Monie Bay NERR
Annotated Bibliography of Relevant Publications and Reports

Apple, J. K., P. A. del Giorgio, R.I.E. Newell. 2004. The effect of system-level nutrient enrichment on bacterioplankton production in a tidally-influenced estuary. *Journal of Coastal Research* 45: 110-133.

Summary: We describe the use of Monie Bay as a natural experiment to evaluate the effect of system-level nutrient enrichment on natural bacterioplankton communities. Monie Bay, a component of the Chesapeake Bay National Estuarine Research Reserve System, is a subestuary of the Chesapeake Bay, consisting of a shallow semienclosed bay and three tidally influenced creeks varying in their agricultural land use and freshwater inputs. As part of a 2-year study in this system, we identified distinct spatial and seasonal patterns in ambient nutrient concentrations, salinity, and source and quantity of organic matter that were related to differences in agricultural practices and watershed characteristics among the three tidal creeks. Principal components analysis identified freshwater delivery of nutrients and temperature as key factors driving the overall variability of this system. Despite significant variability in nutrient concentrations and bacterioplankton production (BP) throughout the year, we observed persistent response of bacterioplankton to nutrient enrichment, as evidenced by a comparison of 2-year averages in agriculturally developed Little Monie Creek (LMC) relative to the undeveloped Little Creek (LC), and by a comparison of the nutrient enriched upper estuary of LMC to sites nearer the open bay. Bacterioplankton responded positively to pulsed nutrient availability, with elevated rates of BP associated with agriculturally derived nutrient inputs to the Monie Bay system. Freshwater inputs play an important role in mediating the response of bacterioplankton to nutrient enrichment, as evidenced by relatively low estimates of BP in the freshwater-dominated, agriculturally developed Monie Creek. This response is attributed to changes in organic matter quality in the system and the direct effect of salinity on bacterioplankton community metabolism.

Apple, J. K. 2005. The regulation of bacterioplankton carbon metabolism in a temperate salt-marsh system. PhD Thesis, University of Maryland, College Park.

Summary. This study describes an investigation of the factors regulating spatial and temporal variability of bacterioplankton carbon metabolism in aquatic ecosystems using the tidal creeks of a temperate salt-marsh estuary as a study site. Differences in land-use and landscape characteristics in the study site (Monie Bay) generate strong predictable gradients in environmental conditions among and within the tidal creeks, including salinity, nutrients, and the quality and quantity of dissolved organic matter (DOM). A 2-yr study of bacterioplankton metabolism in this system revealed a general positive response to system-level nutrient enrichment, although this response varied dramatically when tidal creeks differing in salinity were compared. Of the numerous environmental parameters investigated, temperature and organic matter quality had the greatestinfluence on carbon metabolism. All measures of carbon consumption (i.e., bacterioplankton production (BP), respiration (BR) and total carbon consumption (BCC)) exhibited significant positive temperature dependence, but the disproportionate effect of temperature on BP and BR resulted in the negative temperature

dependence of bacterioplankton growth efficiency (BGE = BP/[BP+BR]). Dissolved organic matter also had an influence on carbon metabolism, with higher BCC and BGE generally associated with DOM of greater lability. Our exploration of factors driving this pattern suggests that the energetic content and lability of DOM may be more important than nutrient content or dissolved nutrients alone in determining the magnitude and variability of BGE. Investigations of single-cell activity revealed that BCC and BGE may be further modulated by the abundance, proportion, and activity of highly-active cells. Differences in single-cell activity among creeks differing in freshwater input also imply that other cellular-level properties (e.g., phylogenetic composition) may be an important factor. Collectively, results from this research indicate that the variability of bacterioplankton carbon metabolism in temperate estuarine systems represents a complex response to a wide range of environmental and biological factors, of which temperature and DOM quality appear to be the most important. Furthermore, this research reveals fundamental differences in both cellular and community-level metabolic processes when freshwater and marine endmembers of estuaries are compared that may contribute to the variability in bacterioplankton carbon metabolism within and among estuarine systems.

Apple, J. K., P. del Giorgio, W. M. Kemp. 2006. Temperature regulation of bacterial production, respiration and growth efficiency in a temperate salt-marsh estuary. Aquat. Microbial Ecol. 43: 243-254.

Summary: There is consensus that temperature plays a major role in shaping microbial activity, but there are still questions as to how temperature influences different aspects of bacterioplankton carbon metabolism under different environmental conditions. We examined the temperature dependence of bacterioplankton carbon metabolism, whether this temperature dependence changes at different temperatures, and whether the relationship between temperature and carbon metabolism varies among estuarine sub-systems differing in their degree of enrichment. Two years of intensive sampling in a temperate estuary (Monie Bay, Chesapeake Bay, USA) revealed significant differences in the temperature dependence of bacterial production (BP) and respiration (BR), which drove a strong negative temperature response of bacterial growth efficiency (BGE). Accordingly, BGE was lower in summer (<0.2) and higher in winter (>0.5). For all measured metabolic processes, the most pronounced temperature response was observed at lower temperatures, with $Q10$ values generally 2-fold greater than in warmer waters. Despite significant differences in resource availability, both the temperature dependence and magnitude of BR and bacterioplankton carbon consumption (BCC) were remarkably similar among the 4 estuarine sub-systems. Although temperature dependencies of BP and BGE were also similar, their magnitude differed significantly, with highest values in the nutrient- enriched sub-system and lowest in the open bay. This pattern in carbon metabolism among subsystems was present throughout the year and was confirmed by temperature manipulation experiments, suggesting the temperature effects on BP and BGE did not override the influence of resource availability. We conclude that temperature is the dominant factor regulating seasonality of BR and BCC in this system, whereas BP and BGE are influenced by both temperature and organic matter quality, with variation in the relative importance of each of these factors throughout the year.

Board of County Commissioners of Somerset County, Maryland. 1988. Toward a better quality of life: a land preservation and recreation plan for Somerset County, Maryland.

Summary: This document provides an outline of plan for Somerset County land preservation and recreation, with emphasis on attracting business and tourism. It includes recreation areas, land use, wildlife management, historic sites, and population.

Board of County Commissioners of Somerset County, Maryland. 1991. Somerset County Comprehensive Plan 1991. John Pickard Associates, Washington DC.

Summary: This comprehensive plan outlines goals for the development of Somerset County. It includes Demographic and economic information, data on facilities such as housing and transportation, and environmental guidelines. There are sections describing specific areas of the county and recommendations for their growth. (those sections not near Monie have been left out of the pdf copied).

Board of County Commissioners of Somerset County, Maryland 1998. The Somerset County land preservation and recreation plan. Urban Research and Development Corporation, Bethlehem, PA.

Summary: As the 1988 plan, this is an outline for Somerset County land preservation and recreation, with emphasis on attracting business and tourism. It includes recreation areas, land use, wildlife management, historic sites, and population. It contains slightly more emphasis on stewardship and protection of sensitive areas than the 1988 plan. This plan also includes more demographic information than previously available.

Bricker, O.P., W.L. Newell, N.S. Simon, I. Clark. 2003. Bog iron formation in the Nassawango watershed, Maryland. USGS poster.

Summary: The ground water of the Pocomoke basin is rich in reduced iron. This is particularly true in the Nassawango sub-basin where bog iron deposits along the flood plain of Nassawango Creek were dug in the mid-1800's to supply an iron smelter near the town of Snow Hill. The rate of bog iron formation was so rapid that areas could be re-mined in a matter of a few years (Singewald, 1911). Bog iron is still forming in this area, and in other parts of the Pocomoke basin. Ground water has been measured with ferrous iron concentrations in excess of 20 ppm. When this water emerges at the surface or is discharged into the river system it rapidly oxidizes to an amorphous particulate iron oxyhydroxide which in time crystallizes to goethite. The iron in this system is important for at least two reasons: 1) iron oxyhydroxides strongly sorb phosphorous and many trace metals. Early reports on the composition of the Nassawango bog ore indicate that it commonly contained 10% P which made the pig iron smelted from this ore brittle when cold (Singewald, 1911), 2) the iron precipitating in the rivers causes turbidity which reduces light penetration to rooted aquatic vegetation and may impact other organisms, for instance, by coating gills and interfering with oxygen transfer. The first effect will play a role in the behavior and cycling of P in the system, while the second effect will impact biota in the system. In the fall of very dry years (1999 and 2001), we found the rivers in the central part of the Pocomoke basin quite turbid although there had been no storms to wash sediment-laden runoff into the rivers. Samples of the particulate matter creating the turbidity were iron-rich and displayed a weak x-ray diffraction pattern of goethite. There also seemed to be some organic

material, probably algae, contributing to the turbidity, but this has not yet been investigated. Whatever the mix of materials that cause the turbidity, they are authigenic in the rivers and are not contributed by runoff. If all of the sediment erosion and runoff could be eliminated, it would have no effect on the turbidity generated by these chemical processes. Any practice recommended to reduce suspended sediment in these waters must take authigenic precipitates into consideration. Best management practices for sediment control in the watershed will have no effect on the turbidity resulting from oxidation of ferrous ions. Our project studies at other locations in the Chesapeake Bay have observed that vivianite (Fe3(PO4)2 **.**8H2O) is forming in sediment at heads of tributary estuaries where tidal water is non-saline and anoxic. Presumably, the phosphate originates from degradation of organic materials in the anoxic environment. Vivianite is commonly encountered in modern sediments that we have cored from similar depositional environments. Vivianite in the estuarine sediments of the Kent Island Formation and Omar Formation may be the source of phosphates in early bog iron that was first mined in Nassawango Creek.

Colona, R. 2005. Furbearer, Rabbit and Squirrel Project, 2004-2005 Annual Report. Maryland Department of Natural Resources.

Summary: This is the annual report of the MD DNR on furbearing mammals throughout the state of Maryland. Somerset County is a notable abundances of otter, rabbits and squirrels. We are aware of no cumulative reports that report long term trends in abundance or focus on Somerset County, much less Monie NERR or Deal Island Management area.

Cornwell, J. C., J. M. Stribling, J.C. Stevenson. 1994. Biogeochemical studies at the Monie Bay National Estuarine Research Reserve. Organizing for the Coast: Thirteenth International Conference of the Coastal Society, Washington, DC, USA.

Summary:
This study used a transect from open bay (Apple site #1) to upper MC (Apple site #12). They sampled for PO4, NO3+NO2, NH4, CL- , SO4 2-, plus marsh and sub-tidal cores. Marshes are of Holocene age, and they range in a relatively short distance from higher salinity salt marshes with few plant species to virtually freshwater tidal systems of greater macrophyte diversity. The seasonal maximum of PO_4^{-3} occurred in April 1990 (2μM) and attributed to local agricultural activity. There was a lack of a summer PO_4^{-3} maximum (associated with anoxia in other marsh systems (Scudlark and Church 1989)). In addition, N:P ratios at the old railroad bridge were high in June (i.e., 40), suggesting P-limitation in this system. Nitrogen also peaked in June. Sediment sulfide concentrations and organic content (>30%) were high in upper Monie Creek and transitioned to low values in the open bay sediments (i.e., <10% organic). This indicates a shift from anoxic to less anoxic sediments. The supply of nitrate and phosphate in dominated by agricultural runoff was timed to seasonal and event-scale freshwater inputs. The source of ammonium to the water column appears to be the sediments, via ammonification. Consumption of nutrients by plant uptake (N and P) and denitrification (N) leads to reduced concentrations of inorganic nutrients in the water column over the course of the growing season. Monie Bay has many biogeochemical features representative of Chesapeake Bay marshes.

Hamilton, P.A., J.M. Denver, P.J. Phillips, R.J. Shedlock. 1993. Water-Quality assessment of the Delmarva Peninsula, Delaware, Maryland, and Virginia—effects of agricultural activities on, and distribution of, nitrate and other inorganic constituents in the surficial aquifer. U.S. Geological Survey Open-File Report 93-40. Towson, MD.

Summary: The Delmarva Peninsula, which includes most of Delaware and the entire Eastern Shore of Maryland and Virginia, consists of a flat to gently rolling central upland flanked by low plains that slope toward Chesapeake Bay, Delaware Bay, and the Atlantic Ocean. Total land area is about 6,050 square miles. Agriculture is the most prevalent land use, accounting for about 48% of the study area. As in many agricultural areas, crop yields are linked to the amounts and kinds of fertilizers that are applied to the soil. The potential movement of these chemicals into ground water is a concern among water-resource managers and residents of the Delmarva Peninsula because the flat topography and porous soils provide favorable conditions for chemicals applied on the land to move downward to the water table.

The chemical character of natural water (minimally affected by human activities) in the surficial aquifer is controlled primarily by the chemical properties of precipitation, in combination with mineral dissolution and biological activity in the aquifer. Like precipitation, natural ground water is moderately acidic (pH is about 5.8). Concentrations of dissolved constituents are low (indicated by a median specific conductance value of 115 microsiemens per centimeter at 25 degrees Celsius) because the surficial aquifer consists mostly of relatively insoluble quartz sand. In addition, the high permeability of the sediment increases ground-water-flow rates and reduces contact and reaction time between water and aquifer minerals.

Nitrate, derived from nitrification of ammonia in inorganic fertilizers and manure, is the dominant anion in agricultural areas. Concentrations of nitrate in 185 water samples collected in agricultural areas ranged from 0.4 to 48 milligrams per liter as nitrogen, with a median concentration of 8.2 milligrams per liter as nitrogen. Nitrate concentrations exceeded the U.S. Environmental Protection Agency (USEPA) maximum contaminant level for drinking water of 10 milligrams per liter as nitrogen in about 33 percent of the 185 water samples.

Ground water affected by agricultural activities contains significantly higher concentrations of dissolved constituents (indicated by a median specific conductance value of 170 microsiemens per centimeter at 25 degrees Celsius) than natural ground water. Concentrations of calcium and magnesium are higher because of liming of soils, and concentrations of potassium and chloride are higher because of applications of potash used to supplement the nitrogen-based fertilizers. Alkalinity concentrations commonly are lower in water affected by agricultural activities than in natural water because bicarbonate ion is consumed in buffering reactions with acid produced during nitrification of ammonia.

Effects of agricultural activities on the quality of ground water are not limited to the near-surface parts of the aquifer underlying farm fields but are common at or near the base of the aquifer, 80 to 100 feet below land surface. The median concentration of nitrate in water beneath agricultural areas collected from 24 wells deeper than 80 feet below land surface was 8.5 milligrams per liter as nitrogen, and nitrate concentrations in 9 of these water samples exceeded the USEPA maximum contaminant level for nitrate in drinking water. Concentrations of nitrate and other inorganic constituents in water from the surficial aquifer differ among hydrogeomorphic regions of the Delmarva Peninsula. Hydrogeomorphic regions are characterized by related features – including surficial geology, geomorphology, topography, soil characteristics, and land use – that can impart characteristic regional ground-water-quality

patterns. Six hydrogeomorphic regions are delineated on the peninsula – well-drained uplands, poorly drained uplands, poorly drained lowlands, fine-grained lowlands, surficial confined region, and the inner coastal plain.
Median concentrations of nitrate in water from the surficial confined region (about 1.1 milligrams per liter as nitrogen) and the lowlands (about 0.1 milligrams per liter as nitrogen) are significantly lower than the median concentration in water from the well-drained uplands (about 8.9 milligrams per liter as nitrogen). The surficial aquifer underlying the surficial confined region and lowlands commonly contains abundant fine sand, clay, silt, peat, and other organic matter. The clay and silt deposits inhibit downward flow, and, therefore, inhibit leaching and transport of fertilizers to the water table. In addition, anaerobic ground water in these regions inhibits nitrification of ammonia and promotes denitrification of nitrate. In contrast, the surficial aquifer underlying the uplands mainly consists of permeable quartz sand and gravel, allowing nitrate and other constituents to move more readily to the water table than in the surficial confined region and lowlands. Nitrate concentrations are variable locally, depending on ground-water flow and land use. In near-surface ground water (less than 30 feet below land surface), nitrate concentrations generally reflect recharge through overlying land within about 100 to 200 feet of a well. Nitrate concentrations in ground water are highest beneath farmland and lowest beneath woodlands and marshes. Nitrate concentrations in ground water are elevated beneath residential areas because of septic tank effluent and lawn fertilizers. Elevated concentrations of nitrate in deep ground water reflect recharge through distant agricultural or residential land rather than through agricultural or residential land directly around a well. In some areas of the Delmarva Peninsula, deep ground water containing elevated nitrate concentrations is overlain by ground water with lower nitrate concentrations. This vertical variability of nitrate concentration is most common beneath marshes and woodlands adjacent to streams and other discharge areas. In these areas, the near-surface ground water is recharged through soils covered with natural vegetation, and the deep ground water is recharged through soils in distant agricultural or residential land.

Aquifer composition, in combination with ground-water flow and land use, affects the local stratification of nitrate in water from the surficial confined region and lowlands. Nitrate concentrations commonly are elevated in ground water beneath agricultural or residential areas where the composition of the surficial aquifer is sandy. Nitrate concentrations are minimal or less than the laboratory reporting limit in ground water beneath agricultural or residential areas underlain by fine sand, clay, silt, peat, and other organic matter.

Hotton, L.D., G. Timko, B. Eyler. 2005. Maryland Deer Project 2004-2005 Annual Report. Maryland Department of Natural Resources.

Summary: This is an annual report of the assessment of Deer populations in the state of Maryland. The report reviews the objectives of deer population management and the history of White tail and Sika deer in Maryland. The report reviews the economic benefits of deer hunting in the state. Deer harvest has been increasing throughout the state over the last 10 years. Harvest rates in Somerset County are at the lower end of the range reported by counties. This may be attributable to the relatively low hunting pressure and low human population in the county.

Hunter, K.L., D.A. Fox, L.M. Brown, K.W. Able. 2006. Responses of resident marsh fishes to stages of *Phragmites australis* invasion in three Mid-Atlantic estuaries, U.S.A. Estuaries and Coasts 29(3):492-503.

Summary: Modification of brackish marshes by non-indigenous *Phragmites ausralis* has occurred across a broad geographical area in eastern North America. Among its effects on marsh processes, *Phragmites* may be increasingly unfavorable to marsh surface fishes as its invasion progresses with an estuary. We assessed the effects of Phragmites invasion on resident marsh surface fishes by examining the populations responses of *Fundulus heteroclites* (mummichog, 5B48 mm TL) and *F. luciae* (spotfin killifish, 5B41 mm TL) to four distinct invasion stages in three estuaries of the U.S mid Atlantic region (New Jersey, Delaware, and Maryland). We documented precipitous declines in mean catch per unit effort of *F. heteroclites* in pit traps from natural marsh (51.6), through initial (33.8), early (12.3), and late invasion stages (2.4) across all sites. A similar pattern was documents for *F. luciae*, with mean catch per unit effort in pit traps declining from natural marsh (48.9), through initial (39.1), early (9.3), and later invasion stages (2.7). Population structure of both species also changed somewhat across invasion stages such that we collected a narrower size range of individuals of both species from late invasion stages. Patterns suggest that as the *Phragmites* invasion progresses, there is a decline in habitat function for larval and juvenile *F. heteroclites* and an increased risk of extirpation of *F. luciae* from brackish marshes along the east coast of the U.S.

Jones, T. W. 1994. Temporal and spatial variability of estuarine marsh creek water quality in an agriculturally impacted marsh. Biology Department, Salisbury State Univ., Salisbury, MD (unpublished data presentation).

Summary: Data are reported graphically for temperature, salinity, and concentrations of dissolved inorganic nutrients (HN_4, NO_3, NO_2, PO_4), particulate nutrients (POC, PON, PP), total suspended solids, phytoplankton chlorophyll-a in tidal creeks of the Monie Bay NERR site. Samples were collected at twice monthly frequencies along salinity gradients of three tidal creeks. Samples were also collected at 2-4 hour intervals over full tidal cycles at selected sites. Strong seasonal and inter-creek patterns were observed. Creeks draining agricultural watersheds exhibited higher concentrations of nutrients and chlorophyll-a compared to creeks draining forest and marsh lands. Results will be further analyzed in subsequent reports.

Jones, T. W., L. Murray. J. Corrwell. 1997. A Two-Year Study of the Short-Term and Long-Term Sequestering of Nitrogen and Phosphorus in the Maryland National Estuarine Research Reserve. Monie Bay, Maryland, Maryland National Estuarine Research Reserve**.** Biology Dept, Salisbury State University, Salisbury, MD.

Summary: Experimental approach evaluates nutrient storage on three time scales: It is likely that short-term nutrient sequestration is most sensitive to pulsed events, thus it is on this scale that bacterioplankton are the most effective indicator. Two years of monitoring of these systems indicated that Little Monie Creek (LMC) and Little Creek (LC) were similar with respect to salinity, temperature, and water volume - with the exception of spring flow that reduces the salinities in the upper reaches of LMC relative to that of LC. LMC has higher nutrients and chlorophyll than LC, which is attributed to differences in the watersheds of the two creeks.

LMC and Monie Creek (MC) were consistently higher in TSS, N, P, and chlorophyll-a than LC throughout the study period, with P showing the greatest difference. In general, a gradient from high to low nutrients is MC>LMC>LC, with MC and LMC being very close. Higher above and belowground biomass of tidal marsh plants were measured in LMC compared to LC. This suggests an input of nutrients to that system, and the apparent correlation of plant biomass with rainfall and runoff events indicates an input from the agricultural watershed. Based on a transect in LMC from headwaters to the open bay, agricultural runoff nearly doubles the concentration of nitrogen and phosphorus along the creek axis. Phosphorus concentrations in LMC are four-fold higher than that of LC, and nitrogen concentrations are elevated two- to three-fold. Salinity values were lowest in Feb – April and highest in summer and fall. Values in MC were consistently lower than LMC and LC (which are similar). Nitrate concentrations were extremely low most of the year (i.e., June thru November, <2μM). An early spring peak (~50 μM) occured in February, then gradually declined thru April. Concentrations were highest in LMC, then MC, and did not change substantially throughout the year in LC. Ammonium concentrations peaked in December and again in March in all creeks; otherwise values were low.

Kearney, M.S., R.E. Grace, J.C. Stevenson. 1988. Marsh Loss in Nanticoke estuary, Chesapeake Bay. *Geographical Review* 78(2):205-220.

Summary: Marsh loss in the Nanticoke estuary dates from the 1920's. Since 1938 overall rate of loss has averaged 49.6 ha annually, with rates increasing down estuary. Most losses have occurred in submerged upland marshes; tidal freshwater marshes are stable. Interior ponding has been the primary mechanism of loss. Rising water levels are postulated to be the underlying force behind marsh losses in this estuary.

Kearney, M. S., J. C. Stevenson, L.G. Ward. 1994. "Spatial and Temporal Changes in Marsh Vertical Accretion Rates at Monie Bay - Implications for Sea-Level Rise." *Journal of Coastal Research* 10(4): 1010-1020.

Summary: Spatial and temporal changes in vertical accretion rates and sediment characteristics were investigated in a large submerged upland, estuarine marsh on the Eastern Shore of Chesapeake Bay. Eighteen cores were collected from sites spanning shoreline, tidal channel-side and interior marsh environments. Accretion rates over various time scales (~30 years, ~100 years, and ~200 years) were determined using ^{137}Cs, ^{210}Pb, and pollen geochronologies. Marsh-wide, long-term vertical accretion rates have averaged about 3.0mm/yr for the last two centuries, about the rate of submergence for the area over the last half century recorded by tide-gauges. But this average figure masks considerable spatial variability (ranging from 0.15 to 0.63 mm/yr), even within the same overall depositional environment. Shoreline and channel-side sites, where grain size and bulk density analyses indicate greater allochthonous mineral sediment inputs, generally were characterized by the higher vertical accretion rates, although at some sites sediment collapse from the weight of recent overwash horizons yielded lower than average rates of vertical accretion for this environment. Loss-on-ignition analyses show that spatial relations in vertical accretion are not constant. The balance between organic and inorganic accumulation shifts over time as storms come and go and hydraulic conditions in tidal channels change. Interior marsh sites, displaying the most consistent sediment characteristics with depth, tend to be the most stable areas in terms of vertical accretion budgets after initial colonization by marsh

plants. Temporal changes in marsh vertical accretion rates were also equally variable, with rates integrated over a century or more sometimes less than half those based on the last few decades. substantial decadal departures are nevertheless imbedded in these long-term accretion trends, presumably reflecting equally short-term fluctuations in sea-level rise. These departures plus the evidence of incipient autocompaction in relatively recent sediments suggest that employing very short-term estimates of vertical accretion rate can potentially over-estimate marsh accretionary response to future sea-level rise.

Long, R. 2005. Wild turkey and upland game birds, 2004-2005 annual report. Maryland Department of Natural Resources.

Summary: This report includes descriptive and qualitative information on wild turkey populations and hunting throughout the state. It contains no quantitative information on bird abundance, and it does not give county-specific information.

Ludwig, J.C., K. McCarthy, A. Rome, R.W. Tyndall. 1987. Management plans for significant plant and wildlife habitat areas of Maryland's Eastern Shore: Somerset County. Maryland Natural Heritage Program, Department of Natural Resources, Annapolis, MD.

Summary: This report provides a broad description of an initiative to establish wildlife habitat management plans and designated focal areas. It refers to legal regulations related to endangered species in the state of Maryland. This may be related to the establishment of the Deal Island Wildlife Management Area.

Lyon, J.C. 2004. Old Somerset Hundreds and Land Grant Maps. http://www.rootsweb.com/~mdsomers/lyonmaps/index.html

Summary: This is a collection of maps that details the divisions of Somerset County from 1600 on. They show county lines, land surveys, and colonial and American Indian settlements. Among the Somerset "Hundreds" (a medieval English term indicating subunits within a county) was the Monie Hundred established before 1742 and later increasing in size by >3-fold by 1783.

Maryland Department of Business & Economic Development. 2002. Somerset County Maryland Brief Economic Facts. http://www.choosemaryland.org/regionsandcounties/easternregion/somersetcounty.html.

Summary: Information and brief statistics on location, climate, population, employment, hourly wages, personal income, tax rates, education, transportation, utilities, recreation and culture in Somerset County, Maryland.

Maryland Department of the Environment. 2005. Water quality analysis of fecal Coliform for eight basins in Maryland: Assawoman Bay, Sinepuxent Bay, Newport Bay, and Chincoteague Bay in Worcester County; Monie Bay in Somerset County; Kent Island Bay in Queen Anne's County; Rock Creek in Anna Arundel County; and Langford Creek in Kent County. U.S. Environmental Protection Agency, Region III. Philadelphia, PA.

Summary: Eight water quality segments, including Monie Bay, were listed as impaired regarding their TMDLs of fecal coliform in 2002. This report uses bacteria data collected by the MDE's shellfish program to re-analyze these waters. Monie was reclassified to conditionally approved, pending more data.

Maryland Department of Natural Resources, Wildlife and Heritage Service. (2004). Current and historical rare, threatened and endangered species of Somerset County, Maryland.

Summary: Simple document listing state, federal and global status of rare, threatened and endangered plants and animals in Somerset County, Maryland.

Maryland Department of Natural Resources, Wildlife and Heritage Service. (2004). Maryland 2004 Bald Eagle Survey.

Summary: This simple document contains data on the number of bald eagles found throughout Maryland from 1974 through 2004. Data are also available on total, occupied, and active bald eagle nests in 2004. These data are broken down by county.

Matthews, E. D. and R. L. Hall. 1966. Soil Survey: Somerset County, Maryland. United States Department of Agriculture and Maryland Agricultural Experiment Station, Greenbelt, MD.

Summary: This report characterizes the seasonal temperature and precipitation patterns in the county. Annual summation of average monthly precipitation levels at this time was 46.4 inches, and the average number of days with temperatures reaching below freezing was 99 per year. Land use in the county was dominated by hardwood forest, and small grain crops occupied ~28,000 acres while truck crops (vegetables and fruits) were grown on ~ 10,000 acres. Soils in the Monie Bay watershed were mostly tidal marsh and the Othello-Portsmith association, which is comprised of poorly-drained silt loams.

Merrill, J. Z. and J. C. Cornwell. 2000. The role of oligohaline marshes in estuarine nutrient cycling. Concepts and Controversies in Tidal Marsh Ecology. M. P. Weinstein and D. A. Kreeger. Boston, Kluwer Academic Publishers**:** 425-440.

Summary: Oligohaline marshes, poised at the land-sea margin, often occur where the estuary is most enriched in inorganic particles and nutrients. Although light can limit the production of planktonic communities, high nutrient concentrations and regular tidal inundation results in highly productive macrophyte and algal communities. Despite potentially important water quality values, relatively few detailed studies of N and P cycling in oligohaline marshes are evident in the literature. Because of the temporal variability in marsh flux studies, the net annual retention of N and P is best assessed by measurement of N and P burial in the sediment. In the Chesapeake Bay and other estuaries and subestuaries, high rates of tidal marsh N and P burial indicate an important water quality function. A recent study shows the marshes of a Chesapeake Bay tributary retain a large portion of nitrogen and phosphorus entering the river from above the fall line. The marshes trap 35% of the nitrogen and 81% of the phosphorus which would otherwise be recycled, exported, or buried in the subtidal sediments of the estuary. Although

there are few studies, high nitrate supply rates, potentially high nitrification rates, and high rates of sediment metabolism can result in high rates of denitrification. More complete studies of tidal marsh nutrient cycling, particularly nitrogen cycling, are needed for a better understanding of the importance of these tidal freshwater marshes to estuarine nutrient balances. Alternative methodologies for denitrification measurement are needed for more accurate measurements, and more attention needs to be paid to scaling individual measurements to whole marsh ecosystems. A new method for the measurement of net $N_{2(g)}$ exchange was applied to a Chesapeake Bay tributary to develop an annual estimate of net denitrification in the marsh sediments. Denitrification rates were ~60 μmol N m^{-2} h^{-1} with high seasonal variability. Annual calculations were made based on a loose correlation to annual ambient nitrate concentrations. This preliminary calculation suggests that an additional 10% of the fall line nitrogen may be removed by such marsh systems. More measurements of net $N_{2(g)}$ exchange and computer simulation models are required to determine the net removal of fall line nitrogen by the upper estuarine marshes.

NOAA/NERRS. 2003. NERRS Strategic Plan 2003-2008, National Estuarine Research Reserve System**:** 14.

Summary: Brief summary of goals and objectives for National Estuarine Research Reserve protected areas from 2003 through 2008. This document also includes a listing of all current areas included in the National Estuarine Research Reserve program.

NOAA/NERRS Research Report: NERR Abstracts.

Summary: Abstract summaries from studies conducted in CBNERRS sites.

Power, L.P and M. Paolisso. 2005. Linking estuarine ecology and community heritage: a socio-cultural needs assessment of the Monie Bay component. Report prepared for the Chesapeake Bay National Estuarine Research Reserve, Maryland Department of Natural Resources.

Summary: This document reports results of an assessment of socio-cultural needs of the local community in relation to the Monie Bay NERR site. The study uses methods of environmental anthropology including carefully designed surveys of the local human community to identify and analyze explicit cultural-ecological knowledge of stakeholder groups and to provide recommendations for MD DNR regarding expansion of scientific and education outreach that engages the local community. The project proposes five cultural models for marshes such as those of Monie: (1) marshes as recreation, (2) marsh as filter, (3) marsh as buffer, (4) marsh as protection, and marsh as heritage. The project recommends several courses of action to improve the linkage in Monie NERR between scientific understanding, natural resources, and human community. (a) The local community is strongly supportive of scientific research at Monie NERR, and there was strong interest in a continuing series of informal talks presented in the region given by scientists, watermen, and farmers. (b) The community expressed interest in developing tourism based on the ecology and heritage of the region. (c) There was a very strong interest in development of a place to focus outreach activity at Monie NERR, such as visitor center or museum. There was associated interest in establishing and maintaining nature trails,

boardwalks, and self-guided tour; however, the strongest point was the need for a visitor center, where people from the community could meet, hear talks and discuss related issues. (d) Many local folks expressed interested in volunteering to work at and support a Monie NERR facility.

Rooth, J. E. and J. C. Stevenson. 2000. Sediment deposition patterns in *Phragmites australis* communities: Implications for coastal areas threatened by rising sea-level. Wetlands Ecology and Management 8(2-3): 173-183.

Summary: The explosive expansion of the common reed *Phragmites australis* over the last 50 years in the wetlands of the U.S. mid-Atlantic has been of concern to biologists, resource managers and the general public. The replacement of *Spartina* spp. communities by the invasive *P. australis* has been widely reported, but the ecosystem effect of this replacement is poorly understood, especially with regard to sediment accretion processes and elevation change. It is hypothesized that a more detailed understanding of individual plant species and their role in marsh accretion may provide an improved ability to predict the effect of projected sea-level rise in coastal wetlands. Two coastal salt marsh sites on the Eastern Shore of Chesapeake Bay in Maryland (USA) were studied to quantify depositional environments associated with *P. australis*. Short-term sediment deposition (24 hr) and storm deposition (17 d) were measured using filter paper plates, and vertical accretion and elevation change (6 mo.) were measured using a marker horizon coupled with a sedimentation erosion table (SET). Greater rates of mineral and organic sediment trapping were associated with the *P. australis* community in both a subsiding creek bank marsh (34 g m^{-2} day^{-1} in *P. australis* vs. 18 g m^{-2} day^{-1} in *Spartina* spp.) and a laterally eroding marsh (24 g m^{-2} day^{-1} in *P. australis* vs. 15 g m^{-2} day^{-1} in *Spartina* spp.). Litter accumulation in *P. australis* stands is responsible for the higher depositional pattern observed. Additionally, below ground accumulation in *P. australis* communities (as much as 3mm in 6 months) appears to substantially increase substrate elevation over relatively short time periods. Thus *P. australis* may provide resource managers with a strategy of combating sea-level rise and current control measures fail to take this into consideration.

Schaffner, L. and D. Gillett. 2006. Benthic macrofaunal studies in the Monie Bay NERR site. Virginia Institute of Marine Science, Gloucester Pt, VA. (Unpublished data).

Summary: In an effort to assess the habitat quality of the shallow (~1m below MLW) portions of the Monie Bay Reserve, 18 samples were randomly collected with 182-cm^2 x 25-cm cores to determine the abundance and composition of the macrobenthic community. On August 2, 2004, 9 cores were taken within the muddy, low-energy environments of tidal creeks and salt marshes and 9 cores were taken at a sandy, high-energy. As would be expected, the two environments had distinctly different benthic communities. In the muddy, low-energy environments, the macrobenthic community was numerically dominated by the tubificid oligochaete *Tubificoides heterochaetus* and to a lesser degree by the tubificid oligochaete *T. brownae* and the aorid amphipod *Leptocheirus plumulosus*. In contrast, over 75% of the biomass of the community was represented by the tellinid bivalve *Macoma balthica*. In sandy, higher energy environments, the macrobenthic community was numerically dominated by the venerid bivalve *Gemma gemma*, ostracods, and nemerteans. The largest biomass components of the macrobenthic community in sandy habitats were the glycerid polychaete *Glycera dibranchiata*, the spionid polychaete *Marenzellaria viridis*, and the tellinid bivalve *M. balthica*.

Shedlock, R.J., J.M. Denver, M.A. Hayes, P.A. Hamilton, M.T. Koterba, L. J. Bachman, P.J. Phillips, and W.S.L. Banks. Water-quality assessment of the Delmarva Peninsula, Delaware, Maryland and Virginia: results of investigations 1987-91. U.S. Geological Survey Water-Supply Paper 2355-A.

Summary: A regional ground-water-quality assessment of the Delmarva Peninsula was conducted as a pilot study for the U.S. Geological Survey's National Water-Quality Assessment (NAWQA) Program. The study focused on the surficial aquifer and used both existing data and new data collected between 1988 and 1991. The new water samples were analyzed for major ions, nutrients, radon, volatile organic compounds, and a suite of herbicides and insecticides commonly used on corn, soybeans, and small grains. Samples also were collected from wells completed in deeper, confined aquifers and from selected streams, and analyzed for most of these constituents. The study employed a multi-scale network design. Regional networks were chosen to provide broad geographic coverage of the study area and to ensure that the major hydrogeologic settings of the surficial aquifer were adequately represented. Local-scale well networks were installed in several of the major hydrogeologic settings to study changes in ground-water quality along flow paths in the surficial aquifer.

Both the existing data and the data from samples collected during the study showed that agricultural activities had affected the quality of water in the surficial aquifer over most of the Peninsula. Water from most wells completed in the surficial aquifer in areas underlain by agricultural land had a distinct chemical signature. These waters had a chemical composition dominated by calcium, magnesium, and nitrate ions, indicating that they had been significantly affected by leaching of fertilizers and lime applied to the fields. The data showed no significant contamination by volatile organic compounds, radon, or trace elements in either the surficial aquifer or any of the confined aquifers.

Nitrate was detected at concentrations above 3.0 milligrams per liter in water from the surficial aquifer in most areas of the Peninsula. The concentration of nitrate exceeded the U.S. Environmental Protection Agency's Maximum Contaminant Level of 10 milligrams per liter (as nitrogen) in about 20 percent of the samples. The highest nitrate concentrations were found in shallow ground water below agricultural fields, but concentrations above 3.0 milligrams per liter were detected at all levels of the surficial aquifer at many locations in the study area. In contrast, concentrations of nitrate were generally less than 1.0 milligrams per liter in samples from wells in the confined aquifers.

The spatial distribution of nitrate in the shallow ground-water system is related to ground-water-flow patterns and characteristics of the landscape, mainly land use, drainage patterns, soils, and geology. The highest median concentrations of nitrate, for example, are in an area of the Peninsula referred to as the well-drained upland. This area has the highest percentage of agricultural lands and well-drained soils in the Peninsula, and also has the longest ground-water-flow paths. Relatively high concentrations of nitrate are found in water from the surficial aquifer in other areas of the Peninsula, but the lower percentage of agricultural lands in these other areas yields lower median nitrate concentrations relative to the median concentration in the well-drained upland.

Very low concentrations of herbicides (generally below U.S. Environmental Protection Agency Maximum Contaminant Levels) were found in water from shallow wells near agricultural fields. The concentrations of these compounds were generally below 1 microgram

per liter. Although herbicide detections were common in shallow parts of the ground-water system, pesticides generally were not found in deeper parts of the surficial-aquifer system used for water supply, and were found in only one sample from the confined aquifers. The most commonly detected compounds were metolachlor, atrazine, simazine, alachlor, and cyanazine, which are herbicides commonly used on crops in the study area. Desethylatrazine, a degradation product of atrazine and simazine, was also commonly detected. Trace concentrations of insecticide were found in only two samples. Most of the pesticide detections are in waters that were probably recharged after the late 1960's, when these compounds were first widely used on crops in the study area.

The spatial distribution of herbicides in shallow ground water, like that of nitrate, is related to land use and ground-water-flow patterns. Most of the pesticide detections were in samples from wells near farm fields. Metabolites of the triazine herbicides were detected in samples from wells in several of the local-scale well networks. Neither the metabolite data nor the depth-distribution data on pesticides, however, shed much light on the potential for pesticides to migrate to deeper parts of the ground-water system over time.

Both elevated nitrate concentrations and trace concentrations of herbicides were found in nontidal streams under base-flow conditions. Nitrate concentrations in surface waters are related to land-use patterns and differences in soil types, but no seasonal patterns were observed in the nitrate data from the regional surface-water network. Surface waters from well-drained watersheds commonly contained higher concentrations of nitrate and other ions from agricultural chemical sources than surface waters from watersheds in poorly drained areas. Pesticide concentrations in surface water showed seasonal patterns and were less related to land use and soil patterns than nitrate concentrations. Concentrations of the parent compounds of the triazine herbicides were highest in streams during late spring base-flow periods, after pesticides were applied to the fields. Desethylatrazine concentrations in streams did not show as much seasonal variation as the parent compounds and remained at concentrations similar to those found year round in shallow ground water. This similarity indicates that ground water is the primary source of desethylatrazine in surface water, and that the higher concentrations of the parent compounds of triazines in the spring base flow are derived from other sources, such as bed sediment, soil water or ground water within a few feet of the water table under agricultural fields.

Somerset County Maryland Economic Development Commission. 2005. Economic Development Annual Report: Fiscal Year 2005.

Summary: This annual report includes statements from county economic officials regarding development in 2004-2005. Statistics are presented on labor, income, population and real estate. Plans for increasing business in the county are outlined, and economic development supporters are listed.

Speiran, G.K., P.A. Hamilton, M.D. Woodside. 1997. Natural Processes for Managing Nitrate in Ground Water Discharged to Chesapeake Bay and other surface waters: more than forest buffers. U.S. Geological Survey publication FS-178-97.

Summary: Ground-water discharge is a significant source of nitrate load to tidal creeks, coastal estuaries, and Chesapeake Bay. Different studies have found that forest buffers greater than 200 feet wide remove most of the nitrate from passing ground water. These buffers are commonly

included in regional nutrient-management strategies. Results of a U.S. Geological Survey study on the Eastern Shore of Virginia, however, indicate that the presence of forest buffers alone may not significantly decrease nitrate load in ground-water discharge. The effectiveness of forest buffers largely depends on the composition of local soils and ground-water flow paths. Study results also indicate that large amounts of nitrate are removed from ground water by the natural process of denitrification, which may occur independently of the presence or absence of forest buffers. The results of this study indicate that in addition to the presence of forest buffers, a range of other natural factors, such as soil texture and organic matter content and ground-water flow paths, affect the fate of nitrate in ground water. These factors are important to include along with forest buffers in developing comprehensive nutrient management strategies.

Stevenson, J.C., L.G. Ward, M.S. Kearney. 1988. Sediment transport and trapping in marsh systems: implications of tidal flux studies. Marine Geology. 80:37-59.

Summary: Although the concept that marshes act a major sediment sinks may be accurate when viewing them over the last few millennia, tidal transport studies suggest considerable variability with most marshes presently exporting material on an annual basis. High-salinity marshes along the mid-Atlantic Coast of the United States appear to be losing 1^{-2} kg m^{-2} y^{-1} while submerged upland marshes on the Delmarva Peninsula are eroding at rates of up to 14 kg m^{-2} yr^{-1}. By comparison, at least one deltaic marsh on the Dutch coast along with several estuarine marshes appear to be accumulating sediment. In order to assess the trapping ability of marshes in large estuaries, we constructed a sediment budget for Chesapeake Bay which included a variety of wetland types. Calculations indicate that estuarine marshes trap 5-11% of the annual Chesapeake Bay sediment input, or about one half that previously estimated. It appears that most sedimentation in estuaries, and perhaps other coastal systems, occurs in subtidal flats below the limit of emergent marsh vegetation. As mud flats become vegetated and estuarine infilling proceeds, there may be a tendency for tidal currents to become ebb-dominated which promotes a net export of particulates. The extent to which major storm events are capable of returning enough material to balance the long-term accretionary budget of tidal marshes and keep them abreast of rising sea level is open to question. Differences in tidal dynamics, seasonal changes in sea levels and higher temperatures may help explain why, in the U.S., southern marshes are more susceptible to export and eventual erosion than northern marshes. We hypothesize that another factor, the recent reductions of terrigenous sediment inputs from the southern river systems of the U.S., may also be critical. Sediment starvation may have led to undernourishment of wetland systems of the coastal zone over the last half century which may be reflected in the net export measured in the tidal marshes in this region. Furthermore, we postulate that changes in sediment inputs are more important than eustatic sea level rise in causing the past losses of marshes which are now undergoing mass erosion. Thus, future wetland survival will depend as much as particulate inputs to the coastal zone as on the prospects of a global rise in sea level, and more efforts should be made to quantify the sediment budgets of tidal marshes.

Stribling, J. M. and J. C. Cornwell. 1997. Identification of important primary producers in a Chesapeake Bay tidal creek system using stable isotopes of carbon and sulfur. *Estuaries* 20(1): 77-85.

Summary: The use of multiple stable isotopes in the study of trophic relationships in temperate estuaries has usually been limited to euhaline systems, in which phytoplankton, benthic microalgae, and *Spartina alterniflora* are major sources of organic matter for consumers. Within large estuaries such as Chesapeake Bay, however, many species of consumers are found in the upper mesohaline to oligohaline portions. These lower salinity wetlands have a greater abundance of macrophytes that use C3 photosynthesis to fix carbon, in addition to *S. alterniflora*, which fixes carbon via the C4 photosynthetic pathway. In a broad survey of the biota and sediments of a brackish tidal creek tributary to Chesapeake Bay, combined $\delta^{13}C$ and $\delta^{34}S$ measurements disclosed a balanced contribution to secondary production from phytoplankton, C3 macrophytes, *Spartina* sp., and benthic microalgae. Surface sediment $\delta^{13}C$ suggested that the organic matter from C3 plants was derived both from allochthonous sources (terrestrial runoff) and from autochthonous production (marsh macrophytes). Unlike most estuarine systems studied to date, which are dominated by algae (phytoplankton and benthic microalgae) and C4 macrophytes, C3 plants are of greater importance in the diets of consumers in this low-salinity creek system.

Stribling, J. M. and J. C. Cornwell. 2001. Nitrogen, phosphorus, and sulfur dynamics in a low salinity marsh system dominated by *Spartina alterniflora*. Wetlands **21**: 629-638.

Summary: In the upper reaches of estuaries, the pulsing of nutrient inputs and salinity occurs on fine temporal and spatial scales. We investigated the supply and exchanges of N, P, and S along a salinity gradient in a Chesapeake Bay subestuary. Interactions among nutrients in surface water, sediment porewater, and shoots of the dominant marsh macrophyte *Spartina alterniflora* were also examined. The system was characterized by a spatial gradient in nutrient availability, with the low salinity region representing abundant allochthonous nitrogen and phosphorus inputs and minimal sulfur availability. Autochthonous production and consumption of nutrients were most important at the midpoint of the salinity gradient. These patterns were reflected in the N, P, and S content of *S. alterniflora* over one growing season. This brackish tidal creek system also had a gradient of temporal variability in levels of inorganic nitrogen, phosphorus, and sulfur. The higher salinity portion experienced the damping effect of waters of more constant nutrient composition, whereas the upper portion of the system was characterized by highly pulsed nutrient availability. Interchanges between nutrient pools were apparent throughout the system. Sediment, and even surface-water, concentrations of nutrients seemed to respond to plant root zone oxidation and uptake and release of nutrients. Porewater biogeochemical processes were linked to surface-water nutrient dynamics as well.

Stribling, J. M., J. C. Cornwell, C. Currin. 1998. Variability of stable sulfur isotopic ratios in *Spartina alterniflora*. *Marine Ecology Progress Series* 166: 73-81.

Summary: The sulfur stable isotopic composition of *Spartina alterniflora* in a low salinity tidal creek system was related to differences in porewater sulfur chemistry determined by salinity, hydrodynamics, and season. The extent of porewater sulfide accumulation, the reoxidation of sulfide minerals, and sulfate limitation of sulfate reduction were important processes controlling the $\delta^{34}S$ of the sulfur available for plant uptake. The influence of sedimentary sulfate reduction rates on *S. alterniflora* $\delta^{34}S$ was demonstrated in the comparison of 2 sites with similar sulfate supply but differing hydrology; plant $\delta^{34}S$ values were heavier where sediments were more

oxidized relative to plant $\delta^{34}S$ values from a frequently flooded marsh with more reduced sediments. The role of sulfate supply in determining *S. alterniflora* $\delta^{34}S$ was apparent in the comparison of 3 sites with similar hydrology but differing salinity; shoot $\delta^{34}S$ decreased with increasing salinity. In low salinity marshes, oxidation of stored sulfide minerals in winter and spring led to lighter shoot $\delta^{34}S$ values, while sulfate depletion in late summer was associated with isotopically heaver shoot sulfur. Variability on spatial and temporal scales in sulfur stable isotopic composition of *S. alterniflora* has implications for the use of its $\delta^{34}S$ values in studies of trophic dynamics in estuarine marshes. The sulfur chemistry of the marsh sediments and the sampling season may both influence the stable isotopic signature of this important primary producer.

Stribling, J.M., O.A. Glahn, X.M. Chen, J.C. Cornwell. 2006. Microtopographic variability in plant distribution and biogeochemistry in a brackish-marsh system. Marine Ecology Progress Series. 320: 121-129.

Summary: Microtopography is often observed and studied in plant communities where stress limits distribution, for example in desert and peatland ecosystems. Brackish marshes, relatively poorly studied despite their importance in many coastal areas, frequently display similar fine scale variability. In these systems, stress derives from the combination of flooding and salinity fluctuations. We examined the relationship between spatial variability of vegetation and biogeochemical features of sediment in a brackish tidal ecosystem in two nearby marshes of differing hydrology and vegetation distribution. The first, a low-elevation, interior marsh, was frequently flooded and poorly drained, and it exhibited distinct hummock / hollow topography. This plant distribution was reflected in patchy sediment biogeochemical features at the same scale. The second marsh, on a well-drained, elevated streamside bank, contained homogeneous vegetation cover and relatively uniform sediment chemistry. The formation of the hummock / hollow topography in the interior marsh appeared to be controlled by the plants, as they maximized growth in a high-stress, variable environment. The plants favorably modified discrete patches of these environments to such a degree that the hummock sediment biogeochemistry was very similar to that of the higher-elevation homogeneous marsh. The microtopography of this interior brackish marsh strongly resembles that of other stress-impacted ecosystems.

United States Department of Commerce. 2001. Profiles of general demographic characteristcs: 2000 census of population and housing, Maryland. U.S. Census Bureau, Washington, DC.

Summary: This report provides a compilation of statistics for the state of Maryland from the 2000 U.S. Census. It includes demographics and housing information for Somerset County and the town of Princess Anne.

Walbeck, D.E., R.D. Drobney, F.C. Rohwer. 1990. Waterbird use of open marsh water management ponds in Maryland. 1990 Prec. Ann. Conf. SEAFWA: 182-188.

Summary: During autumn 1985, we investigated waterbird use of Open Marsh Water Management (OMWM) ponds and use of natural ponds in an adjacent impoundment in

Maryland. Dabbling ducks used ponds with dense widgeongrass (*Ruppia maritima*) more than ponds with sparse or no widgeongrass (P<0.01). Wading birds and shorebirds used the natural ponds more than the OMWM ponds (P<0.01), mainly because the OMWM ponds had vertical sides and were too deep (x = 0.42m) to allow foraging. Pond surface areas were positively correlated with numbers of birds (P <0.05) and inversely correlated with densities of birds (P<0.01).

Ward, L. G., M. S. Kearney, J.C. Stevenson. 1988. Assessment of marsh stability at the estuarine sanctuary site at Monie Bay, implications for management. Washington, DC, NOAA, National Ocean Service, Office of Ocean Resource Management, Sanctuary Program Division**:** 78.

Summary: The marshes at the Monie Bay research Reserve are composed of three sedimentary environments; high wave energy bay bank marshes characterized by low organic (<10% LOI), coarse-grained storm overwash deposits overlying finer-grained marsh sediments; low energy tidal channel bank deposits composed of moderately organic (10-30% LOI), fine-grained sediments; and organic rich (>30% LOI), fine-grained black marsh sediments. The average grain size of the marsh sediments range from ~1.1 to 10.4 , but have a major mode between 9.0 to 10.0 (channel back and back marshes) and a secondary mode between 4.0 to 5.5 (bay bank marsh overwash deposits and underlying soil sediments). The dry and wet bulk densities of the marsh sediments vary from ~0.09 to 0.78 gms/cc and ~0.70 to 1.40 gm/cc, respectively, and are inversely related to both organic and moisture content. The organic content of the marsh near the sediment surface is frequently lower than at depth due to storm effects, bank erosion, higher sediment loading of the estuary after deforestation and urbanization, and more frequent flooding of the marsh surface due to sea level rise. Vertical accretion rates in the marshes based on palynological analysis (shift in *Quercus:Ambrosia* ratio due to an agricultural horizon dated ca. 1790) range from 0.15 to 0.63 cm/yr. Determination of accretion rates using Lead-210 geochronology agree with the pollen derived rates. Approximately 75% of the accretion rates were less than the local rate of sea level rise (0.4 cm/yr). Comparison of vertical aerial photographs taken in 1938 and 1985 indicate little change in the marsh surface despite the low accretion rates. However, first order tidal channels appear to have undergone apical growth and increased in density.

Ward, L. G., M. S. Kearney, J.C. Stevenson. 1998. Variations in sedimentary environments and accretionary patterns in estuarine marshes undergoing rapid submergence, Chesapeake Bay. *Marine Geology* 151: 111-134.

Summary: Major processes controlling sedimentological characteristics and accretionary rates and patterns were evaluated in two of the most common tidal marsh settings (estuarine tributaries and estuarine embayments) in Chesapeake Bay, one of the largest microtidal estuaries in the world. Textural analyses of 29 vibracores show spatial and temporal trends in grain size and organic matter which reflect differences in depositional settings within the marshes and changes in the controlling processes, as well as broader events in the surrounding watersheds. Spatially, the surficial sediments normally follow expected patterns, with coarsest sediments and lowest organic matter contents found in bay margin or channel margin locations, while the finest, organic-rich sediments occur in interior and submerged upland marshes. However, temporally,

the marshes do not always show the expected increasing dominance of organic input over time (indicated by increasing % loss on ignition with decreasing depth), indicative of the marsh building process. Sea-level rise, tidal channel migrations, and anthropogenic effects likely contribute to decreases in organic matter contents in the upper sediment column. Furthermore, accretion rates and stratigraphic characteristics can be affected by these same processes, illustrating the importance of understanding temporal changes in marsh depositional environments over various time scales before sedimentologic and accretionary patterns are evaluated. Examination of the vibracores reveals that the marsh is composed of a complex stratigraphy with at least four major stratigraphic sequences occurring: (1) emerging or developing marsh sequences characteristic of channel margin and interior marshes; (2) submerging or mineral matter enriched marshes, also characteristic of channel and interior marsh areas; (3) high-energy marsh sequences characteristic of bay margin environments; and (4) submerged upland marsh sequences. The sedimentological properties of the stratigraphic sequences are controlled by overwash processes, tidal channel migrations, duration of tidal flooding, various anthropogenic effects, and sea-level rise. Accretion rates and patterns over the last ~200 years, determined from pollen histories, differ between the marshes along the estuarine tributary (Nanticoke River) and those found in the tidal embayment (Monie Bay). Marshes in the upper-estuarine tributary have a larger riverine sediment input, and trapping of the high sediment loads in the upper estuary often yields marsh accretion rates (maximum of 0.74 cm/yr) which are greater than relative sea-level rise (~0.4 cm/yr), resulting in stable marshes. By comparison, estuarine processes limit penetration of high sediment loads to the lower reaches of marshes along the tributary and, as a consequence, accretion rates are generally lower than the rate of relative sea-level rise, and marsh loss is prevalent. Overall, accretion rates in the marshes in the embayment are close to or less than the local sea-level rise and do not have as distinctive spatial patterns as the tributary marshes. Although marsh loss has yet to be identified as a significant process here, decreases in organic content of the upper sediment column may signal the early stages of submergence due to sea-level rise.

Werkheiser, W.H. 1990. Hydrogeology and ground-water resources of Somerset County, Maryland. Department of Natural Resources, Maryland Geological Survey. Annapolis, MD.

Summary: This report assesses the groundwater resources of Somerset County as of 1990. Its goals were (1) to refine understanding of the hydrogeologic conditions, (2) to describe ground water quality, and (3) to evaluate impacts of proposed increases in groundwater withdrawals from Crisfield and Princes Ann. The report describes the seven major aquifers underlying the county. The first of these, *surficial aquifer*, is limited capacity used for household purposes, relatively soft and acidic with high nitrate concentrations in areas near farming. The *Pocomoke aquifer* is present only in the SE part of the county, has elevated concentrations of iron and manganese. The Manokin aquifer is the principal source of water for Somerset County. It has highly variable water quality ranging from relatively soft water low in solutes to the south and east to hard water high in chlorides toward Chesapeake Bay. Water in the Deal Island/Monie NERR area has chloride concentrations exceeding USEPA standards. The Paleocene and Potomac aquifer systems supply water to major towns and cities in Somerset and other counties along the Bay. Model analyses suggested that projected increases in water use in Somerset could encounter salinity problems within 50 years.

Whigham, D.F., J. O'Neill, M. McWethy. 1982. Ecological implications of manipulating coastal wetlands for purposes of mosquito control. Wetlands: Ecology and Management. B. Gopal, R.E. Turner, R.G. Wetzel, D. Whigham, eds. P 459-476.

Summary: Open Marsh Water Management, a technique to control salt marsh mosquitoes, is being used extensively along the Atlantic Coast of the United States. There are, however, few data to evaluate the ecological implications of OMWM. A large-scale study, using 3 variations of OMWM, was initiated in 1978 to determine effects of the procedure on high marsh wetlands in the Maryland portion of the Chesapeake Bay. Preliminary results have shown that significant changes have occurred in the 3 sites that were manipulated. Vegetation in the Open and Water control sites is now dominated by *Distichlis spicata*, and *Iva frutescens* is becoming more important. The Closed system is now dominated by *Spartina patens*. Within each site, tissue nutrient concentrations of nitrogen and phosphorus were significantly higher. There were significant differences between sites and the most significant effects were near ditches. There have been no major site differences in water quality parameters and there has been no indication that OMWM has resulted in any deterioration of water quality in the adjacent estuarine streams. Tide cycle studies indicate that the Open system exports all materials that we have been monitoring. Qualitative measurements of surface water, however, indicate that there are no major releases of nutrients during flooding events.

Zelenke, J.L., J. Stevenson, J.C. Cornwell. 1994. Deposition of inorganic and organic phosphorus in Maryland tidal marshes: a preliminary analysis. *In*: Toward a Sustainable Coastal Watershed: The Chesapeake Experiment. Proceedings of a Conference. Chesapeake Research Consortium Publ. No. 149 pp. 630-633.

Summary: The environmental degradation of the Chesapeake Bay is though to be the result of excess nutrient inputs, primary nitrogen and phosphorus. The major sources of these nutrients include diffuse and point-source inputs from the watershed, atmospheric deposition, and phosphorus inputs from the coastal ocean (Boynton et al. 1995). The long-term burial of phosphorus into subtidal sediments is the ultimate of virtually all of the phosphorus inputs, and the fluxes to subtidal sediments have received considerable attention. Chesapeake Bay tidal marsh sediments also retain phosphorus, although the form and burial rate of phosphorus have not been examined prior to this study. This study seeks to determine the relative importance of tidal marsh sediments in nutrient retention by examining deposition in three National Estuarine Research Reserve Sites included in the northern Chesapeake Bay. If tidal marsh sediments are an important sink for nutrients, their proper management in the Chesapeake Bay area is critical to the Bay's ecology. Our approach to determining the rate of nutrient burial in northern Chesapeake marshes involves the dating of cores using ^{210}Pb techniques to estimate sedimentation rates and the measurement of nutrient concentrations in vertical core profiles. While we have determined the concentrations of phosphorus in numerous cores, the quantification of burial rates awaits completion of ^{210}Pb dating. In this paper, we show the concentrations and forms of phosphorus buried in several different marsh sites, including Patuxent River, Monie Bay, and the Choptank River. The importance of tidal marshes to phosphorus retention will be examined relative to the total inputs of phosphorus to the system.

An earlier study of the Choptank River marshes lead to the rough estimate that 5 – 10% of phosphorus loading from atmospheric and watershed inputs was retained in marsh sediments.

Zelenke, J.L. and J.C. Cornwell. 1996. Sediment accretion and composition in four marshes of the Chesapeake Bay. HPEL Data report. University of Maryland, Center for Environmental Science, Horn Point Laboratory. Cambridge, MD.

Summary: Funding was provided by NOAA in 1993 to investigate the nutrient recycling times of marsh systems. Short turnover times and dynamic fluxes are expected in the flooding water, while plant biomass is expected to delay nutrient uptake and release over the course of a year. The longest time scale of nutrient removal from the system is incorporation into the sediments of the marsh. Sediment generation through the burial of both organic matter from the marsh plants and inorganic matter from flooding waters results in vertical accretion of the marsh surface. Nutrients within this matrix are permanently removed from the estuary. Here we present the data gathered which was used to estimate long term nutrient retention by four Chesapeake Bay marsh systems.