An Ecological Study of Gunston Cove

2016

FINAL REPORT
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by

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Table of Contents

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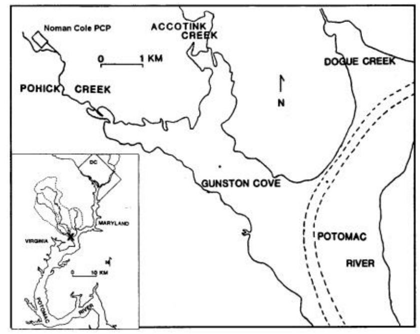
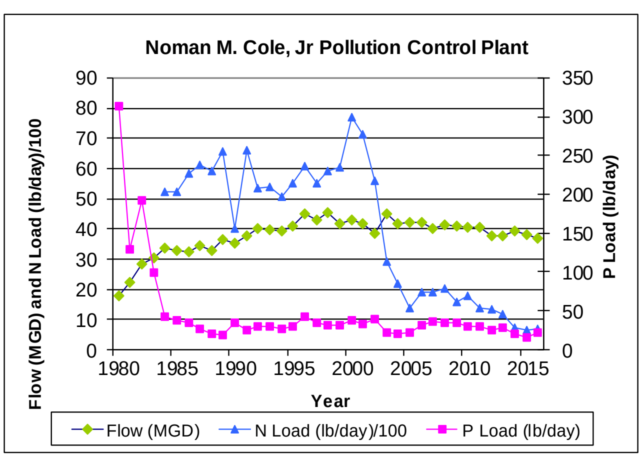
Executive Summary



Gunston Cove is an embayment of the tidal freshwater Potomac River located in Fairfax County, Virginia about 12 miles (20 km) downstream of the I-95/I-495 Woodrow Wilson Bridge. The Cove receives treated wastewater from the Noman M. Cole, Jr. Pollution Control Plant and inflow from Pohick and Accotink Creeks which drain much of central and southern Fairfax County. The Cove is bordered on the north by Fort Belvoir and on the south by the Mason Neck. Due to its tidal nature and shallowness, the Cove does not seasonally stratify vertically, and its water mixes gradually with the adjacent tidal Potomac River mainstem. Thermal stratification can make nutrient management more difficult, since it can lead to seasonal oxygen-diminished bottom waters that may result in fish mortality. Since 1984 George Mason University personnel, with funding and assistance from the Wastewater Management Program of Fairfax County, have been monitoring water quality and biological communities in the Gunston Cove area including stations in the Cove itself and the adjacent River mainstem. This document presents study findings from 2016 in the context of the entire data record.

The Chesapeake Bay, of which the tidal Potomac River is a major subestuary, is the largest and most productive coastal system in the United States. The use of the bay as a fisheries and recreational resource has been threatened by overenrichment with nutrients which can cause nuisance algal blooms, hypoxia in stratified areas, and a decline of fisheries. As a major discharger of treated wastewater into the tidal Potomac River, particularly Gunston Cove, Fairfax County has been proactive in decreasing nutrient loading since the late 1970's. Due to the strong management efforts of the County and the robust monitoring program, Gunston Cove has proven an extremely valuable case study in eutrophication recovery for the bay region and even internationally. The onset of larger areas of SAV coverage in Gunston Cove will have further effects on the biological resources and water quality of this part of the tidal Potomac River.

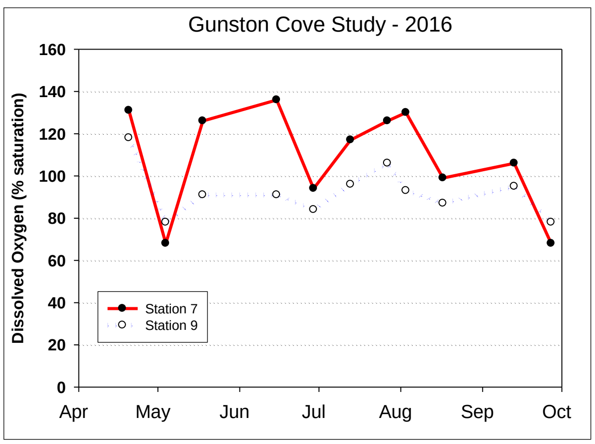


As shown in the figure to the left, phosphorus loadings were dramatically reduced in the early 1980's. In the last several years, nitrogen, and solids loadings as well as effluent chlorine concentrations have also been greatly reduced or eliminated. These reductions have been achieved even as flow through the plant has slowly increased.

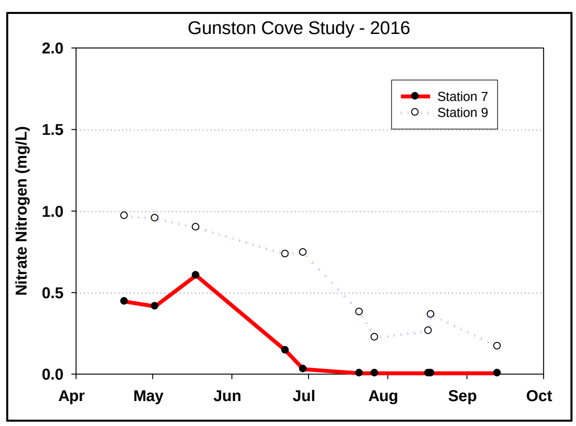
The ongoing ecological study reported here provides documentation of major improvements in water quality and biological resources which can be attributed to those efforts. Water quality improvements have been substantial in spite of the increasing population and volume of wastewater produced. The 30 plus year record of data from Gunston Cove and the nearby Potomac River has revealed many important long-term trends that validate the effectiveness of County initiatives to improve treatment and will aid in the continued management and improvement of the watershed and point source inputs.

The year 2016 was characterized by well above normal temperatures for the summer months. Monthly precipitation was well above normal in May, but close to normal in other months. Two sampling dates (early May and late June) occurred following significant flow events.

Mean water temperature was similar at the two stations reaching a maximum over 30°C in late July. Specific conductance declined substantially at both stations in the wake of the early May flow events, then gradually increased through the remainder of the year.

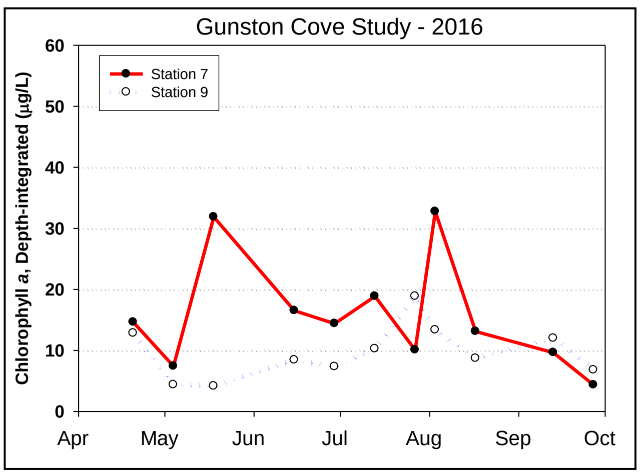


Chloride showed a similar pattern, but was consistently somewhat higher in the cove. Dissolved oxygen saturation (DO) was normally substantially higher in the cove than in the river due to photosynthetic activity of phytoplankton and submersed aquatic vegetation (SAV) (figure at left). An exception to this occurred in the wake of the early May flow event when both areas showed a depression in DO which was very marked in the cove. A second, lesser decline in late June was in the wake of a second flow event. Field pH patterns mirrored those in DO: higher values in the cove than the river and strong response to the early May flow event. Total alkalinity was generally higher in the river than in the cove and was fairly constant seasonally. Secchi disk transparency was generally lower in the cove in spring and showed a depression in the early May sampling as well as the late June sampling. By late summer Secchi disk transparency in the cove increased above river values and approached 1.8 m by late September. Light attenuation coefficient and turbidity followed a similar pattern.



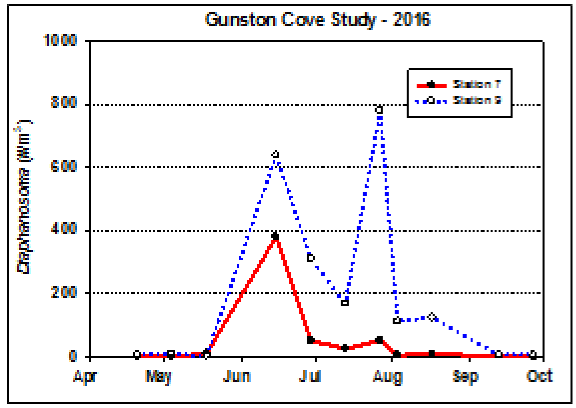
Ammonia nitrogen was consistently low in the study area during 2016. All but one value was below the limits of detection which makes analyzing any temporal or spatial trends impossible. Un-ionized ammonia remained below values that would cause toxicity issues, but exact values were not possible due to the high incidence of nondetects on total ammonia. Nitrate values declined seasonally at both sites due to algal and plant uptake and possibly denitrification. By late July nitrate nitrogen in the cove was below detection limits where it remained through the remainder of the year (see figure above). River nitrate nitrogen levels reached a low of about 0.2 mg/L. Organic nitrogen exhibited substantial variability with a decline in values in the cove through the course of the year. Total phosphorus was similar at both sites and showed little seasonal change. Soluble reactive phosphorus was very low and consistently below detection limits in the cove and higher in the river. N to P ratio declined strongly at both stations reaching a minimum of about 12 in September which is still indicative of P limitation of phytoplankton and SAV. Biochemical oxygen demand (BOD) was generally higher in the cove than in the river. Total suspended solids (TSS) was fairly constant throughout the year. Peak value in the river was observed in late June; interestingly, the early May flow event did not seem to affect TSS. Volatile suspended solids (VSS) was also fairly constant between sites and seasonally.

In the cove algal populations as measured by chlorophyll *a* declined strongly in the wake of the early May flow event. A strong rebound was observed in late May followed by a gradual decline and another peak in early August. In the river, the early May decline was observed, but levels recovered only gradually reaching a late July peak. Both cell density and biovolume indicated the flow-induced decline in phytoplankton in early May in the cove and in the river. Values in the cove also showed a decline in late June, the time of the second flow event. The early August peak in the cove in chlorophyll was not seen in the cell count data. Due to a cutback in phytoplankton count frequency, cell counts were not done on the late July sample from the river. Cell density data from the cove was dominated by cyanobacteria, the principal species being *Oscillatoria*. In the river, diatoms dominated cell density data for most of the year, first Pennate 2, then Pennate 1, and finally *Melosira*. In late summer other groups were important with *Anabaena* numerous in August and *Dictyospherium* important in September. Cell biovolume was more evenly distributed among various taxa in the cove than was cell density. In the river cell biovolume was dominated by diatoms with discoid centrics most important in the first half of the year and *Melosira* in the second half. Rotifers continued to be the most numerous zooplankton in 2016.



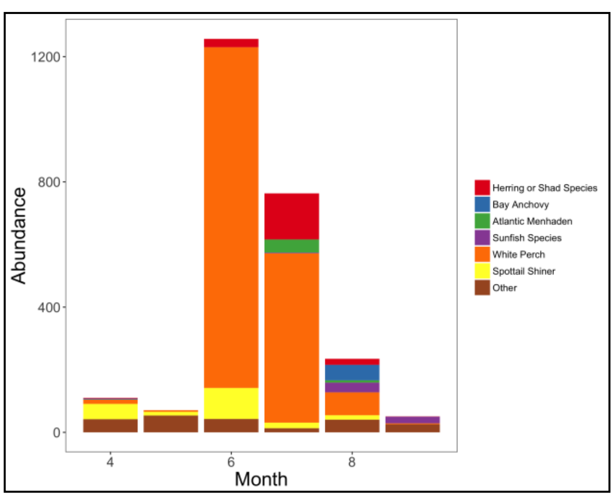
Rotifer densities were unusually high in April in both areas, but declined dramatically in early May in response to the flow event. Another peak was observed in late June. *Brachionus*, *Filinia*, and *Keratells* shared dominance in the cove; *Filinia* was not common in the river, but *Brachionus* and *Keratella* were. *Bosmina*, a small cladoceran that was often common was only present at low densities in 2016. *Diaphanosoma*, a larger cladoceran was found in both area at moderate densities. Both peaked in late June and then declined after in the wake of the flow event. A subsequent higher peak in

Diaphanosoma in the river was not found in the cove (see graph below). Surprisingly, *Daphnia* and *Ceriodaphnia* exhibited their one strong peak in the cove in early May. *Moina* was only found in substantial number is late June in the river. *Leptodora* also seemed to respond positively to the early May flow event in the cove and reached even higher levels in early June in both areas. Copepod nauplii densities reached a peak in both study areas in early June and then declined. A second peak was found in the river in late August. The calanoid copepod *Eurytemora* was very abundant in the cove in early May whereas the river maximum was found in early June. A second calanoid *Diaptomus* was restricted to the river at lower levels. Cyclopoid copepods had a strong maximum in early May in the cove and a mid-July maximum in the river.



In 2016 ichthyoplankton was dominated by clupeids, most of which were Gizzard Shad and Alewife, and to a lesser extent, Blueback Herring, American Shad, and Hickory Shad. White Perch was a dominant species as well, with the same relative contribution to the total ichthyoplankton community as Gizzard Shad. Striped Bass and Inland Silverside was found in relatively high densities as well. *Morone* species (White Perch and Striped Bass) were mostly found in the Potomac mainstem, confirming their affinity for open water. Other taxa were found in very low densities similar to the previous year. The highest density of fish larvae occurred in mid-May, which was driven by a high density of Clupeid larvae.

A total of 2484 fishes comprising 24 species were collected in all trawl samples combined (see Figure below). The dominant species of the fish collected in the trawls was White Perch (69.4%, numerically). In the spring, adult White Perch were primarily caught in the nets while later in the summer juveniles dominated. Other abundant taxa included herring or shad (7.9%), Spottail Shiner (7.7%), Sunfishes (2.2%), and Bay Anchovy (2.1%). Other species were observed sporadically and at low abundances. A total of 35 seine samples were conducted, comprising 3885 fishes of 26 species. This is a little lower than the number of individuals and species collected last year. Similar to last year, the most dominant species in seine catches was Banded Killifish, with a relative contribution to the catch of 56.4%. Other dominant species (with >5% of relative abundance) were White Perch (10.2%) followed by Inland Silverside (7.1%), eastern Silvery Minnow (6.2%), and Alosa sp. (5.2%). In 2016 we collected a total number of 456



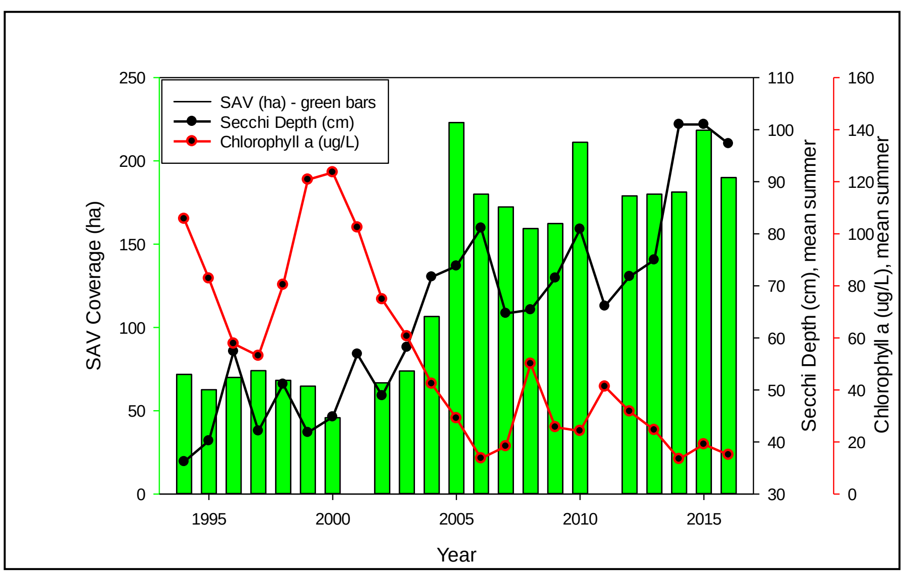
specimens of 15 species in the two fyke nets, which is a little bit less than last year. While Banded Killifish is abundant here as well (23% of the catch), the fyke nets show a high contribution of sunfishes too.

The coverage of submersed aquatic vegetation (SAV) in 2016 was similar to recent years. In 2016, species distributions were mapped. The exotic plant *Hydrilla* was the most dense and widespread species, but the native species *Ceratophyllum* (coontail) was also widespread. As in most previous years, oligochaetes were the most common invertebrates collected in ponar samples in 2016. Chironomids were the second most abundant in the cove, but were found at much lower levels in the river. Amphipods were the second most abundant taxon at Station 9 with isopods also very common.

In the anadromous creek survey (of fish migrating from salt water to spawn in fresh water), Alewife was the dominant species in both larval and adult collections in both Pohick and Accotink Creeks. In the hoop net sets, 170 Alewife, 89 Blueback Herring, and 21 Hickery Shad adults were collected. While these numbers were lower than observed in 2015, they are still strong relative to previous years. In a notable sign of recovery Pohick Creek, which was totally devoid of spawning fish in the early years of the study, now typically harbors more spawners than Accotink Creek. In fact, almost all of the Blueback Herring and Hickory Shad spawning was in Pohick Creek.

Two literature-based special reports were commissioned in 2016, both concerned with benthic macroinvertebrates. These reports were included as separate chapters at the end of this full annual report. One involved development of a benthic index of biotic integrity for the tidal freshwater Potomac River. Progress was made in compiling a complete list of potential macroinvertebrate taxa and features of their ecology like pollution tolerance which are required for index development. Additional data needs such as reference site data were identified. The second special report compiled relevant information on the status and diversity of native freshwater mussels in the tidal freshwater Potomac River. This lays the ground for enhanced efforts to sample these valuable indicator organisms.

Data from 2016 generally reinforced the major trends which were reported in previous years. First, phytoplankton algae populations (which can cause nuisance algal blooms, hypoxia in stratified areas, and a decline of fisheries) in Gunston Cove have shown a clear pattern of declined since 1989. Accompanying this decline have

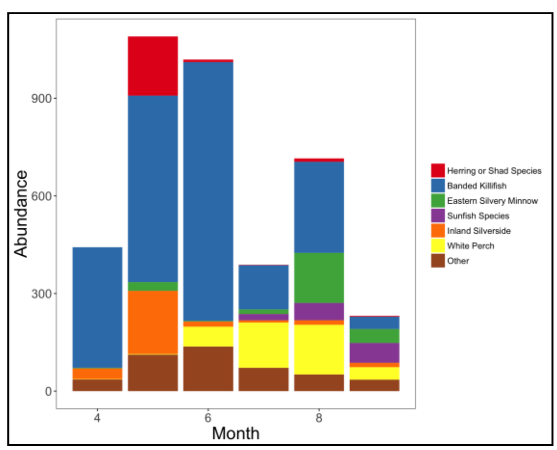


been more normal levels of pH and dissolved oxygen, and increased water clarity which are critical for a life-sustaining aquatic habitat. Data available through 2016 from Virginia Institute of Marine Science for SAV (submersed aquatic vegetation) assessment have indicated that the coverage by plants has remained at elevated levels observed since 2005 (green bars in figure above). The increased water clarity in the Cove has brought the rebound of SAV which provides increased habitat value for fish and fish food organisms. The SAV also filters nutrients and sediments and itself will inhibit the overgrowth of phytoplankton algae. This trend is undoubtedly the result of phosphorus removal practices at Noman M. Cole Pollution Control Plant which were initiated in the late 1970's (see first figure in Executive Summary). This lag period of 10-15 years between phosphorus control and phytoplankton decline has been observed in many freshwater systems resulting at least partially from sediment loading to the water column which can continue for a number of years. Gunston Cove is now an internationally recognized case study for ecosystem recovery due to the actions that were taken and the subsequent monitoring to validate the response.

A second significant change in water quality documented by the study has been the removal of chlorine and ammonia from the Noman M. Cole, Jr. Pollution Control Plant effluent. A decline of over an order of magnitude in ammonia nitrogen has been observed in the Cove as compared to earlier years. The declines in ammonia and the elimination of chlorine from the effluent (to values well below those that may result is toxicity problems) have allowed fish to recolonize tidal Pohick Creek which now typically has more spawning activity than tidal Accotink Creek. Monitoring of creek fish allowed us to observe recovery of this habitat which is very important for spawning species such as shad. The decreased ammonia, suspended solids, and phosphorus loading from the plant have contributed to overall Chesapeake Bay cleanup.

Another trend of significance which is indicative of the Cove recovery is changes in the relative abundance of fish species. While it is still the dominant species in trawls, White Perch has gradually been displaced in seines by Banded Killifish. This trend continued in 2016 with Banded Killifish being much more abundant in seines than White Perch. In general this is a positive development as the net result has been a more diverse fish community. Blue Catfish have entered the area recently, and brown bullhead has decreased greatly in the Cove. Blue Catfish are regarded as rather voracious predators and may negatively affect the food web.

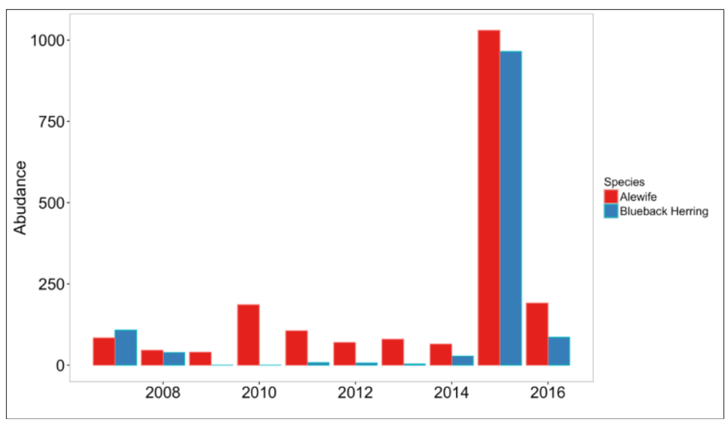
Clearly, recent increases in SAV provide refuge and additional spawning habitat for Banded Killifish and Sunfish. Analysis shows that White Perch dominance was mainly indicative of the community present when there was no SAV; increased abundances of Bay Anchovy indicative for the period with some SAV; and Banded Killifish and Largemouth Bass indicative of the period when SAV beds were expansive. In 2016 seine collections were dominated by Banded Killifish (see graph to the right).



While the seine does not sample these SAV areas directly, the enhanced growth of SAV provides a large bank of Banded Killifish that spread out into the adjacent unvegetated shoreline areas and are sampled in the seines. The fyke nets that do sample the SAV areas directly documented a dominance of Sunfish and Banded Killifish in the SAV beds. In addition to SAV expansion, the invasive Blue Catfish may also have both direct (predation) and indirect (competition) effects, especially on species that occupy the same niche such as Brown Bullhead and Channel Catfish. Overall, these results indicate that the fish assemblage in Gunston Cove is dynamic and supports a diversity of commercial and recreational fishing activities.

Juvenile anadromous species continue to be an important component of the fish assemblage in Gunston Cove. We have seen declines in "river herring" (a multispecies group that includes both Alewife and Blueback Herring) since the mid-1990s, which is in concordance with other surveys around the Potomac and Chesapeake watersheds. In January 2012, a moratorium on river herring was put in effect to alleviate fishing pressure in an effort to help stocks rebound. We reported last year that the larval abundances of the *Alosa* genus was high in 2014, possibly resulting in higher adult abundances in 2015. We indeed saw higher numbers of juvenile Blueback Herring and Alewife in trawls in 2015, but this was not repeated in 2016.

The most direct indication we have of the status of river herring spawning populations is the anadromous study in Pohick and Accotink Creeks (which included Dogue Creek and Quantico Creek up to 2008). We witnessed a one to two orders of magnitude increase in catches from Accotink and Pohick Creeks of Alewife and Blueback Herring (the two species that are considered river herring) in 2015; 2016 catches were somewhat lower, but still substantial (figure to the right). The shad moratorium has been in place in Virginia and neighboring states for four years, which means this is likely the first cohort protected by this moratorium for one full life cycle. Through meetings with the Technical Expert Working group (TEWG) for river herring (http://www.greateratlantic.fisheries.noaa.gov/protected/riverherring/tewg/index.html), it has become clear that not all tributaries of the Chesapeake Bay, in Virginia and elsewhere, have seen increased abundances in 2015; some surveyors even reported declines. Since the decline in river herring was related both to overfishing and habitat degradation, it could be the case that habitat in those areas has not recovered sufficiently to support a larger spawning population now that fishing pressure is released. Thus, the habitat in the Gunston Cove may be of suitable quality to support a larger spawning population now that reduced fishing pressure allows for more adults to return to their natal streams. Continued monitoring in years after this large spawning population was observed, will determine if this spawning season results in a successful year class, and if this is the first year of continued high river herring abundances.



In summary, it is important to continue the data record that has been established to allow assessment of how the continuing increases in volume and improved efforts at wastewater treatment interact with the ecosystem as SAV increases and plankton and fish communities change in response. Furthermore, changes in the fish communities from the standpoint of habitat alteration by SAV and introductions of exotics like snakeheads and blue catfish need to be followed.

Global climate change is becoming a major concern worldwide. Since 2000 a slight, but consistent increase in summer water temperature has been observed in the Cove which may reflect the higher summer air temperatures documented globally. Other potential effects of directional climate change remain very subtle and not clearly differentiated given seasonal and cyclic variability.

We recommend that:

1. Long term monitoring should continue. The revised schedule initiated in 2004 which focuses sampling in April through September has captured the major trends affecting water quality and the biota. The Gunston Cove study is a model for long term monitoring which is necessary to document the effectiveness of management actions. This process is sometimes called adaptive management and is recognized as the most successful approach to ecosystem management.
2. Two aspects of the program should be reviewed.
    a. In 2016 phytoplankton cell counts frequency was decreased from twice monthly to monthly as a cost-saving step. But it does result in some sampling dates not having phytoplankton data to go along with the other variables. If funds are available, we recommend reinstituting twice monthly phytoplankton counts.
    b. As nutrient concentrations have decreased in the river and cove due to management successes, we are now encountering a substantial number of samples which are below detection limits. This becomes a problem in data analysis. To date we have set “below dection limits” values at ½ the detection limit, but this becomes less defensable the greater the proportion of these values. This is particularly true of nitrate and ammonia nitrogen. We recommend reviewing analytical protocols to try to lower detection limits for these two variables.
3. The fyke nets have proven to be a successful addition to our sampling routine. Even though a small, non-quantitative sample is collected due to the passive nature of this gear, it provides us with useful information on the community within the submersed aquatic vegetation beds. Efficient use of time allows us to include these collections in a regular sampling day with little extra time or cost. We recommend continuing with this gear as part of the sampling routine in future years.
4. Anadromous fish sampling is an important part of this monitoring program and has gained interest now that the stock of river herring has collapsed, and a moratorium on these taxa has been established in 2012. We recommend continued monitoring, and we plan to use the collections before and during the moratorium to help determine the effect of the moratorium. Our collections will also form the

basis of a population model that can provide information on the status of the stock.

5. GMU's Potomac Environmental Research and Education Center instituted a continuous water quality monitoring site at Pohick Bay marina in May 2011. This program was suspended in 2014 due to ramp construction near the monitor, but we will consider reinstituting the program in 2017 should the County consider it valuable.
6. As river restoration continues, the benthic community including native mussels is showing signs of rejuvenation. We recommend that more use be made of the benthos in tracking recovery of the River. To that end we recommend that the initative to construct a Benthic Index of Biotic Integrity (B-IBI) for the tidal Potomac River be continued with the goal of having a trial index available by the end of the next contract.
7. The assessment of native river mussel populations which was completed in 2016 found that there is a substantial pool of potential mussel species in the river, but we are not using effective methods to sample them. We propose to try out a new sampling system called a brail with the goal of accurately and comprehensively inventorying the current status of river mussels in the tidal freshwater Potomac.
8. Recent work has raised awareness that some pollutants may be causing sublethal stress on fish populations which are manifest in higher incidences of disease and abnormalities. We recommend that that a pilot study be done to establish a baseline of the incidence of these impacts in specific Gunston Cove taxa and explore the feasibility of routine assessment of fish abnormalities as part of the monitoring program.

List of Abbreviations

BOD	Biochemical oxygen demand
cfs	cubic feet per second
DO	Dissolved oxygen
ha	hectare
l	liter
LOWESS	locally weighted sum of squares trend line
m	meter
mg	milligram
MGD	Million gallons per day
NS	not statistically significant
NTU	Nephelometric turbidity units
SAV	Submersed aquatic vegetation
SRP	Soluble reactive phosphorus
TP	Total phosphorus
TSS	Total suspended solids
um	micrometer
VSS	Volatile suspended solids
#	number