

An Ecological Study of Gunston Cove

2011

FINAL REPORT

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by

R. Christian Jones

Professor

Department of Environmental Science and Policy

Director

Potomac Environmental Research and Education Center

George Mason University

Project Director

&

Kim de Mutsert

Assistant Professor

Department of Environmental Science and Policy

Faculty Fellow

Potomac Environmental Research and Education Center

George Mason University

to

Department of Public Works and Environmental Services

County of Fairfax, VA



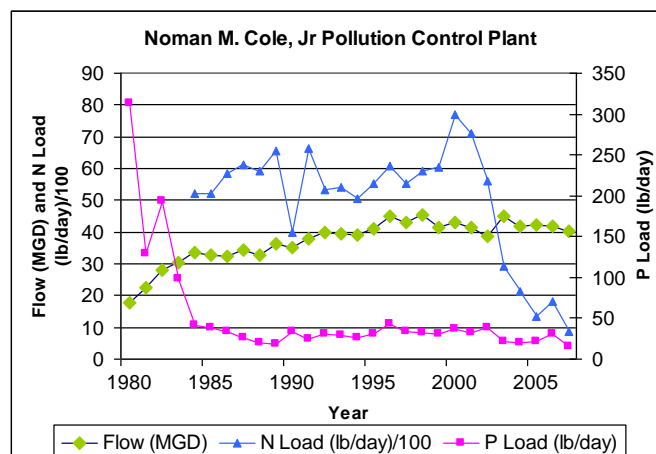
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An Ecological Study of Gunston Cove – 2011 Executive Summary

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 2011 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.



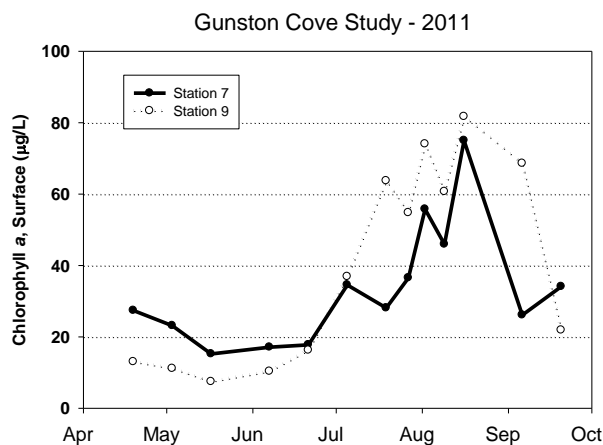
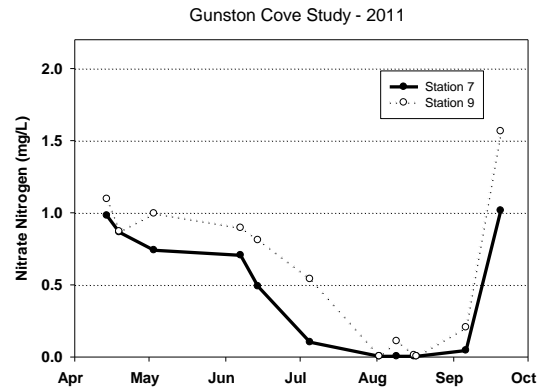
The ongoing ecological study reported here provides documentation of major improvements in water quality and biological resources which can be attributed to those efforts. Water quality improvements have been substantial in spite of the increasing population and volume of wastewater produced. The nearly 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 2011 was characterized by substantially warmer than normal weather with average monthly temperatures from April through August at least 1.5°C above normal. There were 42 days with maximum temperatures above 32.2°C (90°F). Precipitation was well above normal in March and April, but well below normal in May, June, and July. Hurricane Isabel and Tropical Storm Lee passed through the area in late August and early September leaving 45 cm (over 18 in) of rain during a 2 week period. While local

precipitation was low in May, enhanced mainstem discharge was observed in both April and May. Mainstem discharge was well below normal in late July and early August.

Water temperature tracked air temperature on a seasonal basis with river temperature warming more slowly than air temperature in the spring. Specific conductance and chloride were greatly reduced at the river site in April and early May due to the large volume of runoff. From May through August conductance and chloride both rose gradually owing to reduced freshwater inflow. In September both declined with the increased runoff from the tropical storms. Indicators of photosynthetic intensity--dissolved oxygen and pH--exhibited a general seasonal increase related to increased algal growth and were consistently higher at the cove station where the shallow depth allowed for more of the water column to support photosynthesis. Water clarity and light penetration were greatly reduced in the river in April owing to strong mainstem discharge, but recovered in May. The two sites had similar indicators of water clarity through the remainder of the year with values being somewhat less clear than in the last few years.

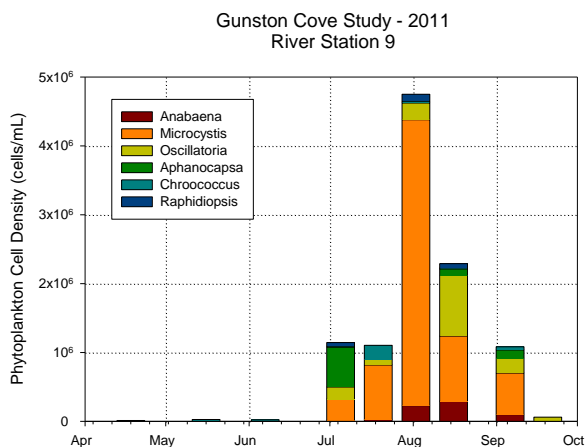
Ammonia nitrogen was quite low in the cove and somewhat higher in the river. Un-ionized ammonia nitrogen was well below toxic levels. Nitrate nitrogen was present at moderate levels at both sites through early June, but declined strongly in June and July remaining low through early September, probably related to algal uptake. This was reinforced by the increase in organic nitrogen in July and August, part of which is algal cells themselves. Total phosphorus was similar at the two sites and generally showed gradual seasonal increase through August followed by a steep decline in the fall. A noteworthy spike in TP in late April in the river was coincident with peaks in total suspended solids and ammonia nitrogen. This spike seems to be related to the high April flows in the river mainstem that was not observed in the local watersheds or the cove. SRP was generally higher in the river and very low in the cove due to greater algal uptake in the cove. An August spike in both TP and SRP was not related to other parameters. N to P ratio gradually declined at both sites approaching N limitation by August. Total



suspended solids were generally somewhat higher in the river, while volatile suspended solids were higher in the cove. VSS showed a peak in August at both sites.

Algal populations as measured by chlorophyll *a* remained relatively low at both sites into early June being consistently somewhat higher in the cove. During late June and July chlorophyll levels rose markedly in both areas with river values actually

exceeding cove values on many dates. Cove values declined markedly in early September while river values decreased strongly in late September. Phytoplankton cell density data indicated that levels increased markedly in July and further ramped up to very high levels in early August. The two sites exhibited remarkably similar values. Phytoplankton biovolume actually showed two peaks (early July and early August) at both sites. Cell density was dominated by smaller cyanobacterial cells which made up over 90% of total cells on most dates at both sites. *Microcystis* was the overwhelming dominant with



Oscillatoria and *Anabaena* being consistent secondary taxa. *Melosira* was the strong dominant in cell density among the eukaryotic algae. In terms of biovolume, diatoms were generally the most abundant group with cyanobacteria being important mainly in July and August. Among the cyanobacteria *Oscillatoria*, *Anabaena*, *Raphidiopsis*, and *Microcystis* made the greatest contribution to biovolume. Among the eukaryotic algae *Melosira* was the overwhelming dominant. As these results indicate, *Microcystis* was very

abundant in late July and early August at both sites. This was part of a larger *Microcystis* bloom that was centered in the river mainstem near Indian Head. At all times, the bloom was actually more pronounced in the river mainstem than in Gunston Cove proper. This contrasts with blooms in the 1980's in which *Microcystis* concentrations were highest in Gunston Cove. In the cove the diatom *Melosira*, a healthy component of the phytoplankton community, was dominant on most dates.

As in previous years, rotifers were consistently more abundant in the cove than in the river. A seasonal pattern was apparent at both sites with highest values in the summer. *Brachionus*, *Keratella*, and *Filinina* were the dominant genera. *Bosmina* was found at high densities in the cove in May, but in the river *Bosmina* reached two peaks in the summer. *Diaphanosoma* showed similar seasonal dynamics at both sites with a very strong peak in early June and a second, smaller peak in August. *Daphnia* had high springtime abundance especially in the cove in May. *Moina*, usually an insignificant taxon, reached high levels in early June in the cove. The predaceous cladoceran *Leptodora* was most common in early June at both sites. Copepod nauplii in the cove reached a strong peak in late May and then declined for the rest of the year. In the river the peak was in early July. *Eurytemora*, a large calanoid copepod, was very abundant in the cove in May, while in the river the peak was even higher, but delayed until early June. Cyclopoid copepods were present at very low levels in the cove, but attained higher levels in the summer in the river culminating in a very strong peak in mid August.

In 2011 ichthyoplankton was dominated by *Dorosoma* sp. (gizzard shad) and, to a lesser extent, alosines (herring and shad). Members of the genus *Morone* (white perch or striped bass) were significant as well. Other taxa were found in very low numbers, which makes 2011 less diverse than 2010. The relative high abundance of alosines is a sign that upstream areas are used a spawning habitat. Identifying successful spawning habitat for

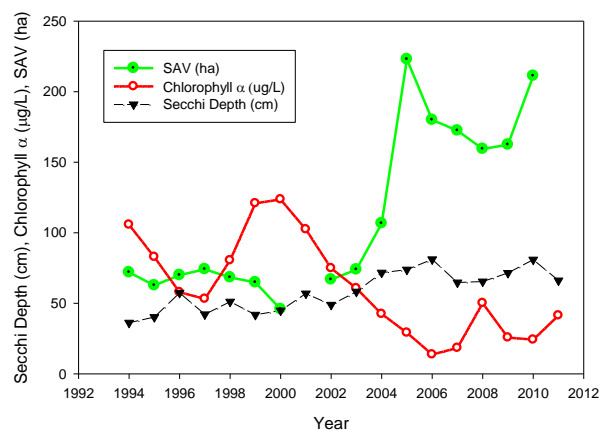
alosines has become increasingly important now that the Virginia stocks of river herring have been identified as collapsed.

In trawls, the overwhelming majority of the fish collected were represented by 2 taxa: white perch (*Morone Americana*) and spottail shiner (*Notropis hudsonius*). Other numerically abundant species included: sunfish (*Lepomis* sp.), blue catfish (*Ictalurus furcatus*), and channel catfish (*Ictalurus punctatus*). As usual, white perch was found throughout the year and at all stations. Spottail shiner were found throughout the year, but almost all specimens were collected at station 7. Blue catfish was found most frequently in early summer and in fall, and mainly in the river. Unlike 2010, *Alosa* sp. were not among the most abundant species in trawl collections.

In seines, the most abundant species by far was banded killifish (*Fundulus diaphonus*), followed by white perch. Banded killifish was not abundant in trawls, which emphasizes the preference of banded killifish for the shallow littoral zone (which is the area sampled with a seine, while trawls sample the open water). This is also evident from the fact that banded killifish was least abundant in Station 11, which is close to the mainstem. Banded killifish and white perch were collected at all stations and throughout the year. The abundance peak of banded killifish was in June, while white perch had higher abundances in July and August. It will be interesting to investigate whether the abundance of banded killifish is indeed reduced in July and August, or whether they are more successful at finding refuge within the SAV beds, which have expanded in July and August. The inclusion of fyke nets in the sampling regime next season, which will be set up to sample the SAV beds, will make this study possible. The list of other species that occurred at high abundances (quillback, bluegill, blueback herring, gizzard shad, spottail shiner, mummichog, striped bass and tessellated darter) is also different than what was abundant in trawls. This indicates that different species use different habitats, and emphasizes the importance of sampling with different gear types to obtain a representative sample of the nekton community present at Gunston Cove.

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.

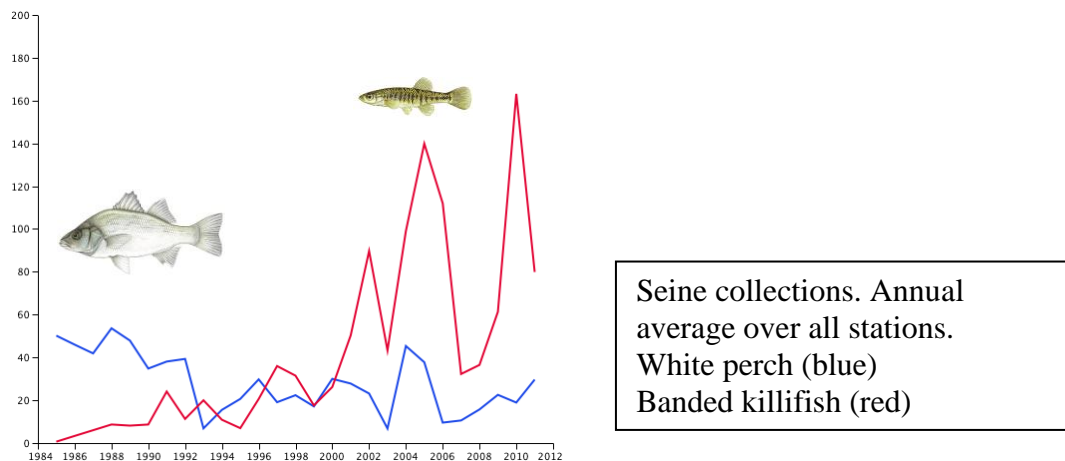
Data from 2011 generally reinforced the major trends which were reported in previous years. First, phytoplankton algae populations in Gunston Cove have shown a clear pattern of decline since 1989; While chlorophyll levels were higher in 2011 than in 2009 and 2010,



they were still much lower than earlier years. Accompanying this decline have been more normal levels of pH and dissolved oxygen, and increased water clarity. 2011 was unusual in that a bloom of the cyanobacterium *Microcystis* occurred in the study area, it was actually more intense in the river and further downstream near Indian Head.

Unfortunately, data were not available from VIMS for SAV assessment in 2011, but observations by field crews indicated about the same coverage as in recent years. 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.

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. This process is sometimes called adaptive management and is recognized as the most successful approach to ecosystem management.
2. New methods of fish assessment such as drop ring sampling have proven effective. However, given the departure of Dr. Kraus and the cost of drop ring sampling, we recommend using fyke nets in heavy SAV areas. These will provide reliable sampling of SAV bed areas when seines and trawls are inoperable there.
3. 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.
4. The Potomac Environmental Research and Education Center obtained funding from George Mason University in conjunction with the NOAA BWET program

and reinstated the Pohick Bay site in May 2011. A report on 2011 data collected at this site will be forthcoming and will be shared with the County. We anticipate keeping this station going for the foreseeable future.

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