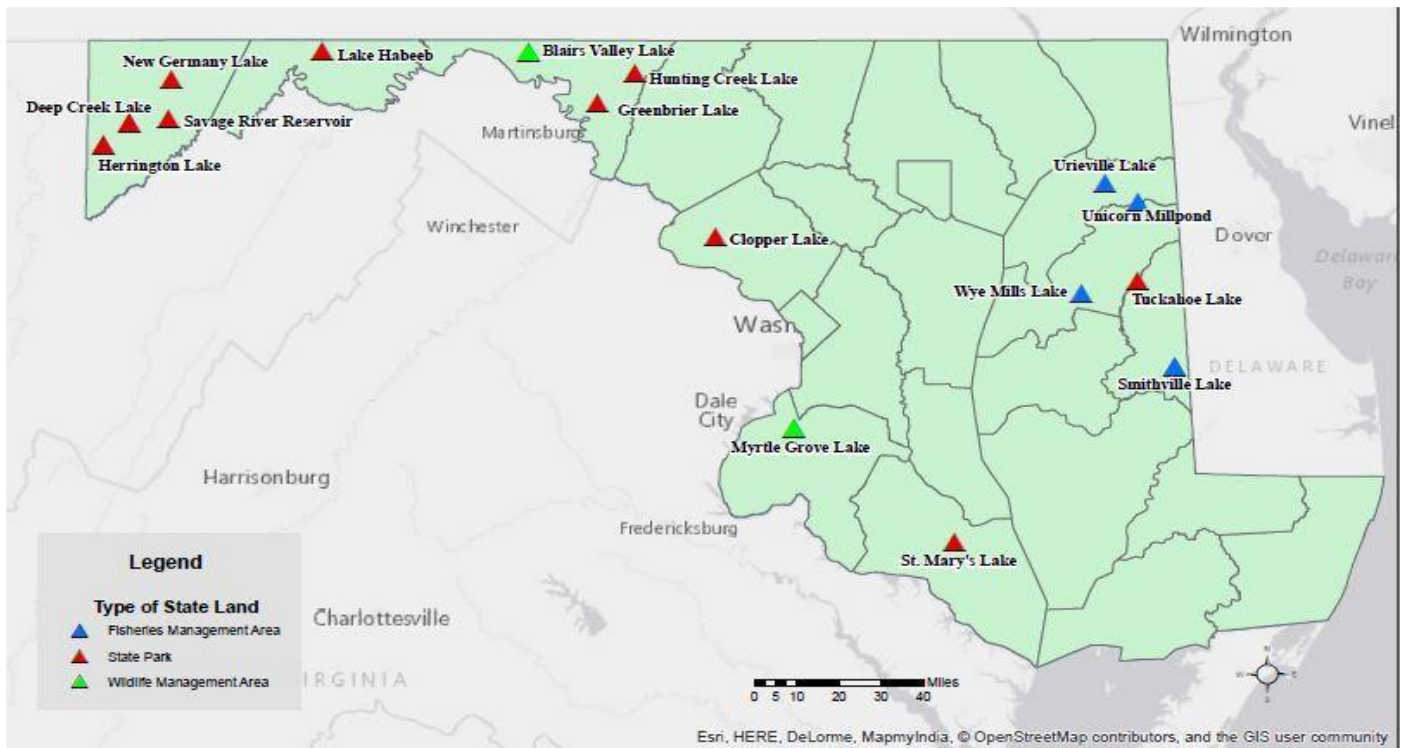


Figure 1. Map of State Lakes

Lake Survey Findings

New Germany Lake

New Germany State Park
Sampled 9/1/2016

New Germany Lake is a 13 -acre reservoir inside New Germany State Park in Garrett County. Created by a dam on Poplar Lick, the lake is used primarily for fishing, swimming, and boating. RAS staff sampled New Germany Lake from 2011 through 2014. In 2011, species diversity was high relative to the size of the lake. Several species of naiads (*Najas spp.*) and pondweeds (*Potamogeton spp.*) were so abundant as to be an impediment to recreation. Other vascular plants of the genera *Isoetes*, *Utricularia*, and *Myriophyllum* were present. Two species of macroalgae, *Chara vulgaris* and *Nitella flexillis*, were also common.



New Germany Lake boat ramp



During the 2011-2012 winter season, water levels in the lake were reduced in the winter in an attempt to reduce SAV growth that was interfering with their swimming area. After drawdown, a decreased biodiversity of SAV was observed, and the invasive

spiny naiad (*Najas minor*) was observed in higher densities throughout the lake. Water level drawdown did not take place again during the 2012-2013 winter season and the summer 2013 SAV survey results indicated that in the absence of that control measure, the native plants seemed to outcompete spiny naiad. During the August 2014 SAV survey native naiads, pondweeds, and macroalgae were recorded at relatively high densities, and no spiny naiad was observed.

A much greater diversity of macrophytes and macroalgae were observed in 2016. Two invasive species were the dominant species in the lake, Eurasian watermilfoil (*Myriophyllum spicatum*) and spiny naiad (*Najas minor*). Muskgrass (*Chara spp.*), Robbin’s pondweed (*Potamogeton robinsii*), Vasey’s pondweed (*Potamogeton vaseyii*) and common water nymph (*Najas guadalupensis*) were also observed.

Tuckahoe Lake

Tuckahoe State Park
Sampled 9/16/2016

Tuckahoe Lake is a 19 -acre reservoir in Tuckahoe State Park in Queen Anne's County. It was created by the damming of Tuckahoe Creek near Crouse Mill Road. The lake is now used for recreation, mainly fishing and boating.

There were no SAV observed during the survey. The lake was bordered with dense smartweed (*Polygonum hydropiperoides*) growing along most of the shoreline. DNR's Fisheries Service last sampled Tuckahoe Lake in 2016, and the electroshocking survey found largemouth bass (*Micropterus salmoides*) were common and common carp (*Cyprinus carpio*) and bluegill (*Lepomis macrochirus*) were abundant. Shoreline and bottom surveys also revealed the presence of the invasive Asian clam (*Corbicula fluminata*).



Tuckahoe Lake boat ramp

Myrtle Grove Lake

Myrtle Grove Wildlife Management Area
Sampled 10/5/2016

Myrtle Grove Lake is a 23 -acre reservoir within the Myrtle Grove Wildlife Management Area in Charles County. Formed by impounding a small tributary to Mattawoman Creek in 1965, the lake is used primarily by residents for recreational fishing. Historically, Myrtle Grove pond has been managed for largemouth bass largemouth bass (*Micropterus salmoides*) and bluegill (*Lepomis macrochirus*). It is also stocked in the spring and fall with put and take rainbow trout (*Oncorhynchus mykiss*) and golden trout (*Oncorhynchus mykiss aguabonita*).

Three invasive species were found in Myrtle Grove Lake. Hydrilla (*Hydrilla verticillata*) was present in a substantial portion of the lake. Near the boat launch were small concentrations of water hyacinth (*Eichhornia crassipes*) and 5-6 large heads of water lettuce (*Pistia stratiotes*). The native emergent plant American lotus (*Nelumbo lutea*) was abundant through much of the lake. RAS staff removed all of the water lettuce and composted them nearby.



Myrtle Grove Lake boat ramp



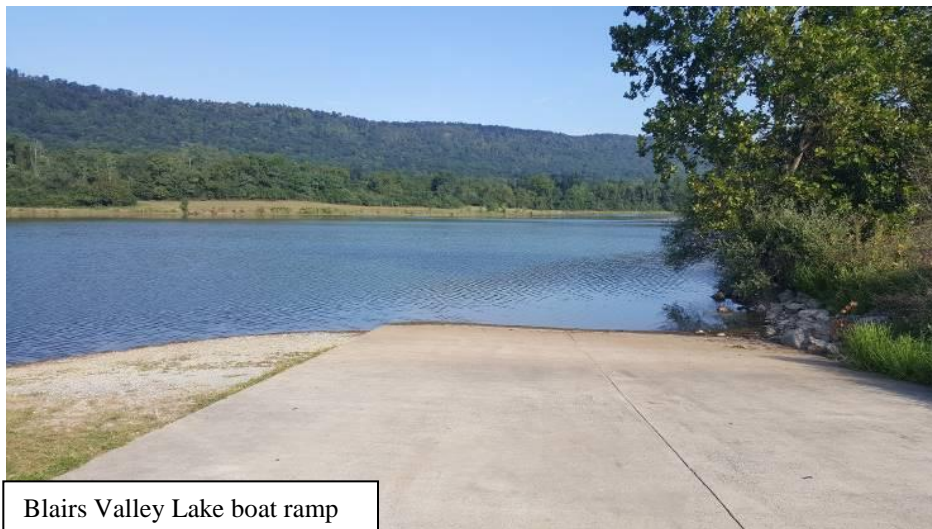
Water lettuce

Blairs Valley Lake

Sampled 9/8/2016

Blairs Valley Lake is a 32 -acre reservoir in Washington County constructed in 1967 by damming Little Conococheague Creek. The reservoir is managed primarily as a warm water fishery for largemouth bass (*Micropterus salmoides*), bluegill (*Lepomis macrochirus*) and tiger muskellunge (*Esox masquinongy X Esox lucius*) as well as a put-and-take fishery for rainbow trout (*Oncorhynchus mykiss*). To permit a five-foot winter drawdown for fish and wildlife management activities, the dam was designed and built with special valves to facilitate drawdown.

Two invasive species were found in Blairs Valley Lake. The entire littoral zone of the reservoir was covered with dense stands of the invasive hydrilla (*Hydrilla verticillata*). This was by far the most vegetation for the size of the water body of any state-owned reservoir. Small patches of spiny naiad (*Najas minor*) were also present. The native spiral pondweed (*Potamogeton spirillus*) was present as well at a very low density.



Blairs Valley Lake boat ramp

Urieville Lake

Sampled 9/22/2016



Urieville Lake is a 35 -acre reservoir in Kent County formed by damming an unnamed tributary to Morgan Creek. Common duckweed (*Lemna minor*), a floating aquatic invasive, covers large areas of the lake surface. The water clarity was excellent under the duckweed. Two invasive SAV species were found in Urieville Lake. In the western arm of the lake, there were dense stands of invasive Brazilian waterweed (*Egeria densa*) that grew nearly to the surface, while curly pondweed (*Potamogeton crispus*) was observed on the eastern side of the reservoir.

The native coontail (*Ceratophyllum demersum*) was common throughout the northern and western side of the lake and slender pondweed (*Potamogeton pusillus*) was observed on the eastern side of the reservoir. Seeds of invasive water chestnut (*Trapa natans*) were found floating in the reservoir. Surveys conducted in 2002 found

large stands of water chestnut, which were removed by DNR biologists. Water chestnut seeds can remain viable for 12-15 years, so it is possible that some may germinate in the future. No water chestnut plants were observed in this survey. When this reservoir was surveyed in 2002 it was dominated by coontail (*Ceratophyllum demersum*), curly pondweed (*Potamogeton crispus*), slender pondweed (*Potamogeton pusillus*) and water chestnut (*Trapa natans*).

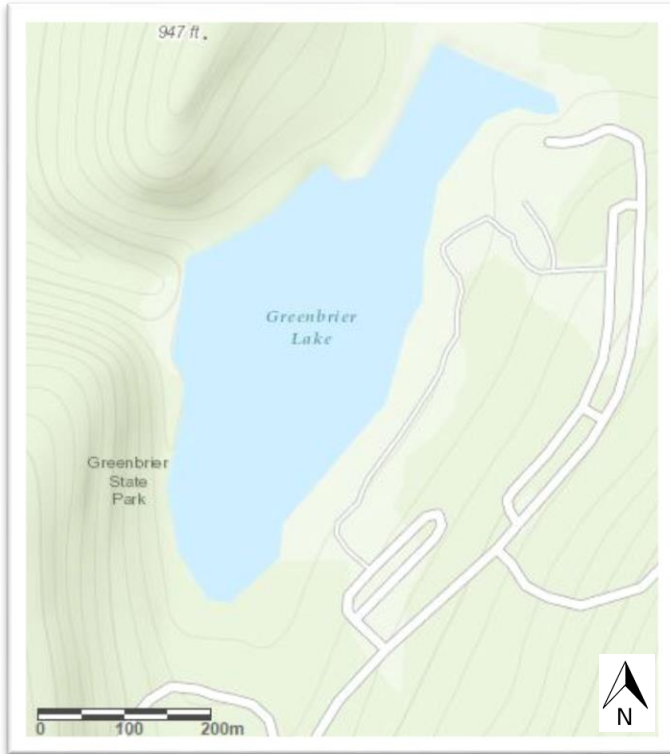
DNR's Fisheries Service last sampled Urieville Lake in 2016 and the electroshocking survey found four species of fish in the lake. Largemouth bass (*Micropterus salmoides*) and bluegill (*Lepomis macrochirus*) were common and common carp (*Cyprinus carpio*) and redear sunfish (*Lepomis microlophus*) were abundant. Shoreline and bottom surveys also revealed the presence of the Asian clam (*Corbicula fluminata*).



Greenbrier Lake

Greenbrier State Park

Sampled 9/7/2016



Greenbrier Lake is a 42 -acre reservoir in Greenbrier State park in Washington County formed by a dam on Little Beaver Creek. Greenbrier Lake is stocked with largemouth bass (*Micropterus salmoides*), bluegill (*Lepomis macrochirus*) and rainbow trout (*Oncorhynchus mykiss*).

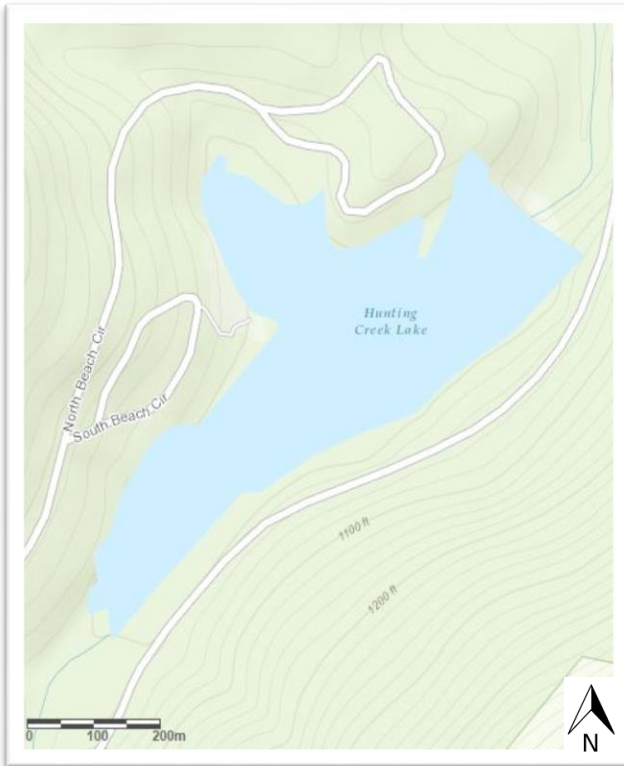
The macrophyte community was dominated by three native SAV; southern naiad (*Najas guadalupensis*), which covered most of the littoral zone, slender pondweed (*Potamogeton pusillus*), and bladderwort (*Utricularia spp.*).



Hunting Creek Lake

Cunningham Falls State Park

Sampled 9/7/2016



Hunting Creek is a 43 -acre reservoir in Cunningham Falls State Park in Frederick County formed by damming Big Hunting Creek. A paved boat ramp is heavily used by fishermen and recreational boaters. Hunting Creek Lake managed for warm water fish species, primarily largemouth bass (*Micropterus salmoides*), bluegill (*Lepomis macrochirus*), redear sunfish and black crappie (*Pomoxis nigromaculatus*)

Only one species of invasive SAV was found in Hunting Creek Lake, spiny naiad (*Najas minor*), though it was only in dispersed locations. Common waterweed (*Elodea canadensis*) blankets nearly the entire shoreline and the boat ramp. Muskgrass (*Chara spp.*) was also very abundant. Slender pondweed (*Potamogeton pusillus*) was

frequently observed in with the common waterweed. One single water stargrass (*Heteranthera dubia*) plant was observed close to the boat ramp.

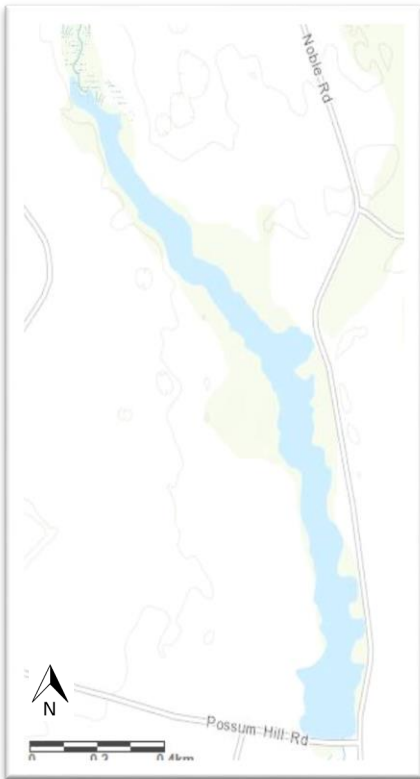


Hunting Creek Lake boat ramp

Smithville Lake

Smithville Lake

Sample date 8/11/2016



Smithville Lake is a 43 -acre reservoir in Caroline County. It was created when a dam was constructed across a tributary to Marshyhope creek. The lake is managed to provide a public angling resource.

No SAV was observed in Smithville Lake. Macroalgae was present throughout most of the shallow areas. There was a floating invasive, common duckweed (*Lemna minor*), present on small portions of the reservoir. Spatterdock (*Nuphar luteum*) dominated the littoral zone and was the only emergent species present along the shoreline. Evidence of a population of the Asian clam (*Corbicula fluminea*) was found along the shoreline.

DNR's Fisheries Service last sampled Smithville in 2015, and the electroshocking survey found two species of fish in the lake. Largemouth bass (*Micropterus salmoides*) were common and bluegill (*Lepomis macrochirus*) were abundant.



Smithville Lake boat ramp

Unicorn Lake

Unicorn Fish Hatchery

Sampled 9/22/2016



Unicorn Lake is a 43 acre reservoir formed by damming Unicorn Branch. The macrophyte community in this reservoir was one of the most diverse in our survey. There was a broad distribution of species throughout the southern end of the reservoir, including waterthread pondweed (*Potamogeton diversifolius*), slender pondweed (*Potamogeton pusillus*), Robbin's pondweed (*Potamogeton robinsii*), water starwort (*Callatriche spp*), spiny naiad (*Najas minor*) and slender waterweed (*Elodea nuttallii*). Of the species found, only spiny naiad is considered invasive.

DNR's Fisheries Service last sampled Unicorn in 2014, and the electroshocking survey found two species of fish in the lake. Largemouth bass (*Micropterus salmoides*) were common and bluegill (*Lepomis macrochirus*) were abundant.



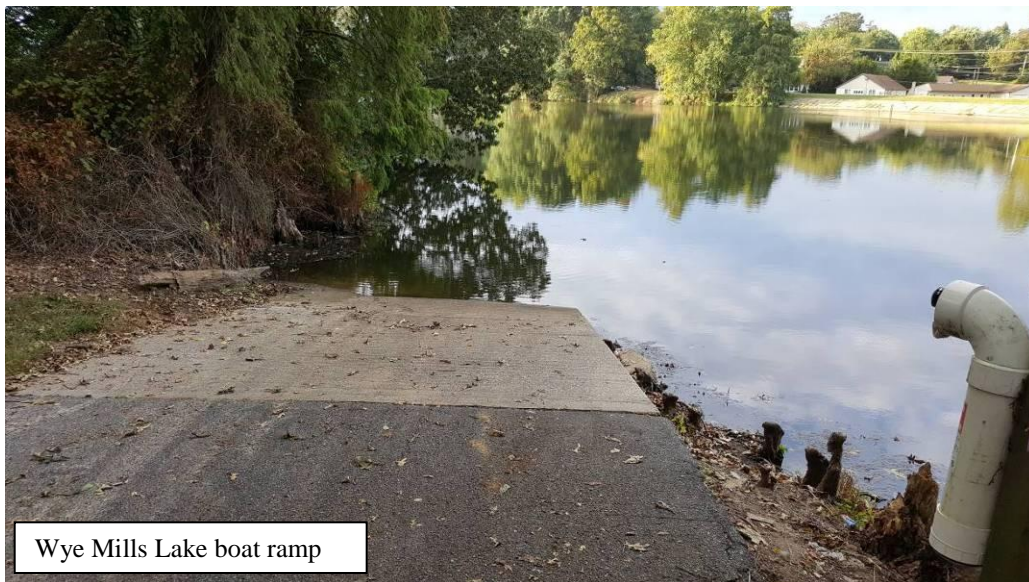
Unicorn Lake boat ramp

Wye Mills Lake

Wye Mills State Park
Sampled 9/16/2016

Fifty acre Wye Mills Lake in Queen Anne's County is one of the largest lakes on the Eastern Shore of Maryland. Created to hold back the Wye East River, water from the reservoir powered a grain mill during colonial times. The reservoir is now managed primarily to provide recreational fishing opportunities.

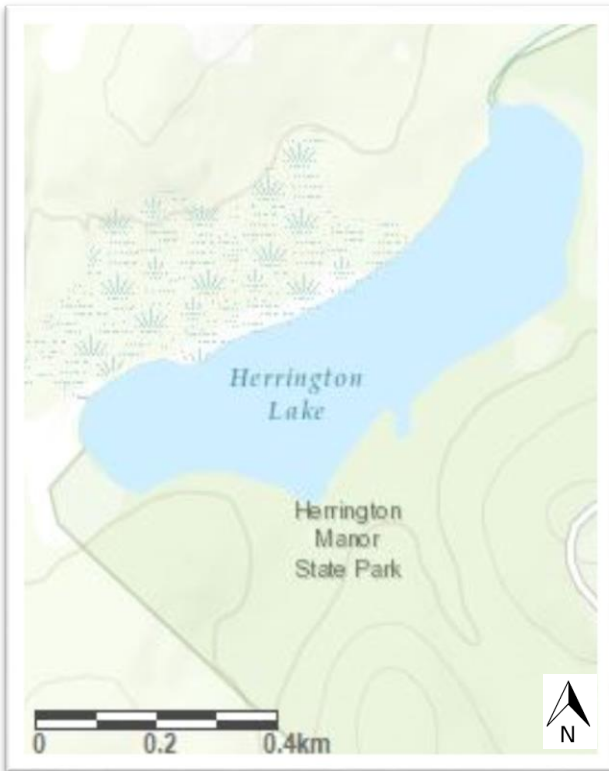
No macrophytes were observed in this lake, and historical fisheries surveys have not reported any macrophytes in the past. DNR's Fisheries Service last sampled Wye Mills in 2014, and the electroshocking survey found four species of fish in the lake. Largemouth bass (*Micropterus salmoides*) and redear sunfish (*Lepomis microlophus*) were common and common carp (*Cyprinus carpio*) and bluegill (*Lepomis macrochirus*) were abundant. Shoreline and bottom surveys also revealed the presence of the native Paper Pondshell mussel (*Utterbackia imbecillis*).



Wye Mills Lake boat ramp

Herrington Lake

Herrington Manor State Park
Sampled 8/31/2016



Located within Garrett State Forest in Garrett County, the 53 acre lake was formed by damming Herrington Creek. Herrington Manor reservoir is in the Ohio River drainage basin, and is used by state park visitors primarily for boating and recreational fishing.

Herrington Lake was drawn down in spring of 2016 to repair the dam, so there was a fair amount of terrestrial vegetation in the lake. Despite the drawdown, there was a robust native macrophyte community present and no invasive species. Bladderwort (*Utricularia spp.*), crested arrowhead (*Sagittaria cristata*), slender pondweed (*Potamogeton pusillus*), and water starwort (*Callitriche spp.*). Spatterdock (*Nuphar luteum*) was also present in smaller areas around the shoreline.



Herrington Lake boat ramp

Clopper Lake

Seneca Creek State Park

Sampled 8/26/2016

Clopper Lake is a 90 acre impoundment on Long Draught Branch within Seneca Creek State Park in Montgomery County. The dam was built in 1975 for recreation and flood control. Clopper Lake averages 18 feet in depth with several shallow coves. Clopper Lake is one of only two lakes surveyed that doesn't have a poured concrete boat ramp.

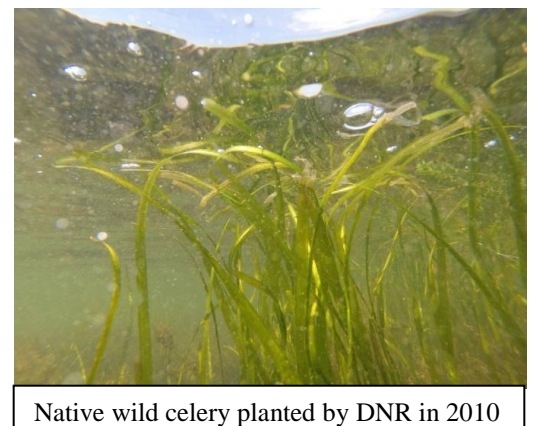
The lake has abundant submerged aquatic vegetation and tree downfalls and beaver huts provide habitat in some areas of the lake for recreational fish species.



Clopper Lake was part of a prior SAV study done by DNR in 2002. At that time, the dominant species at Clopper Lake were waterthread pondweed (*Potamogeton diversifolius*) and the invasive hydrilla (*Hydrilla verticillata*) and spiny naiad (*Najas minor*). Muskgrass (*Chara spp.*) was also present at a lower abundance. Hydrilla was the dominant species in 2016, covering most of the shoreline out to about 10 ft. deep. Southern naiad (*Najas guadalupensis*) and spiny naiad were abundant, with slender pondweed (*Potamogeton pusillus*) in some areas. Wild celery (*Vallisneria americana*) planted by DNR's Bay Grasses in Classes program has persisted since 2010 and was forming seed pods on the day of the survey. It is encouraging that the native wild celery has survived and spread.



Clopper Lake boat ramp

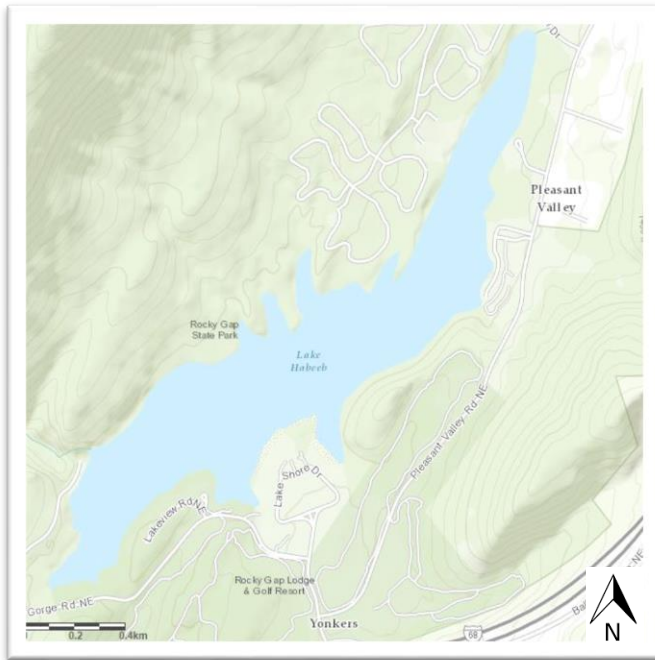


Native wild celery planted by DNR in 2010

Lake Habeeb

Rocky Gap State Park

Sampled 9/28/16



Lake Habeeb is a 243 acre drinking water supply reservoir in Allegany County. The reservoir was formed by damming Rocky Gap Run. The entire shoreline, with the exception of the swimming beach, is covered with macrophytes out to about a depth of 15-20 ft. There are four species of SAV that dominate the lake. Hydrilla (*Hydrilla verticillata*), and milfoil (*Myriophyllum spicatum*) are the most common invasives, native wild celery (*Vallisneria americana*) and largeleaf pondweed (*Potamogeton amplifolius*), which is rare in Maryland, were the dominant native species.



Flowering hydrilla

Hydrilla is the dominant species, particularly in the coves on the north side of the lake and in depths up to 20ft. Large leafed pondweed and milfoil dominate the shallower areas of the reservoir, growing to the surface in the western end of the lake. The lake has populations of southern naiad (*Najas guadalupensis*), longleaf pondweed (*Potamogeton nodosus*), slender pondweed (*Potamogeton pusillus*), ribbonleaf pondweed (*Potamogeton epihydrus*) and

waterthread pondweed (*Potamogeton diversifolius*). Shoreline and bottom surveys revealed the presence of the Eastern Floater mussel (*Anodonta cataracta*).



Lake Habeeb boat ramp

St. Mary's Lake

St. Mary's River State Park
Sampled 10/5/2016

St. Mary's Lake is a 250 -acre impoundment situated in St. Mary's River State Park in St. Mary's County. It was formed by damming the Western Branch of the St. Mary's River. The area is a popular fishing spot. Several species of fish are common to the lake including largemouth bass (*Micropterus salmoides*), bluegill (*Lepomis macrochirus*), redear sunfish (*Lepomis microlophus*), black crappie (*Pomoxis nigromaculatus*) and chain pickerel (*Esox niger*).

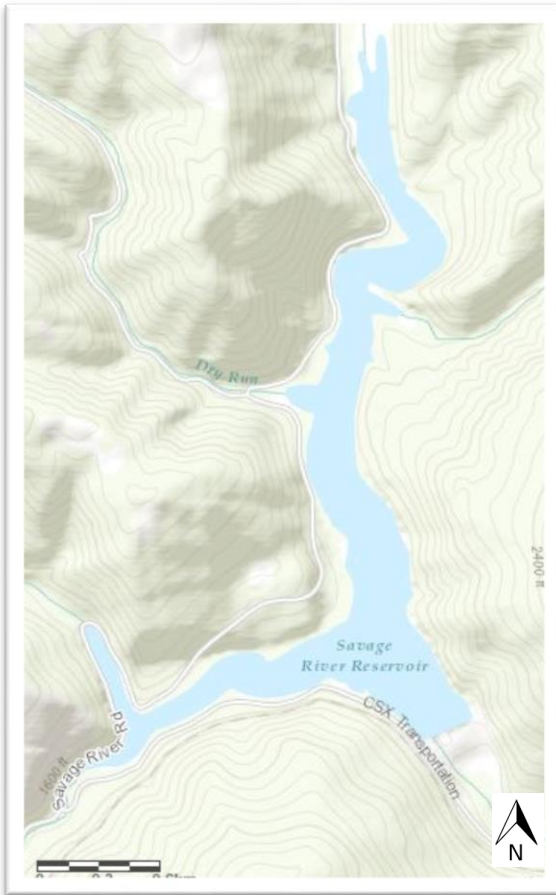
The lake has been designated a trophy bass lake and as such, special fishing regulations may be in effect. The invasive species hydrilla (*Hydrilla verticillata*) was observed in many locations around the reservoir. The native species bladderwort (*Utricularia spp.*) and slender pondweed (*Potamogeton pusillus*) were also found throughout the lake. No mussels were observed during surveys.



Savage River Reservoir

Big Run State Park and Savage River State Forest

Sampled 9/1/2016



Savage River reservoir is a 360 -acre impoundment in Garrett County that was created by damming the Savage River. It is a shared resource, operated jointly by the Army Corp of Engineers and DNR. Due to the drawdown required to maintain a trout fishery in the Savage River, the lake level fluctuates greatly, limiting the ability of SAV to colonize and spread. Savage River reservoir does not have a paved launch, so larger vessels are unlikely to be launched.

No invasive SAV were found during the survey. Slender pondweed (*Potamogeton pusillus*) was the only macrophyte observed. Muskgrass (*Chara spp.*) was also observed. There was a visible algal bloom in the water, and samples revealed the invasive diatom didymo (*Didymosphenia geminata*), five species of cyanobacteria, and high densities of potentially toxic cyanobacteria (see attached macroalgae report for more details).



Savage River Reservoir shoreline

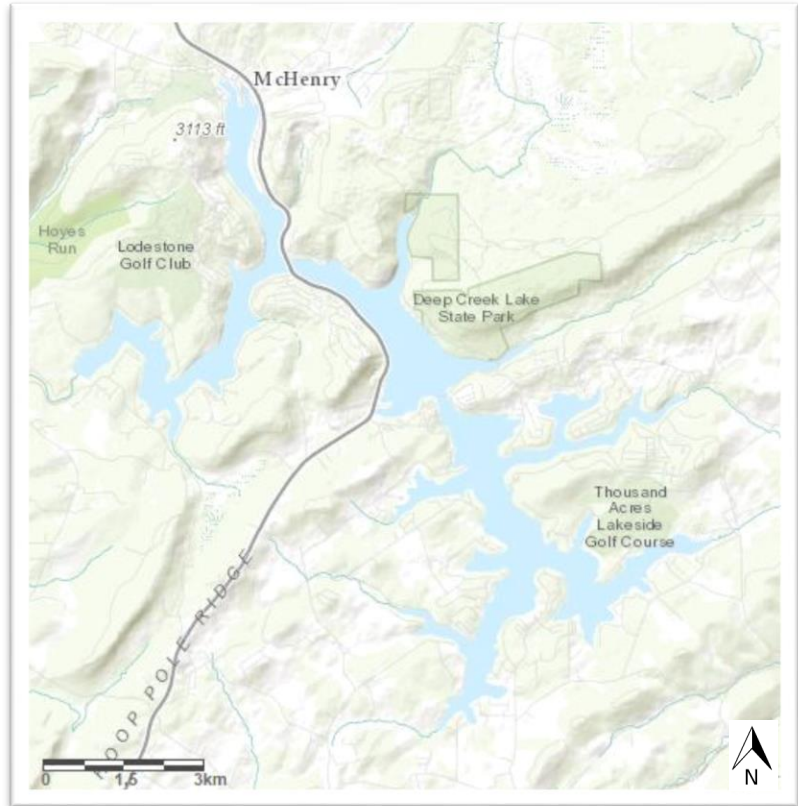
Deep Creek Lake

Deep Creek Lake State Park and Deep Creek Lake Natural Resource Management Area
Sampled 9/3/2016

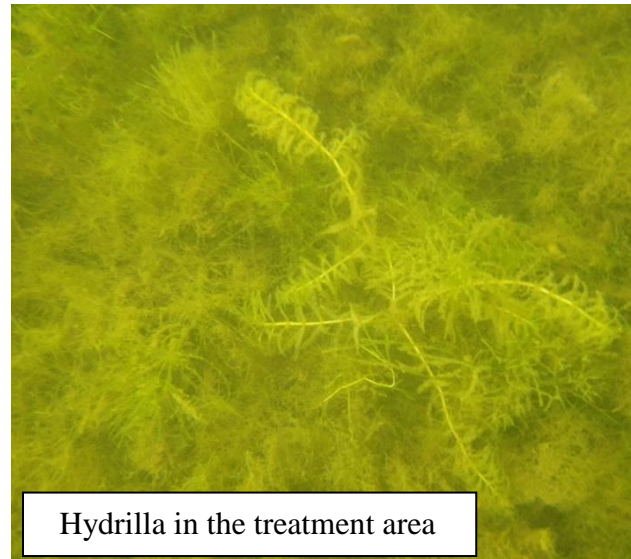
Deep Creek Lake is a 3,900 acre reservoir in Garrett County formed by a dam on Deep Creek. Deep Creek is one of only two reservoirs sampled that are in the Ohio Valley drainage. Currently there are nine primary access points on the reservoir, one public and 8 private or community launches as well as over 1,900 permitted access points for non-motorized vessels

The invasive SAV hydrilla was first observed in Deep Creek Lake in 2013, prompting quick action by DNR to put a control program in place using herbicide to control the population. The

Department convened a national panel of hydrilla experts that guided the development of the herbicide treatment. Beginning in 2014, a certified applicator was contracted to administer herbicide four to five times a year. A pelletized fluridone treatment for hydrilla control begins as soon as the hydrilla emerges. In 2014 and 2015, five small patches were discovered outside the treatment zones and added to the treatment plan. No hydrilla was observed in 2016 at the end of the treatment period.



One of many Deep Creek Lake boat ramps



Hydrilla in the treatment area

In all, 19 different species of macrophytes are observed in Deep Creek Lake. There is a diverse population of SAV growing throughout the lake with densities ranging from sparse to 100% cover. The RAS dive team has surveyed the same transects since 2011. Crested arrowhead (*Sagittaria cristata*), wild celery (*Vallisneria americana*) and slender pondweed (*Potamogeton pusillus*) were the dominant vascular species observed at transect sites throughout the lake in 2015. Other commonly observed plants were *Elodea* spp., *Myriophyllum* spp., and Vasey's pondweed (*Potamogeton vaseyii*) with macroalgae also dominant in several areas. Species zonation was apparent at most sites with crested arrowhead dominating the shallower portions and *Potamogeton* spp., wild celery, *Myriophyllum* spp., and macroalgae most commonly observed at deeper depths.

The invasive Eurasian watermilfoil (*Myriophyllum spicatum*) has been observed in the lake since survey efforts began, and DNR has been tracking its distribution in the lake with shoreline surveys. Results of the survey indicate that *Myriophyllum* occupied <2% of available benthic habitat.

Recommendations

With the survey of all state-owned lakes complete, DNR has a much better understanding of the current distribution of AIS in Maryland water bodies. Moving forward, management for these water bodies will vary greatly. Each lake is funded and managed individually, so what works for one lake may not be applicable to another. This is in keeping with the recommendations of the HB860 workgroup which includes allowing park managers to make independent assessments of the state of their lake and to select strategies to best meet their needs.

For all lakes, we recommend an annual review of existing signage to ensure that appropriate information is made available. For lakes that already have AIS populations, we recommend specific signage indicating the risks of carrying these species to other nearby water bodies. We recommend that lake managers make an attempt to quantify boat use to help assess risk. We recommend that managers consider deliberate introductions of beneficial native SAV species such as wild celery. Greater coordination with adjacent states could minimize the risk of future invasions. We recommend convening an annual or biennial meeting to bring together lake managers to discuss AIS management. Resource Assessment Service has secured funds to facilitate a Mid-Atlantic Lake Forum to this end.

Particular attention is being paid to Deep Creek Lake, Maryland's largest inland water body. Its proximity to the Potomac River and Lake Habeeb, both of which contain the invasives hydrilla and Eurasian watermilfoil, puts Deep Creek Lake at a high risk for introduction of other invasives and re-introduction of hydrilla. With its unique blend of state ownership and local use, the value of the tourism industry to the local economy is important enough to have warranted the initiation of an hydrilla control program. Currently in its 4th year, the hydrilla control treatments have been very successful, with no new hydrilla observed in 2016. A critical component of this program is the Launch Steward program that has provided voluntary AIS inspections at boat ramps since 2014.

The stewards program showed the frequency with which boats containing AIS launch in Deep Creek Lake. In 2016 alone, 3,824 vessels were inspected and the data collected at these inspections provided valuable insight. According to launch steward surveys, 75.6% of incoming boaters commonly used a waterbody with known AIS and 70.7% used a waterbody with known AIS just before visiting Deep Creek.

Should funding become available, the main priority for protecting Deep Creek Lake should be to control the hydrilla at Lake Habeeb. Even if a comprehensive eradication program cannot be implemented, treating in and around the boat launches would reduce the possibility of hydrilla being transported to another water body. While a launch steward is present at Lake Habeeb on a very limited basis, a more permanent launch steward for inspection of outgoing vessels is warranted by the high density of hydrilla and Eurasian watermilfoil.

The rest of the lakes within Maryland vary in terms of invasive species infestations, fishing and boating traffic, and accessibility. Blair's Valley has an almost complete monoculture of hydrilla and lake access and fishing are very limited during the growing season. Wye Mills and Smithville Lake have no submersed macrophytes at all, but have floating nuisance species and invasive wetland plants that restrict fishing access. Some have a robust native community with minimal invasives.

Resource Assessment Service staff are members or affiliated with the Aquatic Nuisance Species Task Force, The Northeast Aquatic Plant Management Society, the Maryland Invasive Species Council, and the North American Lake Management Society and will continue to work within those agencies to enhance Maryland's AIS response in Maryland's lakes.

		State Park Lakes									
		Deep Creek	Herrington	Rocky Gap	New Germany	St. Mary's	Seneca Creek	Greenbrier	Tuckahoe	Hurting Creek	Savage
Species											
Invasive Submersed Macrophytes											
<i>Eurasian Watermilfoil</i>	Milfoil	X		X	X						
<i>Hydrilla verticillata</i>	Hydrilla	X		X		X	X				
<i>Najas minor</i>	Spiny naiad	X			X		X			X	
<i>Potamogeton crispus</i>	Curly pondweed	X									
Native Submersed Macrophytes											
<i>Callitriche spp.</i>	Water starwort		X								
<i>Ceratophyllum demersum</i>	Coontail	X									
<i>Chara spp.</i>	Muskgrass		X		X					X	X
<i>Elodea canadensis</i>	Common waterweed	X								X	
<i>Elodea nuttallii</i>	Slender waterweed	X									
<i>Heteranthera dubia</i>	Water stargrass									X	
<i>Isoetes spp.</i>	Quillwort	X									
<i>Lemna minor</i>	Common duckweed										
<i>Najas flexilis</i>	Slender water nymph	X			X						
<i>Najas guadalupensis</i>	Common water nymph	X		X	X		X	X			
<i>Potamogeton amplifolius</i>	Largeleaf pondweed	X		X							
<i>Potamogeton crispus</i>	Curly Pondweed	X									
<i>Potamogeton diversifolius</i>	Waterthread pondweed	X									
<i>Potamogeton nodosus</i>	Longleaf pondweed	X		X							
<i>Potamogeton pusillus</i>	Slender pondweed	X		X			X				X
<i>Potamogeton robinsii</i>	Robbins' pondweed	X			X						
<i>Potamogeton spirillus</i>	Spiral pondweed					X		X		X	
<i>Potamogeton vaseyii</i>	Vasey's pondweed	X			X						
<i>Sagittaria cristata</i>	Crested arrowhead	X	X								
<i>Utricularia spp.</i>	Bladderwort	X	X			X		X			
<i>Vallisneria americana</i>	Wild celery	X		X							
Native Emergent Macrophytes											
<i>Nuphar luteum</i>	Spatterdock		X								
Invasive Emergent Macrophytes											
<i>Polygonum hydropiperoides</i>	Smartweed								X		

Table 1- SAV, Emergent Plant and Floating Plant Summary

		Inland Fisheries Lakes			Smithville Lake	Heritage Lakes	
		Wye Mills	Urrieville	Unicom		Myrtle Grove	Blairs Valley
Invasive Submersed Macrophytes							
<i>Egeria densa</i>	Brazilian waterweed		X				
<i>Hydrilla verticillata</i>	Hydrilla					X	X
<i>Najas minor</i>	Spiny naiad			X			X
<i>Pistia stratoites</i>	Water lettuce					X	
Native Submersed Macrophytes							
<i>Callitriche spp.</i>	Water starwort			X			
<i>Ceratophyllum demersum</i>	Coontail		X	X			
<i>Chara spp.</i>	Muskgrass						X
<i>Elodea canadensis</i>	Common waterweed			X			
<i>Elodea nuttallii</i>	Slender waterweed			X			
<i>Lemna minor</i>	Common duckweed		X	X	X		
<i>Potamogeton crispus</i>	Curly Pondweed		X				
<i>Potamogeton diversifolius</i>	Waterthread pondweed			X			
<i>Potamogeton pusillus</i>	Slender pondweed		X				
<i>Potamogeton robinsii</i>	Robbins' pondweed			X			
Native Emergent Macrophytes							
<i>Nuphar luteum</i>	Spatterdock				X		
Native Floating Macrophytes							
<i>Nelumbo lutea</i>	American Lotus					X	
Invasive Floating Macrophytes							
<i>Eichhorhia crassipes</i>	Water Hyacinth					X	

Appendix A: 2016 DNR Lakes Study- algae synopsis

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Date: March 1, 2017

Background

As part of the 2016 DNR lake study for submerged vegetation, eight lakes were sampled for phytoplankton community. The purpose was to establish baseline data on phytoplankton communities and to determine if any harmful algae, especially potentially toxic cyanobacteria, were present. Cyanobacteria produce two main groups of toxin namely neurotoxins (anatoxin) and hepatotoxins (microcystin).

Methods

Eight lakes were sampled for phytoplankton community including New Germany Lake (Aug 29, 2 sites), Clopper Lake (Aug 29, 2 sites), Herrington Lake (Aug 31, 2 sites), Savage River Reservoir (Sept 1, 4 sites), Urieville Lake (Sept. 22, 2 sites), Unicorn Lake (Sept 22, 2 sites), Mrytle Grove Lake (Oct 5, 1 site) and St. Mary's Lake (Oct 5, 1 site).

Algae samples were collected at the surface and preserved with Lugols solution. Phytoplankton communities were assessed within 4-11 days of collection. Microscopic algae identification was completed using a Sedgewick rafter cell. Phytoplankton cell counts were determined using methods described by Butler (2012).

Results

The phytoplankton community was analyzed for potentially harmful species. Overall 13 cyanobacteria species were observed in the samples. Three cyano-species of concern were found in four of the eight lakes. Species of concern included potentially toxic cyanobacteria such as *Anabaena sp.* (Savage Reservoir, Seneca Creek, Myrtle Grove and St Mary State Park), *Aphanizomenon sp.* (Savage Reservoir and St. Mary's Lake) and *Cylindrospermopsis sp.* (Myrtle Grove Lake and St Mary's Lake). One additional harmful algae species was observed in the samples. *Didymo* (rock snot) was observed in Savage Reservoir- previously known in four streams in Maryland (Gunpowder River, Savage River downstream of reservoir, North Branch Potomac River and Big Hunting Creek downstream from Hunting Creek Lake in Cunningham Falls State Park).

New Germany Lake (13 acres, part of New Germany State Park) – The highest total cyanobacteria abundance observed was 37,314 cells/ml (Table 1). No potentially toxic species were detected but four non-toxic cyanobacteria were observed in the lake (*Aphanocapsa*, *Chroococcus*, *Cuspidothrix* and *Woronichinia sp.*). Pennate diatoms dominated the counts at New Germany Reservoir 975. Cyanobacteria counts were highest at the dam site where *Aphanocapsa sp.* was the dominant algae (29,568 cells/ml)

Savage Reservoir (360 acres, used for municipal drinking water, part of Big Run State Park and Savage River State Forest) - The highest total cyanobacteria abundance observed

was 11,912 cells/ml (Table 1). A visible bloom was noted throughout the lake. Two potentially toxic cyanobacteria were observed in the lake (*Anabaena planktonica* and *Aphanizomenon*). Both are potential anatoxin (potent neurotoxin) producers. One sample exceeded 10,000 cells/ml of *A. planktonica*- the highest recorded during this study (Appendix A). In addition, *Didymo* (aka Rock Snot) was identified for the first time in the reservoir; it has previously been found downstream of Savage Reservoir.

Clopper Lake (90 acres, part of Seneca Creek State Park) - The highest total cyanobacteria abundance observed was 31,326 cells/ml (Table 1). Two potentially toxic cyanobacteria were observed (*Anabaena planktonica* and *Aphanizomenon sp.*). *Aphanizomenon sp.* had a cell density that was the highest observed during this study (5,400 cells/ml) and *Anabaena* density was the second highest observed at 7,400 cells/ml (Appendix A). This species can produce anatoxin (potent neurotoxin). Nine non-toxic species were noted: *Aphanocapsa incerta*, *Chroococcus*, *Coelosphaerium*, *M. incerta*, *M. weissenbergii*, *Oocystis*, *Pseudanabaena* and *Woronichinia*. Four of these species were the highest observed counts during this study (*Aphanocapsa incerta*, *Coelosphaerium*, *M. incerta*, *M. weissenbergii*, *Oocystis*) (Appendix A).

Herrington Lake (53 acres, Herrington Manor State Park) - The highest total cyanobacteria abundance observed was 5,000 cells/ml (Table 1). No potentially toxic cyanobacteria were observed (Appendix A). Five non-toxic cyanobacteria genera were observed (*Chroococcus*, *Coelosphaerium*, *Oocystis*, *Pseudanabaena* and *Woronichinia*). Four were only observed at the dam site yet *Chroococcus* was highest in the center of the lake.

Unicorn Lake (43 acres average depth 4 feet, Unicorn Fish Hatchery) – The highest total cyanobacteria abundance observed was 38,315 cells/ml (Table 1). No cyanobacteria of concern were observed. One site showed *Pseudanabaena sp* which was detected at very low levels of 1,756 cells/ml (not shown toxic in Maryland). While the second site was dominated by *Aphanocapsa sp* (38,315 cells/ml) - the highest observed during this study- and *Chroococcus sp*.

Urieville Lake (35 acres average depth 3 feet, Urieville State Park, Phosphorus and sediment TMDLs with history of aquatic vegetation infestation) – The highest total cyanobacteria abundance observed was 6,745 cells/ml (Table 1). Non-toxic *Chroococcus sp* was found (<6,500 cells/ml) to be dominant at one site and the highest abundance observed during this study (Appendix A). While the second site had overall low counts of algae and cryptomonads were dominant (1,000 cells/ml).

Myrtle Grove Lake (23 acres, Myrtle Grove Wildlife Management Area) – The highest total cyanobacteria abundance observed was 27,244 cells/ml (Table 1). Six non-toxic (*Aphanocapsa*, *Chroococcus*, *Coelosphaerium*, *Cuspidothrix*, *Merismopedia*, *Oocystis*) and two potentially toxic species (*Anabaena planktonica* <1,500 cells/ml and *Cylindrospermopsis sp.* at 5,000 cells/ml) were detected on October 5, 2016. This lake had the highest concentration of *Cylindrospermopsis sp* and *Merismopedia* observed during the study (Appendix A).

St. Mary's Lake (250 acre St Mary's State Park) - The highest total cyanobacteria abundance observed was 18,926 cells/ml (Table 1). Three potentially toxic cyanobacteria species (*Anabeana planktonic*, *Cylindrospermopsis* and *Aphanizomenon sp.*) were identified from the October 11, 2016 samples. Four non-toxic genera (*Aphanocapsa*, *Chroococcus*, *Aphanizomenon* and *Pseudanabaena*) were also observed and *Psuedanabaena* was at bloom concentrations.

Summary of the number of harmful algal bloom, HAB, species detected and total cyanobacteria cell count from 2016 lake samples. Bolded lake names denotes potential toxin producing cyanobacteria were present.

DNR lake	# HAB species present	Total Cyanobacteria count (cells/ml)	Site	Sample Date
New Germany Lake	0	1,848 37,314	reservoir dam	8/29/16
Savage Reservoir	3	10,264 11,912 3,241	dorm reservoir crab tree	9/1/16
Clopper Lake- Seneca creek SP	1	23,547 31,326	Seneca boat launch Seneca dam	8/29/16
Herrington Lake	0	1,589 5,000	Center of Lake Dam	9/3/16
Unicorn Lake	0	38,315 1,756	Unicorn 1 Unicorn 2	9/22/16
Urieville Lake	0	6,745 0	Urieville 1 Urieville 2	9/22/16
Myrtle Grove Lake	2	15,623 27,244	Ramp	10/5/16
St. Mary's Lake	3	18,926		10/5/16

Discussion

Cyanobacteria toxins have caused animal poisonings in Maryland and many other parts of the world. These toxins present risks to human health through drinking and recreational activity. In Maryland, five lakes are known to have recurring toxic cyanobacteria blooms (Lake Lariat, Lake Needwood, Fountain Rock Quarry, Higgins Millpond, Northwest Creek). In addition, toxic cyanobacteria blooms have led to water contact advisories for Lake Anita Louise, Lake Williston, Smithville Lake, Piney Run Reservoir, Cunningham Falls, as well as the Transquaking, Potomac and Sassafras Rivers.

Four DNR lakes (Savage Reservoir, Clopper Lake, St Mary's Lake and Myrtle Grove wildlife management area) show potential for toxic algae blooms and further study should be conducted to determine if any toxins are produced that may impact use. Since this algal survey was an opportunistic effort building on a submerged vegetation assessment of DNR lakes, the time period of the sample collection was not always during the preferred month for peak cyanobacteria abundance. Higher concentrations of cyanobacteria were likely present in St Mary's Lake and Myrtle Grove Lake during August.

Potentially toxic cyanobacteria found in DNR lakes included *Anabaena*, *Aphanizomenon* and *Cylindrospermopsis* species. While the State does not currently have bloom thresholds for these species, the World Health Organization suggests a total cyanobacteria cell count

of $\geq 100,000$ cells/ml would warrant toxin testing. Such levels were not observed in this study.

Recommendations

An in-depth study of the occurrence of harmful cyanobacteria is important to develop appropriate management strategies for water resources at a local scale. Continuation of the algal survey and expansion to non-DNR owned lakes in the State is recommended.

Additional phytoplankton sampling should be focused during August and Solid Phase Adsorption Toxin Tracker, SPATT, samplers should be deployed during peak cyanobacteria bloom period (the month of August), to determine if toxins are being produced. To decrease microscopic analyses needed, genetic based tested could be used to determine if potentially toxic cyanobacteria are present in lakes.

Appendix A: Cell counts (in millions per liter) by station. Green highlighted cells are the highest concentration of a given species observed in this study.

Numbers in millions/L	Savage River			Clopper Lake, Seneca		New Germany		Urieville		Unicorn		Myrtle Grove Lake		St Mary	Herrington Lake	
	Crab Tree	Dam	Reservoir*	Boat Launch	Dam	reservoir	Dam	lake 1	lake 2	lake 1	lake 2	RAMP	EDGE	lake	center	Dam
Anabaena planktonica	2	2.8	10.2	7.4									0.00	0.02		
Aphanizomenon sp.			1.1		5.3									0.00		
<i>Aphanocapsa sp.</i>		3.2		6.9	8	1.6	29.6			38.3		5.3	5.4	2.8		
<i>Chroococcus sp.</i>				0.4	1.7	0.3	5.5	6.4	0.0	0.0		1.8	0.04	0.02	1.6	0.1
<i>Coelosphaerium sp.</i>		8.3		1.6	5.9								0.04			3.0
<i>Cuspidothrix sp.</i>							2.2						0.2			
Cylindrospermopsis sp.												5.0		0.01		
<i>Merismopediasp.</i>				0.5	1.6			0.4				3.5	21.6	5.2		
<i>Microcystis incerta</i> ¹				0.1	3.3											
<i>Microcystis wessenbergii</i>				0.03												
<i>Oocystis sp.</i>					3.3	1.1	3.0						0.01			1.1
<i>Pseudanabaena sp.</i>	1.2			6.5	1.4		45.7							10.9		0.9
<i>Woronchinia sp.</i>				0.03							1.8					0.01
TOTAL CYANO	3.2	14.3	11.3	23.5	30.5	2.9	85.9	6.7	0.0	38.3	1.8	15.6	27.2	18.9	1.6	5

* *Didymo* detected.

X

¹ formerly *Aphanocapsa incerta*

Species in bold **Red text** = potential toxin producers

