An Ecological Study of Gunston Cove

2008

FINAL REPORT

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by

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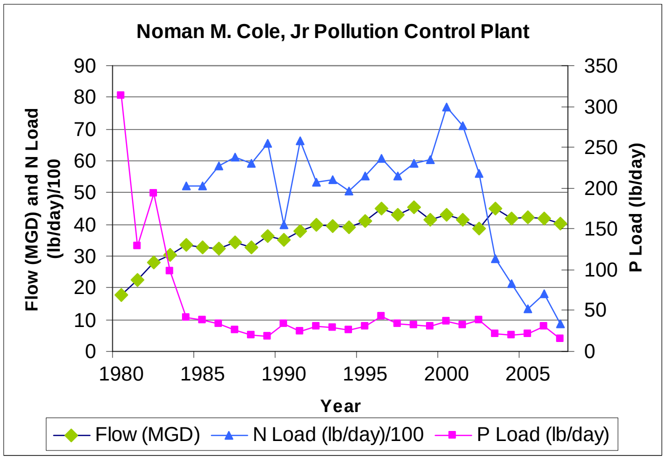
Executive Summary

Gunston Cove is a 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 2008 in the context of the entire data record.

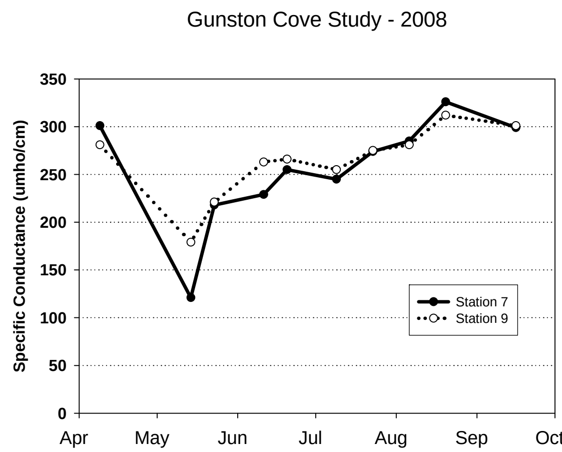
The Chesapeake Bay, of which the tidal Potomac River is a major subestuary, is the largest and most productive coastal system in the United States. The use of the Bay as a fisheries and recreational resource has been threatened by overenrichment with nutrients which can cause nuisance algal blooms, hypoxia 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 25+-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.

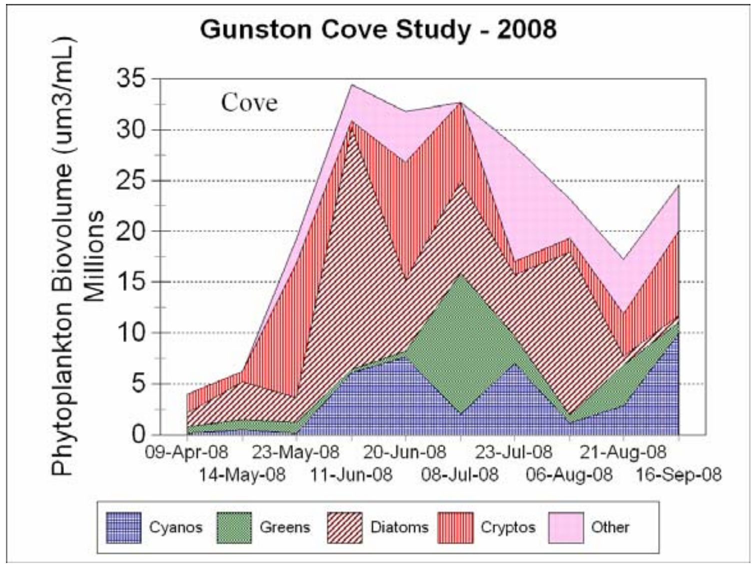
The outstanding weather events in 2008 were the very high rainfall and associated stream inflow in May and the higher than normal summer temperatures, especially in June. The elevated rainfall and associated runoff in May led to flow surges in both the flowing tributaries leading to Gunston Cove and in the Potomac mainstem which impacted water quality in the cove and river. The low water temperatures observed in May probably reflected both slightly below normal temperatures and frequent flushing by runoff. Above average temperatures and tapering rainfall beginning in June allowed biological communities to begin a delayed seasonal increase.

Flushing due to increased freshwater inflow in May was evident in conductivity levels (right) which dropped strongly in mid May in both cove and river. These storm events also affect other water quality parameters. For example, turbidity increased and dissolved oxygen decreased as storm runoff impacted the cove. Ammonia nitrogen, total phosphorus, and total suspended solids increased markedly at both cove and river stations. TSS increases were directly related to the increased flows bringing in more water laden with suspended solids and resulted in substantially decreased water clarity (Secchi disk depth and light attenuation coefficient). Both phosphorus and ammonia nitrogen bind to solids and this could be responsible for their increases. Alkalinity and chloride both decreased markedly in May and chlorophyll *a* showed a clear decline due to flusing and dilution.



In the aftermath of the high May inflows, most parameters resumed their usual seasonal and spatial patterns. Temperature increased rapidly in June and remained above 25°C through mid September. Specific conductance rebounded strongly in June and then gradually increased through the remainder of the summer as did chloride. Dissolved oxygen was generally above saturation in the cove reflecting strong photosynthesis whereas values were generally somewhat below saturation in the river. Consistently higher pH was observed in the cove than the river consistent with higher DO's. Secchi depth rebounded in June and stabilized at 60-80 cm for the remainder of the study period at both study sites. Ammonia nitrogen decreased in June remaining somewhat higher in the river. Nitrate showed minimal response to the May flows, nor did it vary much for the rest of the year remaining generally higher in the river. Organic nitrogen showed a gradual rise through the summer in the cove, but little change in the river. Following the May spike, total P dropped back at both sites remaining virtually constant at about 0.07 mg/L at both sites. SRP showed little seasonal pattern being very low in the cove and somewhat higher in the river. N:P ratio was similar at both sites exhibiting a mild summer peak, always indicating P limitation. BOD was consistently higher in the cove, but did not change much seasonally. TSS and VSS settled to constant levels after May. TSS values were similar at both sites and VSS was consistently higher in the cove.

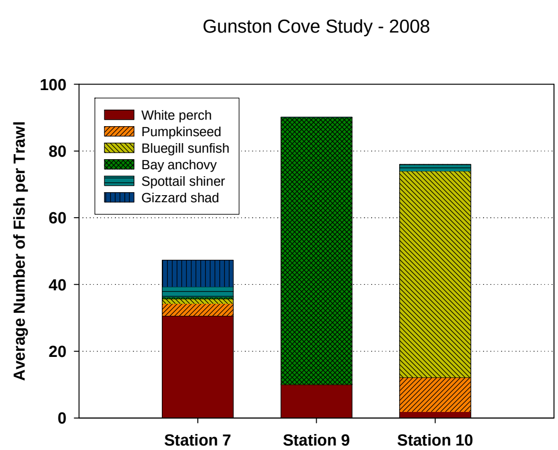
In the cove chlorophyll concentrations rebounded strongly in late May and continued to climb through July reaching higher levels than in recent years. In the river chlorophyll increased through June at much lower levels and declined slowly for the remainder of the year. In the cove phytoplankton density and biovolume increased strongly in June and remained high for the remainder of the summer. In the river there was little change in density seasonally, but a late summer increase in biovolume. Cyanobacteria dominated phytoplankton density in the cove alternating between *Oscillatoria* and *Aphanocapsa*. In the river densities were much lower and an unknown cyanobacterium and *Chroococcus* alternated with *Oscillatoria*. Cryptophytes were also important in density values in the river. Biovolume in the cove (right) increased strongly in late May led by cryptophytes and then diatoms in June including both *Melosira* and discoid centrics. The rest of the summer saw a diverse assemblage of all of the major groups. In the river diatoms were most important all year, principally *Melosira* and discoid centrics.



Rotifers regained abundance in June and remained numerous throughout the year in the cove, with *Brachionus* being dominant for most of the year. In the river rotifers were much less abundant with only a single peak in late August. The small cladoceran *Bosmina* was found in moderate numbers in summer samples from both sites with a peak in the river in late August. The larger cladoceran *Diaphanosoma* was quite high in late June and July at both sites. Following its high abundance in mid May, *Daphnia* was fairly uncommon. *Leptodora* was most common in June reaching similar maxima in both cove and river. Copepod nauplii were present at moderate values in the cove over the entire year and showed two larger peaks in the river. *Eurytemora* was abundant in some samples in May and June and was rarer in the late summer and fall. *Diaptomus* peaked in May and June in the cove, but was rare all year in the river. Cyclopoid copepods were abundant in the cove in the spring and in the river in summer.

In 2008 ichthyoplankton was dominated by *Dorosoma* sp (gizzard shad) and *Morone* sp. (white perch or striped bass) which comprised over 90% of the catch. Alosids and yellow perch were found reduced numbers.

In trawls (right), the majority of the catch was composed of 4 species: bay anchovy, bluegill sunfish, pumpkinseed, and white perch. The high abundance of bay anchovy was mainly due to one very large catch at

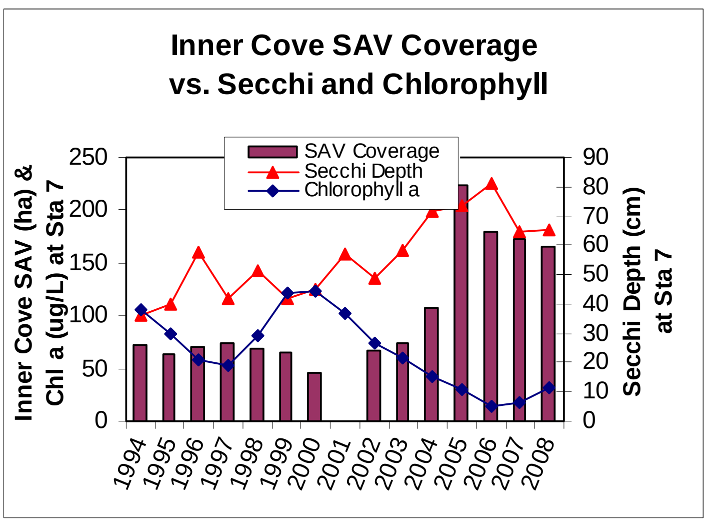


the end of the sampling season. As usual, white perch was found throughout the year at all stations. The sunfish were found throughout the year, but mainly at cove sites. In both groups, adults tended to be captured in spring and juveniles in the late summer. The most abundant species collected in seines was gizzard shad followed by banded killifish, the dominant in most recent years, and white perch, a distant third. Gizzard shad abundance was due to large numbers of juveniles collected in July and August. Banded killifish and white perch were collected at all stations and throughout the year. Our first northern snakehead was collected in April in Pohick Bay.

The emergence of submersed aquatic vegetation (SAV) in the shallow bays and into the cove has necessitated new sampling approaches for fish. We formulated a new sampling strategy in 2007 using drop ring sampling to supplement our seine and trawl techniques which both become difficult or impossible in even moderate SAV densities. Collections in drop ring samplers were dominated by banded killifish with tessellated darter, white perch, and gold fish also being common. Densities of killifish were substantially higher in the SAV than in nearby unvegetated areas sampled with seine whereas white perch were about equal in the vegetated and unvegetated areas. Drop ring sampling in 2008 at a more limited number of sites generally confirmed these results; chief differences were much greater numbers of bluegill sunfish in 2008 and reduced numbers of white perch.

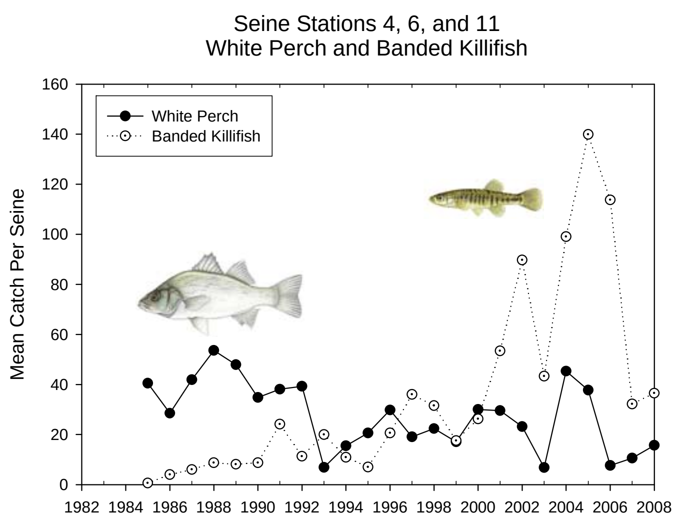
Submersed aquatic vegetation (SAV) continued to be present at high densities in both Pohick and Accotink Bays and to penetrate the inner portions of Gunston Cove in 2008. A fringe of SAV was observed all along the Gunston Cove shoreline and a band of lower density SAV was found across the cove mouth. Coverage reported by aerial surveys was much elevated over pre-2005 levels, but slightly reduced from 2007 and less extensive than in 2005. This was associated with reduced water transparency which in 2008 was due more to phytoplankton than in 2007.

Data from 2008 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 (although chlorophyll values increased somewhat in 2008). Accompanying this decline have been more normal levels of pH and dissolved oxygen, increased water clarity, and a virtual cessation of cyanobacteria blooms such as *Microcystis*. 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. The increase in chlorophyll observed in 2008 may have resulted from unique conditions in 2008 such as the high loading of sediments and associated P from May storms. This merits close scrutiny in 2009.

Another 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. The introduction of snakeheads of recent years (not sampled very well by trawl and seine but found in the cove using drop ring sampling) may have some pronounced effects on the other fish species. The causes and significance of these changes are still being studied as are similar patterns throughout the Chesapeake Bay.. Clearly, recent increases in SAV provide refuge and additional spawning substrate for the adhesive eggs of banded killifish. Data from drop ring studies reported above show that SAV harbors high densities of banded killifish. 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. Combined with the short generation time and high intrinsic rate of population growth of banded killifish, SAV appears to be direct cause of the recent high catch rates. In addition, the invasive blue catfish may also have both direct (predation) and indirect (competition) effects on brown bullhead, but details on these interactions require additional study. Declines in white perch probably have little direct connection to increases in banded killifish, and instead may be due to a combination of reduction in gear efficiency due to SAV and population-wide changes that result from environmental factors and/or fishing mortality. 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.
2. New methods of fish assessment such as drop ring sampling have proven effective and should be deployed as part of the on-going monitoring to effectively sample fish populations in areas which have been heavily colonized by SAV.
3. Complementary to new sampling approaches for SAV, efforts to quantify the catch efficiency of the seine should be continued so that biomass and abundance (in addition to catch rate-based indices) of juvenile fishes can be estimated. This will also facilitate historical comparisons within the cove and comparisons with surveys conducted by MD-DNR.
4. Anadromous fish sampling should be continued with the slightly revised methods adopted in 2007-08. As anadromous river herring were recently listed (2006) as species of concern due to declines throughout the range, continued efforts to monitor these populations should aim to quantify spawning biomass.
5. The Virginia Department of Environmental Quality conducted continuous monitoring of water quality at Pohick Bay park dock for the last two years. Some of this data was included in this annual report and helped to clarify some trends observed in the monitoring data. They are currently in their final year of monitoring. We should consider continuing this data collection via a joint Mason-Fairfax County effort.

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