An Ecological Study of Gunston Cove

2012

FINAL REPORT

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by

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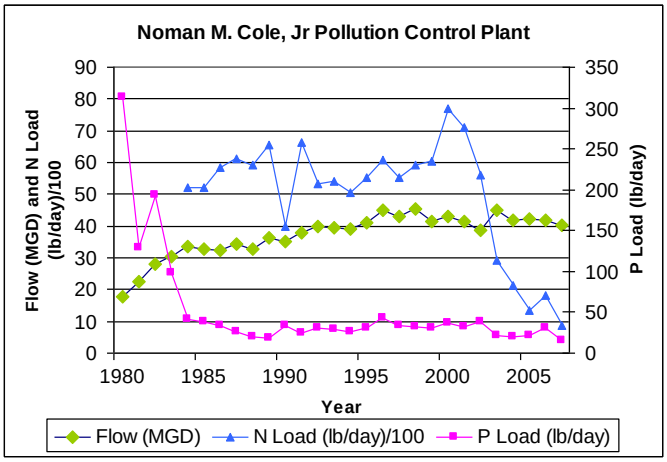
Executive Summary

Gunston Cove is an embayment of the tidal freshwater Potomac River located in Fairfax County about 12 mi (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 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. Since 1984 George Mason University personnel 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 2012 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 declining 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. As shown in the figure to the right, phosphorus loadings were dramatically reduced in the early 1980's. In the last several years, nitrogen loadings have also been greatly reduced. The reduction in loadings has been achieved even as flow through the plant has been increasing.

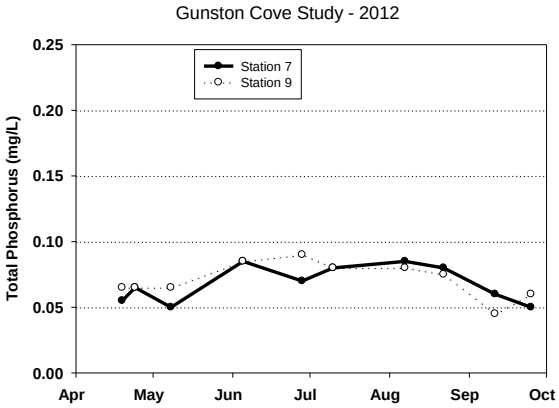


The ongoing ecological study reported here provides documentation of major improvements in water quality and biological resources which can be attributed to those efforts. Water quality improvements have been substantial in spite of the increasing population and volume of wastewater produced. The nearly 30 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 of the watershed and point source inputs.

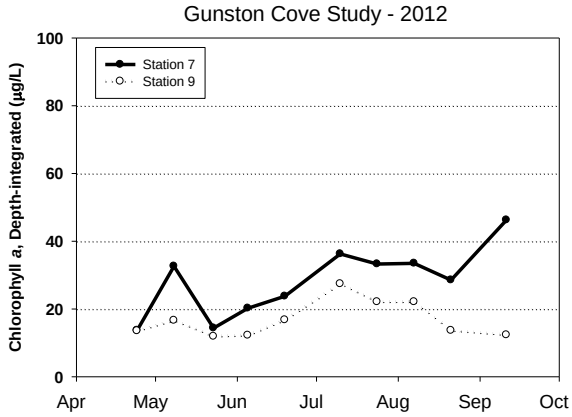
The year 2012 was characterized by above normal temperatures from March through October with highest monthly average of 28.9°C in July. Monthly precipitation was below normal for most of this same period with 20.2 cm occurring during the summer months (June – August) in 2012 compared with the long term average of 26 cm. Rainfall was above normal in both September and October. Mean monthly discharge of the mainstem Potomac at Little Falls was also below normal during this period reaching a

minimum in July. Local tributary inflow into tidal Gunston Cove was generally below normal although May and June were slightly above normal. August had lowest mean monthly flow. Highest flows occurred October as a function of Hurricane Sandy.

Water temperature tracked air temperature on a seasonal basis with little difference between the two sites. Specific conductance was generally in the 300-400 µS/cm range at both sites. Specific conductance and chloride continued to increase through August and dropped back slightly in September. Indicators of photosynthetic intensity (dissolved oxygen-percent saturation and field pH) showed an initial peak in the cove in early May and then a period of sustained increased through the summer. In the river, there was little seasonal change in these parameters. Light penetration was generally slightly higher in the river than in the cove as indicated by Secchi disk depth and light attenuation coefficient. Secchi depth was consistently above 80 cm in the river, but more like 70 cm in the cove. Total alkalinity was generally 60-80 mg/L as $CaCO_3$ with somewhat higher values in the river on most dates.

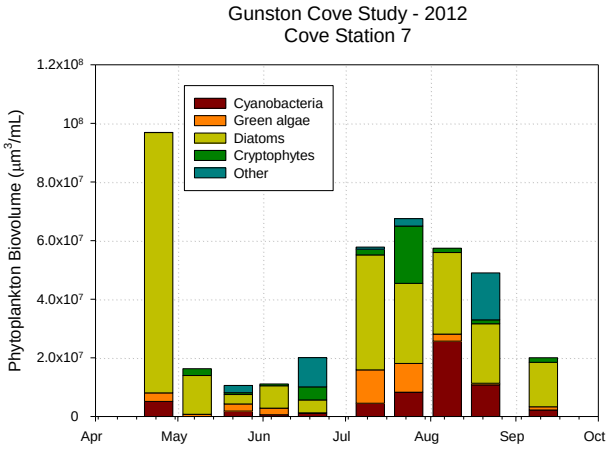


Ammonia nitrogen was very low (<0.05 mg/L) on most dates in both cove and river. Nitrate was found at moderate levels at both sites in the spring and decreased steadily in the early summer to very low levels before rebounding in the fall. River values were consistently about 0.2 mg/L greater than those in the cove. Nitrite nitrogen was much lower being less than 0.02 mg/L in the cove and reaching a peak of 0.04 mg/L in the river. Organic nitrogen showed an inverse temporal trend at the two sites. In the river the peak value was in early May at nearly 1.2 mg/L whereas in the cove there was a maximum at about 0.9 mg/L by late August. Total phosphorus followed similar seasonal trends and values at both sites. Spring and fall values were 0.05-0.07 mg/L while summer values approached 0.10 mg/L. SRP values were generally much lower being mostly below 0.01 mg/L in the cove and 0.01-0.02 mg/L in the river. N to P ratio (by weight) showed a steady seasonal decline at both sites from about 30 in early May to 10 July and early August. Values approached, but did not attain, those associated with the onset of nitrogen limitation (7.2). BOD showed much fluctuation between dates, but a consistent spatial pattern of higher values at Station 7. Total suspended solids were very similar in almost all months. TSS was consistently slightly higher in the cove in late summer and fall. VSS was slight, but consistently higher in the cove with little seasonal pattern.



Algal populations as measured by chlorophyll a were consistently higher in the cove than in the river with an annual average of about 30 µg/L in the cove and 20 µg/L in the river. After a peak in early May, chlorophyll in the cove increased

through September attaining 45 ug/L in September. In the river the high was about 30 µg/L in early July. Phytoplankton density was closely matched at the two sites from April through early July. Phytoplankton cell density at the Gunston Cove site was dominated by cyanobacteria on all dates and at both sites due to their small size. The dominant taxon in spring was *Anabaena* while *Microcystis* was most important in mid-summer, and *Merismopedia* in the fall. *Oscillatoria* attained substantial numbers in most samples from the cove. In the river *Oscillatoria* was dominant in the spring and into the summer. In August dominance shifted to *Microcystis* and *Aphanocapsa*. Diatoms dominated phytoplankton biovolume in the cove and river for much of the year, being very abundant in late April and again in July and August. Cyanobacteria and cyptophytes were important on some dates. *Oscillatoria* was greatest in cyanobacterial biovolume on most dates with *Anabaena*, *Spirulina*, and *Anabaenopsis* being important in early August. In the river *Oscillatoria* was also the dominant in cyanobacterial biovolume. Noncyanobacterial biovolume was generally dominated by *Melosira* or by discoid centric diatoms with another diatom *Gyrosigma* being important in April and September. A similar dominance by *Melosira* and discoid centrics was observed in the river.



Rotifers were the most numerous zooplankton in the study area with abundances in the cove general twice those in the river. *Brachionus* and *Keratella* were the most abundant at both sites and on most dates with *Keratella* clearly more abundant in the river and *Brachionus* more frequently dominant in the cove. The small cladoceran *Bosmina* was quite abundant in both study areas in spring and in the river was again abundant in early July. The larger abundant cladoceran *Diaphanosoma* was also generally more abundant in the river reaching a maximum of just over 10,000/m^3 in early July in the river. The other herbaceous cladocera were quite low except for *Moina* in early June which reached 3000/m^3 in the river. *Leptodora*, the predaceous cladoceran, peaked at 1500/m^3 in the cove in early June, much higher than the river peak. The seasonal pattern of nauplii (immature copepods) was quite different in cove and river. In the river nauplii densities increased to a peak in early June and then decreased for the remainder of the year. In the cove the increase was more gradual and continued into September. *Eurytemora*, a calanoid copepod reached similar peaks in both study areas of about 5000/m^3 in early June. Other calanoids were also at peak abundance at that time. Cyclopoid copepods were quite abundant in the river, especially in late June and July.

In 2012 ichthyoplankton in Gunston Cove was dominated by *Dorosoma* sp. (gizzard shad) and, to a lesser extent, alosines (alewife or blueback herring). Other clueids (herring or shad) and members of the genus *Morone* (white perch or striped bass) were significant as well. Other taxa made up less than one percent of the total abundance, which, similar to the results in 2011, resulted in low diversity. Highest abundances of each of the taxa were found in the Potomac mainstem, which indicates the presence of

significant spawning habitat upstream of Gunston Cove. The peak in ichthyoplankton production was late April-early May, which confirms this time of year is an important spawning period for all fish.

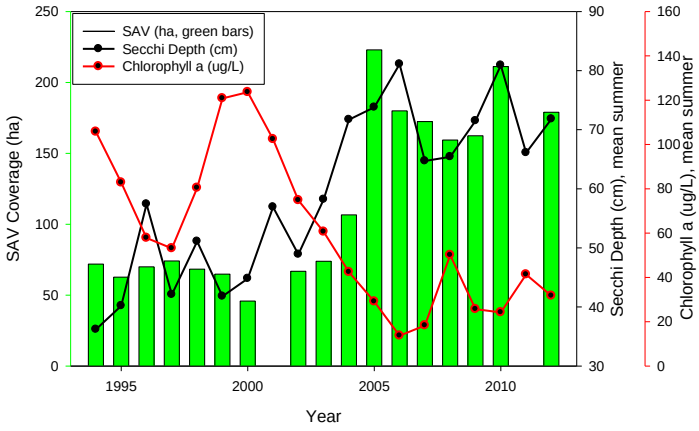
In trawls, the overwhelming majority of the fish collected was white perch (*Morone americana*). Though still the third most abundant, spottail shiner (*Notropis hudsonius*) was significantly less abundant in 2012 then 2011. In 2012, bay anchovy (*Anchoa mitchilli*) was the second most abundant species, and three times more abundant than spottail shiner. Bay anchovy is typically found in more saline waters, but this polyhaline species is found in our catches on an irregular basis. Other numerically abundant species included: sunfish (*Lepomis* sp.), blue catfish (*Ictalurus furcatus*), and yellow perch (*Perca flavescens*). The abundance of blue catfish was an order of magnitude higher than channel catfish, which is an indication of the newly established dominance of the invasive blue catfish over similar species in this area. Blue catfish was only found in the Potomac mainstem, which indicates that Gunston Cove remains important habitat for native species. To put the invasion of blue catfish in perspective; they still only constitute 2.4 % of the total abundance found in trawls. Abundance of alosines was lower in trawls than the (already low) abundance in 2011, which is likely reflective of the overall low abundance of this stock. Our future monitoring of these species will help determine if the recent moratorium on river herring (January 2012) aids in their recovery. Except for blue catfish and bay anchovy, the catches of all species were much higher in the inner cove than in the mainstem, which is another indication of the importance of Gunston Cove as fish habitat.

In seines, the most abundant species by far was banded killifish (*Fundulus diaphonus*), followed by inland silverside (*Menidia beryllina*). White perch was less abundant as usual, and the lower abundance of the open-water dwelling white perch is one of the signs of a transition to a more SAV-associated fish community in Gunston Cove. The abundance peak of banded killifish was in early May, which is earlier than previous years. Whether the order of magnitude lower abundance after May is a result of reduced catchability due to SAV expansion is investigated using fyke nets. Other dominant species in seine caches include spottail shiner, bluegill, eastern silvery minnow, golden shiner and tessellated darter. Again in 2012, the difference in fish community collected with different gear at different habitats emphasizes the importance of sampling with different gear types to obtain a representative sample of the nekton community present at Gunston Cove.

Fyke nets were set up at the end of June near inner cove seine and trawl sites to sample the dense SAV beds. The most abundant species were sunfish (bluegill, redear sunfish, and pumpkinseed) followed by banded killifish. These are all indeed known to be SAV-associated taxa, that use SAV-beds as habitat and spawning grounds. Even though fyke nets are passive gear (fish need to enter the nets to be captured), they proved to be successful with a total catch of 1500 specimens. The catches of banded killifish were similar throughout the period sampled with fyke nets (June 22-Sept 10). The overall abundance is however much lower than in seine catches, and the two gear types cannot be directly compared. To determine whether banded killifish have reduced abundance after a peak in early summer, or if their catchability is reduced due to SAV expansion, fyke nets need to be set up starting early May, which will be done in 2013.

Ponar samples indicated that as in most years oligochaetes were the most common invertebrates in the benthos and were found at about twice the density at Station 9 than at Station 7. In the cove diptera (chironomid/midge) larvae made up the bulk of the remaining organisms although they were present in lower numbers than in most years. A handful of amphipods were found in some of the cove samples. In the river, amphipods (crustaceans commonly known as scuds) were found in moderate numbers. *Corbicula* (Asiatic clam) was absent from the cove and rarer in the river than in recent years.. Diptera were rare in the river and *Corbicula* were absent in the cove.

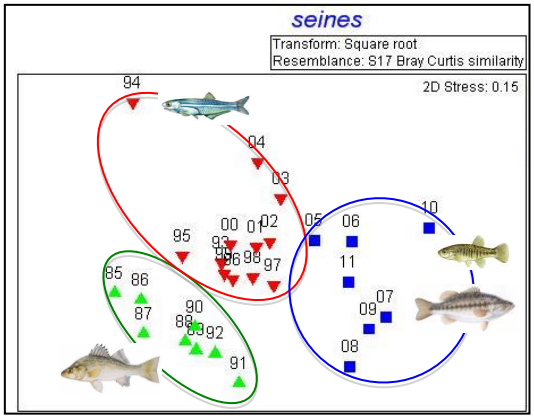
Data from 2012 generally reinforced the major trends which were reported in previous years. First, phytoplankton algae populations in Gunston Cove have shown a clear pattern of decline since 1989. Accompanying this decline have been more normal levels of pH and dissolved oxygen, and increased water clarity. Data were again available in 2012 from VIMS for SAV (submersed aquatic vegetation) assessment and the coverage by plants remained at the elevated levels observed since 2005. The increased water clarity 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 Cole wastewater treatment plant which were initiated in the late 1970's. 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. PCP 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 chlorine have allowed fish to recolonize tidal Pohick 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 has also lowered nitrogen loading from the plant contributing to overall Bay cleanup.

Another trend of significance to managers 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. Blue catfish have entered the area recently, and

brown bullhead has decreased greatly in the cove. To determine some of the most significant changes in the fish community through time, we performed a community analysis using the seine collections.



Seine collections. Community composition changes through time. The community was similar in years without SAV beds (green triangles). Two community shifts coincided with SAV expansion, resulting in distinct communities from 1993-2004 (red triangles), and 2005-present (blue squares). Species most indicative for the community changes through time are pictured.

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. 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, the fish assemblage in Gunston Cove is dynamic and supports a diversity of commercial and recreational fishing activities.

In short, 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. It is important to continue the data record that has been established to allow assessment 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, introductions of exotics like snakeheads, and possible contaminant effects such as those from hormone pollution need to be followed.

Global climate change is becoming a major concern worldwide. In the past five years 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 should capture 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. 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 SAV 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.
3. 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.
4. The Potomac Environmental Research and Education Center instituted a continuous water quality monitoring site at Pohick Bay marina in May 2011. We anticipate keeping this station going for the foreseeable future and will continue to share data with the County.
5. Development should continue on a river health index which will synthesize measurements made from a variety of water quality parameters and biological communities to facilitate tracking of the aquatic health of Gunston Cove and the surrounding area. An initial application of literature-derived indices to 2012 data is underway.

Dedication

This year's report is dedicated to Elaine Schaeffer, Director of the Fairfax County Environmental Services Laboratory, Department of Public Works and Environmental Services, located at the Noman Cole Pollution Control Plant. Elaine has been our liaison with the County since the study's inception in 1984. She has been a strong supporter and a very effective channel of communication with the County as the study has progressed. She will be greatly missed as she retires later this year, both for her intellectual inputs and also for her positive personality. Her guidance has enabled our achievements in documenting this much-earned success story of water quality improvement by Fairfax County which has consistently striven to diminish its impact on the river. Our heartfelt thanks for her contributions.

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