Chesapeake Marshlands National Wildlife Refuge Complex

5th Annual Science Meeting
April 9, 2008

A Simple Electrical Analogy Models the Lake Blackwater Tides

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The tides in Lake Blackwater are predominantly forced by the tides in Fishing Bay. The tides in Fishing Bay are a complicated signal that includes, among other things, short- period components (e.g., semidiurnal), long-period components (e.g., annual) and non-periodic components (e.g., the meteorological tidal residual in Chesapeake Bay). These Fishing Bay components do not have equal effect in Lake Blackwater. Upstream, the amplitudes of the short-period components are much more attenuated than the amplitudes of the long-period components, and the short-period phases are more lagged.

A simple analogy of the system is the classic electrical "RC filter", in which a resister (the Blackwater River) and a capacitor (the Lake Blackwater tidal prism) are connected in series, with voltage being analogous to tidal height. The RC filter is easily characterized mathematically with a single parameter, an exponential decay time constant. The time constant for the Lake Blackwater system can be inferred from the upstream attenuation of the short-period signal. In numerical form, this simple model satisfactorily, if not exactly, describes the tidal transfer function between Fishing Bay and Lake Blackwater captured in the 2003 Army Corps of Engineers and NOAA tidal data.

The model can be used to largely eliminate the Fishing Bay forcing signal from the upstream response, when both are known, thus isolating the local (presumably meteorological) effects in Lake Blackwater. It can be used to estimate the effect on short-period component amplitudes from marsh loss or restoration. With fairly simple development, the model may be useful in estimating inundation effects from a storm surge.

Pollutant Removal Efficiencies and Buffer Widths: A Focus on TP, TN, and TSS

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Proposed housing and golf course developments in the Atlantic Coastal Plain usually require an assessment of potential impacts to stream systems. Most jurisdictions have either explicit or *de facto* regulations or guidelines for stream and wetland buffers. Vegetative buffers can serve many roles – preventing drift of turf chemicals, providing riparian habitats, and reducing contaminant loading from stormwater runoff via natural filtration. This paper provides an analysis of the latter. Key parameters of concern are total nitrogen (TN), total phosphorus (TP), and total suspended solids (TSS). All three parameters can have significant impacts on wetland and freshwater systems. The literature was reviewed to determine the relationship between buffer width and pollutant removal efficiency. In addition, the relationship between buffer width and the onset of concentrated flow was examined. Plots of contaminant removal efficiency (RE) vs. buffer width (B) followed logarithmic relationships, i.e., RE(%)=a(lnRE)+b. R^2 = 0.63, 0.57, and 0.42 for the TP, TN, and TSS relationships, respectively. (All relationships were significant at p = 0.01, except TSS (p=0.058)) This indicates buffer width is a key factor but not the only factor. The second derivative of these plots can be used to estimate the 'point of diminishing returns', i.e., the approximate B at which a large increase in B results in only a relatively small increase in RE. These numbers were 18 m (60 ft), 20 m (65 ft), and 15 m (50 ft), for TP, TN, and TSS, respectively. We suggest that these distances are governed by the transition from overland/sheet flow to concentrated/channelized flow. Calculations are done to demonstrate that the distances to reach concentrated flow in very short grass are 10.7 m (35 ft), 15 m (50 ft), and 21.6 m (71 ft) for slopes of 0.005, 0.01, and 0.02, respectively. Another key consideration for this type of analysis would be the extent to which stormwater runoff is treated with other BMPs prior to entering the vegetative filter strips.

Strategic Habitat Conservation (SHC) and Wetland Restoration within Chesapeake Marshlands

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Strategic Habitat Conservation (SHC) is a science-based approach to guide conservation work by integrating information across multiple programs and collaborating with other agencies to achieve specific outcomes. The elements of SHC represent the scientific method in action including: biological planning, conservation design, conservation delivery, and decision-based monitoring and research. The U.S. Fish and Wildlife Service and the U.S. Geological Survey are working together at national and regional levels to implement SHC. Within Region 5 (northeast region of the Fish and Wildlife Service), the Chesapeake Marshlands NWR Complex is part of the Chesapeake Bay Focus Area for SHC and Blackwater NWR is a pilot refuge for SHC implementation. At Blackwater National Wildlife Refuge (NWR), we are implementing the SHC approach to restore wetlands and we are collaboratively working with many other federal, state, and private organizations including the Army Corps of Engineers, the Maryland Port Administration, National Oceanic Atmospheric Administration, the Maryland Department of Natural Resources, the National Aquarium in Baltimore, Ducks Unlimited, the Nature Conservancy, the Chesapeake Bay Foundations and many other agencies. In addition, we have formed a Technical Advisory Group (expert scientists) and a Citizen's Advisory Group (local stakeholders) to assist and guide restoration efforts. Biological planning is underway for 4 wetland restoration projects. Conservation design is being coordinated with the Technical Advisory Group and the Citizen's Advisory Group. Conservation delivery occurred in 2003 when 8 acres of wetlands were restored and from 1980-1985 when 12 acres were restored. Decision-based monitoring and research is on-going and will be presented by Refuge partners at the Science meeting.

Circulation and Exchange in the Blackwater National Wildlife Refuge Lake and Marsh Complex

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Water circulation, wind waves, and tidal exchange are being investigated in the Blackwater National Wildlife Refuge Lake and Marsh Complex to aid the understanding of marsh loss and to support restoration efforts. The goals of these investigations are to establish the baseline circulation and exchange processes and to enable these processes to be monitored via easily maintained long-term stations and a numerical circulation model. Current meters, wave and tide gauges, and temperature-salinity recorders were placed in the Marsh Complex and in the gateway region at Shorter's Wharf in December 2007. During this interval, a time-series transport survey through this section was carried out via a downward-looking sonar. The instruments have been recovered, and a longer-term current sonar was redeployed near Shorter's Wharf in late December. Although these results are being analyzed, the preliminary information shows the basic wind-driven circulations, the filtered water-level fluctuations in Blackwater Lake, and the exchange flow between the Marsh Complex, Fishing Bay and the main-stem Bay beyond. A second series of intensive measurements is planned for late spring 2008 to examine the circulation and exchange with different wind forcing and with the seasonal steric height change being induced by the warm temperatures and low-salinities of spring runoff. These investigations have been greatly aided by the long-term water-level information obtained via the cooperation of partners in NOAA and USGS. In addition, new developments in the Chesapeake Inundation Prediction System (CIPS) are encouraging in that the high-resolution models can integrate, forecast, and visualize the circulation processes revealed in this study.

The MD Department of Natural Resources Fish & Wildlife Health Program: Collaborations with BNWR

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The Maryland Department of Natural Resources Fish & Wildlife Health Program (FWHP) was developed in 1999 in response to numerous disease issues within the state of Maryland. Since that time we have worked with many federal, state, local and private organizations to address diseases in our state. The FWHP program biologists address species areas of expertise including fisheries, marine mammals & sea turtles, and wildlife. The program is divided into four main components: 1) response to morbidity and mortality events around the state, 2) monitoring of selected species, 3) research to answer management questions, and 4) outreach to disseminate our findings.

Throughout the years the FWHP biologists have been involved with health and disease monitoring and investigations at Blackwater National Wildlife Refuge involving the Delmarva Fox Squirrel, Bald eagles, nutria and various avian die-off events. This presentation will summarize Fish & Wildlife Health Program collaborations at the refuge as well as .past and current disease investigation efforts around the state.

An Update on Nutria Eradication in Chesapeake Bay Marshlands

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Non-native nutria (Myocastor coypus) have been linked to the destruction of more than 8,000 acres of marshlands at the Blackwater Unit of the Chesapeake Marshlands National Wildlife Refuge Complex. Feral populations were first established in the 1940's in Dorchester County, Maryland, and populations have since expanded throughout the Delmarva Peninsula, threatening marsh habitats throughout the Chesapeake Bay watershed. In 2002 we launched a campaign to eradicate this invasive species from Chesapeake Bay marshlands. Traditional harvest techniques, including trapping and hunting, are being applied within an Integrated Wildlife Damage Management framework in order to achieve a systematic and progressive removal of nutria Chesapeake bay wetlands. To date, 11,500 nutria have been removed from nearly 130,000 acres of marsh throughout Maryland's lower eastern shore. We provide an update to ongoing efforts to reduce and monitor populations and expand eradication efforts throughout the Delmarva Peninsula.

Effects of prescribed fire rotations on above- and below-ground vegetative biomass production in a tidal freshwater marsh

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Fire has long been considered an important component of many ecosystems and evolved into a broadly accepted tool in vegetation and wildlife management in wetlands. Blackwater National Wildlife Refuge (BNWR), 12 miles south of Cambridge on the eastern shore of Maryland, USA, is a tidal freshwater marsh complex and has been using fire as a marsh management tool since the 1970's. The primary purpose for using fire was to increase and enhance marsh vegetation to support and sustain the waterfowl that use the refuge as habitat. We conducted a study to evaluate vegetation responses during the years 2004 and 2005 as affected by different fire regimes at BNWR. Our study investigated the effects of prescribed fire rotations specifically on the above- and below-ground vegetative biomass. There were four different fire rotation treatments: annual burn, 3-5 year burn, 7-10 year burn, and a control (i.e. no burn). Two study areas were identified and each divided into the four fire treatment sites. At each treatment site, ten above- ground (0.5 m^2) and ten below-ground biomass samples (0.1 m diameter x 0.3m) were harvested per year (N=80). All the biomass harvested was separated by species for five plant species naturally growing at the site, including *Distichlis spicata*, *Spartina alterniflora*, *Schoenoplectus americana* , *Spartina cynosuroides* and *Spartina patens*. Moreover, below-ground samples were divided into two portions by two different soil depths, 0-10cm and 10-30cm, with alive and dead parts distinguished. For above-ground biomass, species richness, stem density, litter, and dry weight were evaluated. For below-ground biomass, the live and dead biomass were compared and analyzed. On-going data analysis showed no statistical difference in above-ground biomass of vegetation between burn regimes, but a significant increase in alive, below-ground biomass for annual burn over the other burn regimes. Further data analysis is underway.

Fish diversity and distribution in the Blackwater River drainage (Chesapeake Bay watershed)

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We surveyed fish assemblages from Blackwater River drainage (Cambridge, MD) in order to document spatiotemporal patterns of fish distribution from November 2004 – June 2007. Fish assemblages were sampled from an historically freshwater section of the upper Blackwater River (UB) which has seen increases in salinity levels due to a man-made connection to the Little Choptank River since the 1800's. Three sites spaced along the stream gradient were sampled from Little Blackwater River and the upper Blackwater River. Fish assemblages strongly differed between the upper Blackwater River and Little Blackwater River, likely due to differences in salinity between the two habitats. Salinity of upper Blackwater River ranged from 9 – 12 ppt, on average, while the Little Blackwater River ranged from 0 – 5 ppt, on average. Little Blackwater River served as a nursery for freshwater-dependent fishes, such as white perch (*Morone americana*) and brown bullhead (*Amerius nebulosus*). For 10 monthly sampling events (March-December 2007), we sampled 379 juvenile white perch at two freshwater and three brackish habitats. Body condition (i.e., length corrected mass) for white perch differed among sites, and was greater in freshwater than in brackish habitats. However, growth rate (change in TL over time) did not differ between freshwater and brackish habitats. We conclude saltwater intrusion and immigration of euryhaline species in upper Blackwater River likely contributed to deterministic extirpations and strong spatial differences in assemblage structure for the Blackwater River drainage. Freshwater habitats may act as a nursery, supporting greater body condition for some species such as white perch. Blackwater National Wildlife Refuge (NWR), with partners, recently constructed a weir to block saltwater being conveyed from the Little Choptank River via the canal. The results of this restoration event are currently under investigation.

Benthic Nutrient Flux Rates and Organic Degradation In Blackwater Pond at Blackwater National Wildlife Refuge

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In the summer of 2007, a preliminary study done on the biogeochemistry of the pond of Blackwater National Wildlife Refuge explored the rate of benthic nutrient fluxes and concentrations of porewater constituents as part of an Research Experience for Undergraduates (REU) with Maryland Sea Grant for the University of Maryland Center for Environmental Science Horn Point Laboratory. As the location for future marsh restoration sites, the biogeochemistry of the existing substrate will be an important factor to consider in the restoration process. Because of the potential restoration of the marsh using dredge sediments with high levels of nitrogen and phosphorus, a biogeochemical evaluation of the system is needed. The objective of this study was to provide preliminary sediment biogeochemical data for this ecosystem.

In a series of incubation experiments, it was found that flux rates (Oxygen, Nitrogen, Nitrate + Nitrate, Ammonium, Phosphorus) in the Refuge pond are low with the exception of one location characterized by submerged intact peat. Of primary interest were the rates of denitrification and the possible presence of benthic microalgae. Results revealed Blackwater Lake to have high variability at the sediment-water interface. Porewater profiles for two sites were analyzed for the presence of soluble reactive phosphorus, iron, ammonium, H_2S, and methane gas. Differences in these constituents differed greatly at each location, showing again the high variability and uniqueness of the system. This knowledge on the biogeochemical behavior in the system will be an important consideration as the restoration goes forward, with concerns for changes in the nutrient balance that could lead to eutrophication of the Refuge and areas downstream.

Distributional Patterns of Native and Introduced Populations of *Phragmites* in the Tidal Marshes of Delaware and Chesapeake bays with Landscape Implications for Their Future Management.

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Starting in the fall of 2002, major tidal tributaries in the mid-Atlantic were surveyed for native and introduced populations of *Phragmites* to document their size, density, and landscape position. These surveys found native populations to be quite common on the eastern shore of Maryland in Chesapeake Bay but uncommon in Delaware Bay, due most likely to differences in historic agricultural practices. All native populations were located in freshwater and oligohaline habitats, typically occurring along the creek edge. Introduced populations were found in freshwater through polyhaline habitats and were more widely distributed, ranging from the creek edge across the marsh plain to the marsh-upland interface. A consistent distributional pattern was noted in most watersheds where introduced populations dominated the lower drainage with native populations being confined to the upper tidal reach where introduced populations were less common. A similar pattern was documented in Delaware and has lead to implementation of the "Native Reserve Program", a landscape approach to invasive species control, focusing initially on the upper basin where the vegetation is still dominated by natives and introduced species, like *Phragmites*, remain uncommon. This control effort works progressively downstream with the ultimately goal of eliminating introduced *Phragmites* totally from the drainage.

Prescribed Fire Frequencies and Nesting Success of Secretive Marsh Birds at Blackwater National Wildlife Refuge (Vegetation Analysis)

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Limited research has been conducted on the effects of prescribed fire on tidal marsh wildlife species, including migratory birds. Preliminary research by Dr. Peter Marra (Smithsonian Migratory Bird Center) indicates that annual winter burns at Blackwater National Wildlife Refuge (NWR) do not appear to affect bird community richness and diversity, but may increase nest predation in seaside sparrows in drought years. The Chesapeake Marshlands NWR Complex and conservation partners are concerned about the potential effects of prescribed fire on the secretive marsh bird community of Blackwater NWR and nearby Fishing Bay WMA (e.g. salt marsh breeding sparrows, rails, American and Least Bittern, Common Moorhen). In 2007, the Biological Program at the Refuge initiated a long-term project to evaluate the effects of prescribed fire on secretive marsh birds at Blackwater NWR. Objectives of the project are to: 1) compare various fire return intervals for differences in the presence, distribution, and estimated density of breeding secretive marsh birds within Blackwater National Wildlife Refuge; 2) assess differences among fire rotations for breeding bird territories using spot mapping as an estimate of breeding bird population density; and 3) compare nest site selection and nest success of secretive marsh birds among various fire rotations. As part of the project, the Refuge is seeking to detect differences in the marsh vegetation community among fire rotations, and differences between nest selection sites and marsh areas not selected for nests. We will present preliminary results of the vegetation surveys associated with this project.

Carbon sequestration and organic matter accumulation in Blackwater tidal marshes

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Tidal marshes have high carbon sequestration (organic matter accumulation) rates due to high net primary productivity, low decomposition rates, and vertical accretion under sea level rise. There is increased interest in estimating and maximizing carbon sequestration rates in tidal marshes due to the need to increase organic matter accretion rates for marsh sustainability and because marsh restoration and conservation projects may be eligible for carbon credits. In this presentation I will discuss several ongoing collaborative research projects being conducted within the Blackwater National Wildlife Refuge. We are monitoring carbon sequestration rates in a natural marsh and a marsh restored using locally derived materials. This study also includes monitoring of methane emissions, soil porewater chemistry, and aboveground biomass production. We are also monitoring carbon sequestration rates within the U.S. Fish & Wildlife Service's controlled burn study. I will also discuss results from a National Wildlife Federation-funded study in which marsh loss and migration were modeled in the Chesapeake Bay region using the Sea Level Affecting Marshes Model (SLAMM). Finally, I will discuss the policy and scientific challenges associated with obtaining carbon credit funding through marsh restoration and conservation.

Continued Response at an 8-acre Pilot Marsh Creation Project at Blackwater National Wildlife Refuge

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In May 2003, in partnership with the US Fish and Wildlife Service and the US Army Corps of Engineers, the National Aquarium in Baltimore led community volunteers in planting 8 acres of created marsh at Blackwater National Wildlife Refuge. The marsh was created using locally dredged material placed within straw bale diked cells as well as in potholes in existing degraded marsh, using both traditional and thin layering placement techniques, and planted with Spartina and Scirpus species. Aquarium staff and volunteers have been monitoring these sites since their creation. In 2005, the Aquarium, in partnership with the US Geological Survey and NOAA's National Geodetic Survey, installed surface elevation tables (SETs) at one of the created sites, at another site created in the early 1980s using similar techniques, and at a natural reference site. Data from these SETs indicate a strong seasonal sink-swell dynamic at all sites, with lower elevations in the winter and recovery at the end of the growing season. Overall, the reference and older restored sites appearing to be losing elevation while the 2003 restoration appears fairly stable. Additionally, surveys at the three sites revealed strongly divergent vegetation communities despite their close proximity and similar elevation.

New Perspectives on Sub-Surface Geology at Blackwater National Wildlife Refuge, Dorchester County, Maryland

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We have collected numerous cores (to 30m depth) at Blackwater National Wildlife Refuge along transects from Cambridge to Robbins (north–south) and from Moneystump Swamp to Kuehnle Pond (east-west). A set of shallow vibrocores were also collected by Hoverprobe for a cross-section of the flooding Blackwater valley west of Barbados Island. This profile indicates a mid-Holocene to Present fill-sequence of 3 to 5 meters of black peat resting on as much as 5 meters of dark gray silt. The antecedent Blackwater River valley is underlain by a complex assemblage of generally sandy to pebbly gravels, 1 to 3 meters thick, that were transported and deposited during the Last Glacial Maximum (LGM). These cold climate deposits are known as the Parsonsburg Formation and they are the common substrate under the Holocene fill-sequence. Locally, Holocene deposits are unconformable on older Pleistocene fill or on Miocene substrate, which presents the major permeability contrast and aquaclude for shallow groundwater flow.

The two north-south and east-west profiles define the variability and extent of complex facies in the late Pleistocene Kent Island Formation below the LGM deposits of the Parsonsburg Sand. Beneath the Blackwater Valley, the dominant facies are bay bottom mud with mollusks that indicate salinity similar to the modern Chesapeake. To the north, under the uplands, sandy channel and bar-form facies are interbedded with bay bottom mud. The uppermost estuarine mud includes oysters in tidal channel and levee deposits near the top of the sequence below the Parsonsburg sand. Farther north along the transect, bay mud deposits are not present and the entire sequence includes 6 meters of peaty, back-swamp deposits overlain by repeating sequences of tidal channel and levee deposits. At the north end of the transect, which is truncated by the Choptank River, the Kent Island sequence is thought to include more continuous, coarse sand deposits. The subsurface data presents a transition from fluvial deltaic to estuarine deltaic deposits that verge to the south with open estuary deposits. Only the basal channel sand and sandy bar-form facies appear to present viable permeabilities for groundwater flow paths and recharge. The basal sand and gravel may be time transgressive and correlative with the deep basal gravels at the base of the estuary-fill sequence.

The 15 to 30 meters of Kent Island deltaic and open estuary deposits are unconformable on impermeable clay-silt beds of a poorly understood sequence of red and green, rhythmically bedded silt and clay. White, semi-indurated clay concretions are scattered throughout these deposits, which are burrowed and unconformable on the underlying Choptank Formation, a marine middle Miocene shelf deposit of the Chesapeake Group. The red and green beds may be a younger unit of the Chesapeake Group, or they may be upper Pliocene or lower Pleistocene deposits.

Preliminary Analyses of Bottom Sediment Characteristics in Lake Blackwater

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A preliminary study of sediment properties in the open water area of the Blackwater National Wildlife Refuge, Lake Blackwater, was conducted in summer 2007. Three cores were collected via a hand-deployed piston corer, and core lengths varied from 30 to 100 cm. Cores were analyzed for organic content, porosity, grain size, and ^{210}Pb (half-life 22.3 y) activity. ^{210}Pb analyses resulted in 100-y average sediment accumulation rates that ranged from a few millimeters per year to more than a centimeter per year. These accumualtion rates, when extrapolated to the entire Lake Blackwater area, can account for a portion of the estimated marsh loss at Blackwater, with the rest assumed to be exported to Fishing Bay. Two types of sediment were observed and classified by their organic content and porosity. The first type, which was represented by two of the three cores, consisted of peaty material with high organic content and porosity values and was indicative of eroded marsh fragments. The second type contained clay-rich mineral sediments with low organic content and porosity values, which are typical of relict river channel sediments. These differences in sediment type could lead to significant differences in seabed strength, and further analyses should be conducted to better constrain the spatial variability of Lake Blackwater sediments.

The Application of Two Geophysical Techniques to Map the Subsurface at Blackwater National Wildlife Refuge, Maryland

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Continuous core, ground penetrating radar (GPR), audio-magnetotelluric (AMT), and LIDAR data indicate that the watershed of Blackwater National Wildlife Refuge (BNWR) is underlain by complex fluvial to estuarine sand and gravel deposits on top of older Miocene deltaic deposits. To aid in the mapping of these relationships, several experiments were conducted during June 2006 and September 2007 to ascertain if surface geophysical techniques could be effectively applied to map shallow ground-water-bearing sands, gravels, and clays.

A 250 MHz ground penetrating radar (GPR) was used to collect eight short profiles. GPR pulses EM energy into the ground and records the attenuated return signals. The return signals are stacked (16X) and recorded every 5 cm of lateral movement. The GPR data are processed like reflection seismic data with de-wow, gain, and migration prior to interpretation.

GPR results were mixed due to high attenuation of the transmitted signal caused by brackish water and conductive clays. The signal attenuation limits the depth of exploration to 2 to 4 m. Nevertheless, several of the profiles show disruption of the subsurface caused by road building and conduits used for drainage. GPR profiles from the Wolfpit Pond area clearly show sand dunes with cross bedding.

A natural source electro-magnetic (EM) technique called audio-magnetotellurics (AMT) was also tested at BNWR. The AMT instrument records 40 frequencies (10 frequencies/decade) over 4 decades from 10 to 100,000 Hertz. A total of five AMT traverses (25 AMT stations) were occupied in and near the BNWR. The first N-S traverse starts near the southern end of the Green Brier Swamp and ends south of the Blackwater River near Robbins. The second NE-SW line starts in Green Brier Swamp and ends near Squirrel Point. The third and fourth traverses form an N-S and E-W cross in the Moneystump area of the BNWR. The fifth line crosses a topographic scarp near Le Compte north of the BNWR. The AMT data are edited, evaluated, inverted, and modeled to form electrical resistivity profiles.

The Green Brier N-S AMT line results suggest a >50 m deep asymmetric channel-shaped low resistivity zone. This AMT profile crosses normal to a 1- to 3-m, E-W topographic scarp. Electrically, the northern edge of the scarp is vertical and is located north of the topographic expression of the scarp. The southern edge of the resistivity low is trough-like and asymmetric. The Green Brier swamp profile trends from NE to SW and crosses the topographic scarp at an oblique angle. Material <20 m deep is more resistive than the material below 20 m; this resistivity gradient dips gradually to the SW. The Moneystump profiles have a resistivity low-high-low pattern from the surface to about 10 m below land surface. The high resistivity positively correlates with the sand recovered from the continuous core. The W to E Le Compte profile also has a low-high-low resistivity pattern but the high is truncated near the topographic scarp.

Tumor Prevalence in Brown Bullheads (*Ameiurus nebulosus*) from the Little Blackwater River, Maryland

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The prevalence of tumors in wild fish has been used as an indicator of environmental quality in freshwater, marine, and estuarine ecosystems. Over the past 16 years, the U.S. Fish and Wildlife Service has conducted brown bullhead (*Ameiurus nebulosus*) tumor surveys in Chesapeake Bay tributaries. The Little Blackwater River is of interest because of concerns about increasing urbanization and development of the watershed with possible impacts on Chesapeake Marshlands National Wildlife Refuge. In 2006, we used fyke nets to collect 30 brown bullheads from an upriver location near the USGS gage and 34 bullheads from a downriver location near the boat launch. Fish were transported to the USFWS laboratory and necropsies were conducted. Histopathology was performed on all livers and on all raised skin lesions. The prevalence was compared with historical data from the Tuckahoe River which has been used as a reference location in the USFWS surveys. Logistic regression was used to evaluate covariates such as age, length, and sex. Liver tumors were diagnosed in 1 (3%) of the fish from the lower site and none of the upper site fish. Skin tumors (which were grossly apparent) were found in 5 (15%) of the lower site fish and 8 (27%) of the upper site fish. For the liver tumors, we used length and sex as covariates to compare the liver tumor prevalence with the Tuckahoe which had a 4% overall prevalence. There was no significant difference in prevalence between the Little Blackwater sites and the Tuckahoe. For skin tumors, age was the only significant covariate. Both sites were elevated compared with the Tuckahoe which had an overall prevalence of 1%. We discuss the implications of these findings with respect to contaminants.

U.S. Army Corps of Engineers/Maryland Port Administration Chesapeake Marshlands Restoration Project: Status Report

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The U.S. Army Corps of Engineers (USACE) *Baltimore Harbor and Channels Dredged Material Management Plan* (DMMP) in August 2005 recommended landscape-scale restoration of tidal marshes in Dorchester County, Maryland as one of the highest value beneficial uses of dredged material. The DMMP anticipated that construction of this proposed project, provisionally titled the *Chesapeake Marshlands Project*, would not likely begin for more than a decade, dependent on when placement capacity for dredged material becomes needed. In accordance with the DMMP recommendation and in coordination with USACE higher authorities, Baltimore District USACE utilized funds remaining from the *Blackwater Refuge Continuing Authorities Program Small Aquatic Ecosystem Restoration Project* (under which Baltimore District USACE constructed the 8 acre demonstration project along Wildlife Viewing Drive in 2002/2003) to scope the USACE feasibility study that would need to be completed as a prerequisite prior to construction of the *Chesapeake Marshlands Project*. In 2006 and 2007, Baltimore District USACE worked collaboratively with resource agencies, academic institutions, and non-profit organizations to scope this feasibility study. A preliminary project management plan (PMP) for the proposed feasibility study was prepared in Spring 2007 that outlined requisite tasks and costs. The preliminary PMP contains rough-draft scopes-of-work (SOW) for scientific and engineering investigations necessary to plan restoration work and ensure compliance with environmental and social laws. Baltimore District USACE and the U.S. Fish and Wildlife Service informally circulated the preliminary PMP for comment in Spring and Summer 2007. Unfortunately, by Spring 2007 Baltimore District USACE had expended funds available to prosecute preparation of the PMP, and work on it ceased.

Baltimore District USACE received additional funds in February 2008 to complete the PMP and negotiate a feasibility cost-sharing-agreement (FCSA) with the Maryland Port Administration for the *Chesapeake Marshlands Project* feasibility study. At this time, the previously-prepared SOWs are being reviewed to refine the list of tasks and costs included in the PMP. Individual SOWs are being revised in coordination with their preparing authors. When this task is completed, the PMP will be circulated for review and vetting. Baltimore District USACE's target for finalization of the PMP and signing of an FCSA are Spring 2008 and Summer 2008, respectively. Because of the magnitude of feasibility study tasks and costs identified, one or more phased feasibility studies may be undertaken, rather than attempting to move forward with a single large study. If this occurs, it is likely that restoration work would also be undertaken in phases as multiple semi-independent projects. Whether or not these phased projects would ultimately produce the magnitude of restored tidal wetlands that Dorchester County holds the potential for remains uncertain.

Measuring Marsh Vegetation Structure Using Multi-angular Remote Sensing

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Remote sensing techniques offer an efficient approach to monitor and quantify changes in marsh vegetation. In particular, off-nadir radiometry, can provide useful information about ground cover conditions, including vegetation structure parameters. It is hypothesized that remote sensing from multiple viewing angles, especially at near-infrared wavelengths, could provide information about vegetation structure for coastal marshes. Of particular interest is leaf area index (LAI), which can be used to tie vegetation structure to photosynthesis and radiation absorption. This study focuses on possible methods of retrieving LAI using space-based instruments or field measurements to assess vegetation structure over a widespread area. To that end, this study has three main components: 1) satellite data, 2) ground data, and 3) retrieval methods. For the satellite component of the study, multi-angular imagery were taken over the Blackwater National Wildlife Refuge using spaceborne instruments with relatively high spatial resolution (15-20 m at nadir). This imagery is being evaluated for applicability to LAI retrieval. This currently includes one stereographic scene from early October 2007 collected from the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) aboard the NASA spacecraft Terra and four late Summer / early Fall scenes that were acquired from the Compact High Resolution Imaging Spectometer (CHRIS) aboard the European Space Agency's Project for On-Board Autonomy (Proba) spacecraft. The ground data component of this study involves at least one field campaign, the first of which was completed late in the 2007 growing cycle. Several thousand high-resolution reflectance spectra (450-900 nm) were collected at multiple viewing angles along a 1.6 km segment of Maple Dam Road from a moving vehicle with an instrument boom situated over the marsh. LAI measurements also were taken every 1/10 of a mile along this transect, once in September and once in early October. Finally, a method to retrieve marsh LAI is being developed from the multi-angular radiometry and LAI data. The work will begin with a statistical analysis to look for any functional relationship between the sampled multi-angular radiometry (satellite and ground measurements) and LAI measured on the ground. However, a more promising approach would be to develop a canopy reflectance model that is dependent primarily on LAI.

Evaluation of Water Resources in the Little Blackwater River Watershed, Dorchester County, Maryland

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In 2006, the U.S. Geological Survey, in partnership with the Maryland Department of the Environment, began an assessment of the Little Blackwater River watershed to provide new information on ground-water and surface-water flow conditions and water quality. The rates and timing of exchange of water between the surface-water and ground-water systems in the Little Blackwater River watershed is one of the objectives of this study. The effect of increasing urbanization of the watershed on water quantity and quality is also being evaluated. The contribution of agricultural practices or increased urbanization, if any, to the marsh loss within the Blackwater National Wildlife Refuge, which is downstream from the Little Blackwater River watershed, is a long-term objective. Marsh loss within the refuge has been extensive, and much of the area of loss is at or near the confluence of the two rivers.

River velocity, stage, temperature, and specific electrical conductance data have been collected and presented in near-real time since October 2006 at two tide gage locations in the watershed. These data are compared with near-real-time atmospheric data from the U.S. Fish and Wildlife Service weather station just outside of the watershed to better understand the effects of wind velocity and precipitation on river velocity and discharge.

Water-quality samples were collected at several locations quarterly from March 2006 through October 2007 during baseflow conditions, and during two storm events in October 2006 and April 2007 to assess the surface-water quality in the watershed. The original water-quality sampling network of three stations sampled for nutrients and major ions was eventually expanded to eight stations. In September 2006, the analyses of biological oxygen demand, total suspended solids, and organic carbon were added to the parameters collected.

Ground-water levels and water-quality data collected from a transect of monitoring wells since September 2007 have been used to assess ground-water flow and quality. Interactions between ground water and the Little Blackwater River as the river responds to recharge events and tidal fluctuations are currently being evaluated as well as nutrient loading from ground water to the Little Blackwater River.

Little Blackwater River Watershed Protection Plan: For the Sake of a Refuge

Poster Presentation

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The Little Blackwater River watershed drains almost half of the incorporated area of the City of Cambridge, as well as surrounding business, residential and agricultural areas in Dorchester County. Its drainage is carried into the Blackwater National Wildlife Refuge, where it empties into the Blackwater River. The headwaters of the Little Blackwater are undergoing substantial changes due to annexation by the City for residential development, an airport expansion project, and the County's development of a technology park.

During controversial hearings on a 3,200-unit development project proposed adjacent to a tributary of the Little Blackwater River, it became clear that little is known about how a blackwater, fresh tidal system functions, and how it would respond to development pressures. This lack of data prevents planners, engineers, and scientists from predicting what impacts, if any, development in the Little Blackwater River watershed will have on the refuge.
After citizens expressed concerns for the need to obtain scientific data, a meeting of stakeholders was held to discuss that need. Stakeholders included local citizens, civic groups, conservation organizations, public works engineers, planners, and scientists from various government agencies. A subset of stakeholders was appointed to assume a technical advisory role to examine the scientific needs and to recruit the necessary funding to implement them. This subset became known as the Little Blackwater Advisory Group (LBAG).

After a series of formative meetings, LBAG developed Vision and Mission statements. It divided its efforts into three technical groups: Physical Environment, Biological Environment, and Land Use, each of which developed a list of Priorities. Recognizing that these Priorities involve substantial costs in equipment, manpower, and analyses, LBAG reaffirmed its continued partnership through a formal process. In 2006, LBAG was formally recognized by the leadership of its partner agencies through a Memorandum of Understanding (MOU). This MOU provides for the continued participation of staff, and the budgeting of funding.

In 2006, a watershed characterization study was completed. In 2007, field studies were conducted and the first set of baseline data was gathered. The State negotiated purchase of two-thirds of the proposed development site and contracted for the design and construction of a restoration plan for the site. A grant was obtained through the National Oceanic and Atmospheric Administration Coastal Communities Initiatives to hire a Coordinator to assist in the management of LBAG activities, and to serve as a watershed planner to develop a watershed protection plan for the Little Blackwater River.

Studies to date include installation of wells for groundwater monitoring, stream flow and stream parameter measurements, fisheries and sediment sampling, and wetland plant identification. A second set of sampling is being planned for the 2008 season. A draft Watershed Protection Plan is expected by the end of September 2008.

Organic Matter Accumulation, Carbon Sequestration and Methane Emissions in the Tidal Marshes at Blackwater National Wildlife Refuge

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Concerns over the mitigation of global warming and the impacts of rising sea levels caused by global warming have focused attention on tidal wetlands. The restoration and management of tidal wetlands may allow such areas to sequester carbon, helping to mitigate global warming, while the accumulation of organic materials will keep the tidal marshes from being inundated by rising sea levels. We are sampling and monitoring soils on two separate islands, Barbados (natural site) and Wildlife Drive (restored in 2003 with locally derived dredged materials), to determine rates of organic matter accumulation and carbon sequestration. Samples have been collected and analyzed in 2006 and 2007. The emissions of methane (a potent greenhouse gas) are also monitored. This research is being performed in collaboration with the National Aquarium in Baltimore and the USGS Patuxent Wildlife Research Center. In a separate study, we are studying how organic matter accumulation and carbon sequestration are effected by prescribed burns. In collaboration with the USGS Patuxent Wildlife Research Center, we are collecting soil samples at sites within the Blackwater long-term burn study in which plots are subjected to controlled burns on 0, 1, 3-5 and 7-10 year cycles. The knowledge gained from this research offers insight into the role tidal marshes can play in mitigating global warming and if these marshes can survive forecasted sea level rise rates.

Surficial Geologic Map of the Blackwater NWR Interpreted from LIDAR, Corehole, and GPR Data

Poster Presentation

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A LIDAR digital elevation model (DEM) with 30 cm contour intervals was produced for the Blackwater NWR (on the Blackwater, Golden Hill, and Taylors Island 7.5" Quadrangles) in 2002. The DEM was used to forecast the impact of rising sea level on the wetlands and low lying terrain during the next century. The resolution of this DEM has facilitated a new interpretation of the geomorphology and Holocene history. Using shallow (<100 ft deep) cores and Ground Penetrating Radar (GPR) profiles, we have developed a process-focused map of the near surface geologic framework. The geomorphic history has been interpreted from cross-cutting relationships of deposited and eroded landforms.

The geologic framework of surficial and shallow subsurface deposits includes Cenozoic to recent sediments from fluvial, estuarine, eolian, and littoral environments. In mapping the surficial geology of this region, we can clearly see the dramatic impact that Pleistocene to Holocene climate variability has had on the Blackwater area. The sub-surface Pleistocene map units represent estuarine platforms with inset cut-fill river deposits from rising and falling sea levels. These platforms are the local substrates for a dynamic allostratigraphic unit consisting of large dune fields, fluvial deposits, and probable paleo-thaw ponds. The assemblage of surficial deposits is an artifact of a former landscape that was constructed, eroded and modified by cold climate processes during the late Pleistocene (Last Glacial Maximum); these processes are no longer active. As climate changed at the beginning of the Holocene, the drainage system was deeply incised. Holocene sediment now fills the low topography as sea level rises. Locally, deposition has consisted mostly of organic-rich silty peat underlying most of Blackwater Lake and the surficial wetlands.

The surficial map and subsurface data help to define the antecedent landscape and ~5,000 year history of wetlands fill in the Blackwater River valley. Climate change, sea level rise, and subsidence, and land use have all contributed to the dynamics of this ephemeral landscape.

Predicting Marsh Loss and Migration in the Blackwater National Wildlife Refuge using the Sea Level Affecting Marsh Model (SLAMM)

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Increasing rates of sea level rise have negatively impacted many marshes across the Chesapeake Bay. The Blackwater National Wildlife Refuge (NWR) has seen dramatic loss with its marshes being converted to open water. To better understand the effects of sea level rise on marsh loss and migration, the Sea Level Affecting Marshes Model (SLAMM), is being applied to the Blackwater NWR and surrounding lands. SLAMM was developed originally to stimulate the predicted wetland conversions during long-term sea level rise. In this region, marshes are struggling to maintain accretion rates to keep pace with the rapid rate of relative sea level rise. Different management practices, such as thin-layering, prescribed burns, and herbivory exclusive, are currently being used and evaluated to improve marsh sustainability. To examine the implications of accretion rates, management practices and marsh migration, SLAMM was used to predict future possibilities for the Blackwater NWR marshes and help determine what practices can be used to reduce the amount of marsh lost.