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ANNOTATED BIBLIOGRAPHY OF RESEARCH CONDUCTED IN THE CHESAPEAKE BAY NATIONAL ESTUARINE RESEARCH RESERVE – VA

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INTRODUCTION

This annotated bibliography of research conducted within the Reserves boundaries is a living document and updated periodically as new and past publications become available to the Reserve. It is designed to identify and provide an abstract/summary of research publications conducted within the four component sites of the Chesapeake Bay National Estuarine Research Reserve - Virginia system. Selected reference material is also available for Reserve relevant work conducted at multiple sites within the York River system.

In order to help facilitate searches, the bibliography is categorized by Reserve components (Goodwin Islands, Catlett Islands, Taskinas Creek, and Sweet Hall Marsh) and by work conducted in Multiple Sites along the York River. In addition, each component is subcategorized into biological, geological, chemical and physical, and cultural and socioeconomic subject headings based on the primary focus of the publication. Publications are listed in alphabetical order by senior author under appropriate headings. Following the reference citation, an abstract or summary of the publication is provided.

Hard copies of each reference are maintained in the Reserves library. These references are not available for general circulation; however they are available for reading and copying purposes.

I. GOODWIN ISLANDS

A. Biological

Ayers, L.A. 1995. Finfish Communities of Two Intertidal Marshes of the Goodwin Islands, York River, Virginia. Master's Thesis. The College of William and Mary, Williamsburg, Virginia. 60pp.

ABSTRACT

The finfish communities using the intertidal surfaces of a bay-exposed marsh and a sheltered, channel marsh of the Goodwin Islands, York River, Virginia were studied from May to November 1994. Samples were taken approximately twice monthly using a flume weir at three stations in each marsh. Species composition, abundance and biomass were estimated, and growth patterns and production rates were described for the dominant species. A total of 3001 fish were collected from 11 species and 8 families. *Fundulus heteroclitus* dominated both marshes and accounted for 83.07% of the total number of fish caught, and 84.83% of the total biomass collected. *Menidia menidia* was the second most abundant species at 9.00% of the total number of fish, but *F. majalis* was second in the total biomass at 7.51 % of the total. Abundance first peaked in June, and a second peak occurred in November. Biomass had a small peak in the beginning of August, and a large peak in late September. Analysis of variance showed the number of species captured did not differ significantly between the marshes. However, both the number of individuals and biomass were significantly higher in the protected marsh. Correspondence analysis showed that species composition in the protected marsh was mostly cyprinodontids, but in the open marsh species composition varied more throughout the sampling season. Species densities were highest at 9.8 ± 3.3 fish m^{-2} for *F. heteroclitus* in the protected marsh. Production for *F. heteroclitus* over the summer in the protected marsh was high at 10.1 g dry wt. m^{-2} due to the large number of rapidly growing larval and juvenile fish.

Buzzelli, C.P. 1996. Intergrative Analysis of Ecosystem Processes in the Littoral Zone of the Lower Chesapeake Bay: A Modeling Study of the Goodwin Islands National Estuarine Research Reserve. Ph.D. Dissertation. The College of William and Mary, Williamsburg, Virginia. 137pp + appendices.

ABSTRACT

Approximately 40% of the bottom of Chesapeake Bay is less than 2.0m in depth and many of these broad shoal environments are bordered by wetlands. The vegetated and nonvegetated subtidal and intertidal environment is a dynamic mosaic of highly productive estuarine habitats linked by the exchange of waterborne materials. This study developed simulation models of primary production and material exchange for tour littoral zone habitats of the Goodwin Islands National Estuarine Research Reserve (NERR) in lower Chesapeake Bay. Field studies were conducted to determine the sediment biogeochemical and biomass characteristics of sandy, shoal, seagrass, silt-mud, and marsh habitats. Ecological models were developed for each habitat based upon their position and ecological characteristics. The models simulate the dynamics of phytoplankton, particulate and dissolved organic carbon, dissolved inorganic nitrogen, sediment microalgae, *Zostera marina*, and *Spartina alterniflora.* Following sensitivity analysis and validation the models were used to estimate annual primary production, nitrogen processes, and material exchange. The net annual rate of phytoplankton production was 66.0, sediment microalgae ranged 101-169, *Zostera marina* community production was approximately 350 g C m^{-2} yr^{-1}, and *Spartina altemif1ora* shoots and root-rhizomes produced 1150 g C m^{-2} yr^{-1} (g C m^{-2} yr^{-1}). Nitrogen uptake was in excess of demand in phytoplankton while the reverse was true for the macrophytes. The marsh habitat accounted for 43% of the total annual primary production for the ecosystem despite being the smallest habitat while the largest habitat (nonvegetated subtidal) required 52% of the total ecosystem nitrogen demand. All four habitats imported phytoplankton, particulate organic carbon, and dissolved inorganic nitrogen annually. While the intertidal habitats imported dissolved organic carbon the subtidal habitats showed net annual export. These models were developed to assess ecosystem structure, function, and change in the littoral zone of Chesapeake Bay. Ecosystem structure was assessed through field research and model development. Ecosystem function was assessed by using the model to generate annual producer, habitat, and ecosystem carbon and nitrogen budgets. The model is currently being used to investigate the interactive effects of water quality, primary production, and habitat composition in order to assess potential change in the estuary.

Buzzelli, C.P. 1998. Dynamic simulation of littoral zone habitats in lower Chesapeake Bay. I. Ecosystem characterization related to model development. *Estuaries* 21(4B): 659 – 672.

ABSTRACT

The fringing environments of lower Chesapeake Bay include sandy shoals, seagrass meadows, intertidal mud flats, and marshes. A characterization of a fringing ecosystem was conducted to provide initialization and calibration data for the development of a simulation model. The model simulates primary production and material exchange in the littoral zone of lower Chesapeake Bay. Carbon (C) and nitrogen (N) properties of water and sediments from sand, seagrass, intertidal silt-mud, and intertidal marsh habitats of the Goodwin Islands (located within the Chesapeake Bay National Estuarine Research Reserve in Virginia, CBNERR-VA) were determined seasonally. Spatial and temporal differences in sediment microalgal biomass among the habitats were assessed along with annual variations in the distribution and abundance of *Zostera marina* L. and *Spartina alternijlora* Loisel. Phytoplankton biomass displayed some seasonality related to riverine discharge, but sediment microalgal biomass did not vary spatially or seasonally. Macrophytes in both subtidal and intertidal habitats exhibited seasonal biomass patterns that were consistent with other Atlantic estuarine ecosystems. Marsh sediment organic carbon and inorganic nitrogen differed significantly from that of the sand, seagrass, and silt habitats. The only biogeochemical variable that exhibited seasonality was low marsh NH_4^+. The subtidal sediments were consistent temporally

in their carbon and nitrogen content despite seasonal changes in seagrass abundance. Eelgrass has a comparatively low C:N ratio and is a potential N sink for the ecosystem. Changes in the composition or size of the vegetated habitats could have a dramatic influence over resource partitioning within the ecosystem. A spatial database (or geographic information system, GIS) of the Goodwin Islands site has been initiated to track long-term spatial habitat features and integrate model output and field data. This ecosystem characterization was conducted as part of efforts to 1ink field data, geographic information, and the dynamic simulation of multiple habitats. The goal of these efforts is to examine ecological structure, function, and change in fringing environments of lower Chesapeake Bay.

Buzzelli, C.P., R.L. Wetzel, and M.B. Meyers. 1998. Dynamic simulation of littoral zone habitats in lower Chesapeake Bay. II. Seagrass habitat primary production and water quality relationships. *Estuaries* 21(4B): 673 – 689.

ABSTRACT

Seagrasses are indicators of ecosystem state because they are sensitive to variations in water composition and clarity resulting from watershed-level impacts. A simulation model designed to study *Zostera marina* (eelgrass) habitat dynamics in a variable littoral zone environment was used to address the potential ecological responses to eutrophication in lower Chesapeake Bay. The adjacent channel boundary environment is a source of dissolved and particulate materials to the littoral zone. In the simulations, concentrations of key water quality variables in the adjacent estuarine channel boundary were either halved or doubled relative to the base case to investigate light versus nitrogen effects. The role of the seagrass meadow in littoral zone carbon and nitrogen dynamics was evaluated when meadow size was changed in the model. Particulate and dissolved organic carbon accounted for 83% of the submarine light attenuation in the seagrass meadow. In all model runs, the water column concentrations of chlorophyll *a* and dissolved inorganic nitrogen (DIN) were below the habitat criteria proposed as critical to seagrass survival. Eelgrass community production was carefully regulated by the interactive effects of light, nitrogen, and grazing on epiphyte growth. Increased eelgrass coverage in the littoral zone led to a simulated doubling of ecosystem primary production but reduced the fraction of production by planktonic and sediment microalgae. The simulation model presented here demonstrated the importance of material input from the channel in littoral zone biogeochemical dynamics. Submarine light regulated primary production more strongly than inorganic nitrogen concentrations in the model. External DIN concentrations influenced seagrass survival indirectly: enrichment stimulated growth of epiphytes and phytoplankton and promoted shading of the seagrass leaf. The model was based upon an unimpacted ecosystem and deteriorated water quality negatively influenced primary production greater than the increases triggered by improved conditions. Increased material loading to the littoral zone reduced submarine light availability, increased phytoplankton production, lowered ecosystem production, and reduced subtidal vegetated habitat. This simulation model of the estuarine littoral zone model combines hydrodynamics, biogeochemical sources and sinks, and living resources in order to better understand structure, function, and change in aquatic ecosystems.

Buzzelli, C.P., R.L. Wetzel, and M.B. Meyers. 1999. A linked physical and biological framework to assess biogeochemical dynamics in a shallow estuarine ecosystem. *Estuarine, Coastal and Shelf Science* 49: 829 – 851.

ABSTRACT

The littoral zone of Chesapeake Bay contains a mosaic of shallow vegetated and nonvegetated habitats with biotic components that are sensitive to changes in biological and physical driving factors. Static and dynamic modeling frameworks provide an integrative way to study complex hydrodynamic and biogeochemical processes in linked estuarine habitats. In this study we describe a spatial simulation model developed and calibrated relative to a specific littoral zone, estuarine ecosystem. The model consisted of four distinct habitats that contained phytoplankton, sediment microalgae, *Zostera marina* (eelgrass), and *Spartina alterniflora*. There was tidal exchange of phytoplankton, particulate and dissolved organic carbon and dissolved inorganic nitrogen between the littoral zone ecosystem and the offshore channel. Physical exchange and biogeochemical transformations within the habitats determined water column concentrations in each habitat. Predicted subtidal water column concentrations and *Z. marina* and *S. alterniflora* biomass were within the variability of validation data and the predicted annual rates of net primary production were similar to measured rates. Phytoplankton accounted for 17%, sediment microalgae 46%, the *Z. marina* community 24% and *S. alterniflora* 13% of the annual littoral zone primary production. The linked habitat model provided insights into producer, habitat and ecosystem carbon and nitrogen properties that might not have been evident with stand-alone models. Although it was an intra-ecosystem sink for particulate carbon, the seagrass habitat was a DOC source and responsible for over 30% of the littoral zone carbon and nitrogen primary production. The model predicted that the Goodwin Islands littoral zone was a sink of channel derived POC, but a source of DOC to the surrounding estuary .The framework created in this study of estuarine ecosystem dynamics is applicable to many different aquatic systems over a range of spatial and temporal scales.

Cicchetti, G. 1998. Habitat Use, Secondary Production, and Trophic Export by Saltmarsh Nekton in Shallow Waters. Ph.D. Dissertation. The College of William and Mary, Williamsburg, Virginia. 276pp.

ABSTRACT

I present a quantitative study of habitat use, secondary production, and trophic export by intertidal nekton. I used 1.75 m^2 drop rings and throw rings to sample communities of shallow water nekton at high and low tides in salt marshes, intertidal flats, and seagrass beds ***(Ruppia maritima).*** Thirty-two species of nekton were captured between June and October 1995, with a mean overall abundance of 28.6 inds m^{-2} and a mean biomass of 3.8 9 m^{-2} (dry weight). The blue crab, *Callinectes sapidus,* was the biomass dominant species. Seagrass and marsh edge habitats were extensively used by all sizes of blue crab, from recruiting juvenile to adult. Year- to-year variation was seen between 1995 and 1996 in blue crab

recruitment. *Palaemonetes* shrimp were the most abundant nekton in the study, and interesting patterns of allopatry and apparent sympatry were found among the three species inhabiting this area. *Fundulus heteroclitus, F. majalis,* and *Lucania parva* were the dominant marsh resident fishes, while *Gobiosoma bosc* was the most abundant fish in seagrass habitats. Certain sciaenids used marsh habitats in a transient or opportunistic manner, as did *Menidia menidia.* The marsh surface was apparently used as a nighttime refuge by *M. menidia.* Behavioral patterns for five marsh residents *(F. heteroclitus, F. majalis, L. parva, G. bosc,* and *P. intermedius)* differed from patterns reported elsewhere. This is taken as evidence of behavioral flexibility in habitat use between regions.

On the community level, each sampled habitat saw a unique pattern of use. Seagrass and marsh edge areas both supported a large biomass of nekton at high tide, but seagrass habitats held greater densities of nekton. Fundulids, blue crabs, *Palaemonetes pugio* and transient fishes used marsh surface habitats at high tide and took low-tide refuge in adjacent habitats. Secondary production in marsh habitats was estimated at approximately 7.4- 8.0 gdw m^{-2} 150 d^{-1} (28.4- 30.7 gww m^{-2} 150 d^{-1}) for the entire salt marsh nekton community between June and October, 1995 (150 days) if corrected for poorly sampled small size classes and for the removal efficiency of the gear .Gut contents of nekton were examined, and a mathematical model was constructed to estimate consumption by nekton in marsh and unvegetated habitats. The model also estimates export of animal tissue as predation by transient species. Predation on invertebrates was highest in marsh edge areas, at 44.2 gdw m^{-2} 150 d^{-1} of animal prey removed; predation at the edge by transients (export) was 28.0 gdwm-2 150 d-l. The value of marsh edge was clearly linked to both the vegetated and the unvegetated sides of the interface as refuge and feeding. Predation in the entire marsh area flooded at mean high tide was approximately 13 gdw m^{-2} 150 d^{-1}, and transient export was 5.6 gdw m^{-2} 150 d^{-1}. The major path for export from marsh interior habitats into deeper waters was blue crab predation on the marsh resident crabs *Uca* and *Sesarma.* Predation in unvegetated areas was 13.3 -17.0 gdw m^{-2} 150 d^{-1} and export was 8.0- 11.7 gdw m^{-2} 150 d^{-1}. The unvegetated intertidal was an important resource for nekton due to long periods of inundation and abundant polychaete prey. The largest part of the intertidal nekton community used all three habitat types (marsh, unvegetated, and seagrass), and the trophic contribution of each habitat was significant. Marsh, unvegetated, and seagrass habitats function together in this area to provide trophic support for intertidal nekton.

Fishman, J.R. 1994. The Role of Predation on *Zostera marina* L. (Eelgrass) Seed Abundance. Master's Thesis. The College of William and Mary, Williamsburg, Virginia. 60pp.

ABSTRACT

Predator effects on *Zostera marina* L. seed abundance were studied in the York River, Virginia using enclosure and exclosure caging experiments. Seeds were placed in cages in two experiments with the following treatments: Predator exclosure experiment with a full predator exclosure cage, partial exclosure top-only cage, partial exclosure side-only cage, and uncaged plots; and a predator enclosure experiment with a *Callinectes sapidus* enclosure cage and a *Micropogonias undulatus* enclosure cage. Additionally, two-week long trials of sequentially protected and exposed seeds were also performed. Replicate treatment plots were sampled by removing the top 5-10 cm of sediment surface with a suction sampler and viable seeds in each plot were counted.

Resultant seed abundance in the *C. sapidus* cages were significantly less than the full exclusion cage, while seed abundance in the *M. undulatus* cages were not significantly different than the full exclusion cage. The least number of seeds were found in the uncaged and partial cage treatments. Results of the sequentially protected and exposed trials were similar to results from the one-week uncaged treatments. These experiments suggest that predation can affect the abundance of *Z. marina* L. seeds, possibly causing up to 65% of the seed losses observed in these experiments. Results suggest that predation is an important force governing the sexual reproductive success and propagation of eelgrass beds and that the degree of seed loss via predation may be related to predator and primary food abundance.

Mercer, L.P. 1973. The Comparative Ecology of Two Species of Pipefish (Syngnathidae) in the York River, Virginia. Master's Thesis. The College of William and Mary, Williamsburg, Virginia. 37pp.

ABSTRACT

Syngnathus fuscus and *S. floridae* are differentially distributed relative to depth, salinity and season in the York River estuary. Both species inhabit eelgrass beds with *S. fuscus* being more abundant than *S. floridae* in water shallower than about 1.5 m. *S. floridae* is most abundant at salinities between 17 and 22 ppt, whereas *S. fuscus* is most abundant between 13 and 20 ppt. *S. fuscus* occurs at salinities as low as 4 ppt, whereas *S. floridae* occurs at salinities no lower than 15 ppt. *S. fuscus* is most abundant in mid-June and leaves the shallows by late August. *S. f loridae*, however, is most abundant in August and remains in shallow water through November. Both species apparently over-winter in the channel in a torpid state until spring. The presence of juveniles from June through October indicates a prolonged spawning season for both species. Analysis of stomach contents indicates that *S. fuscus* and *S. floridae* feed predominantly on amphipods, isopods, and mysids, but in slightly different proportions.

Metcalf, K.S. 1991. The Relationship of Habitat and Spatial Scale upon the Developmental State and Settlement of Blue Crab Postlarvae in Chesapeake Bay. Master's Thesis. The College of William and Mary, Williamsburg, Virginia. 36pp.

ABSTRACT

Developmental state of blue crab postlarvae was identified in planktonic and benthic megalopae from within and outside Chesapeake Bay on various spatial scales. Planktonic megalopae advanced significantly in developmental state from the continental shelf, off the Chesapeake Bay mouth, through upriver stations in the York River, a tributary of Chesapeake Bay. This developmental evidence supports the export-reinvasion theory of blue crab recruitment, and is inconsistent with a retention hypothesis for blue crab larval recruitment. In the tributary, benthic megalopae were

significantly more advanced in developmental state than planktonic megalopae. Temporal variation in developmental state was also observed over days and months. In addition, time to metamorphosis was significantly and positively correlated with developmental state. These results suggest that advancement in developmental state of megalopae during reinvasion of the estuary may act as a predictor of likelihood of settlement on a baywide scale.

Moody, K.E. 1994. Predation on Juvenile Blue Crabs, *Callinectes Sapidus* Rathbun, in Lower Chesapeake Bay: Patterns, Predators, and Potential Impacts. Ph.D. Dissertation. The College of William and Mary, Williamsburg, Virginia. 36pp.

ABSTRACT

Various investigations of the population dynamics of blue crabs in Chesapeake Bay indicate that predator-induced mortality in the juvenile phase may determine year-class strength. In a tethering study, which spanned three seasons in shallow-water habitats of the lower York River, daily mortality rates of juvenile crabs were measured across three variables: crab size (30-70 mm carapace width), habitat type (seagrass, mud, and sand), and month (May-November). Vulnerability to predation was consistently lower for larger crabs, approaching a size refuge from predation at approximately 90 mm carapace width. Predation was most intense in unvegetated sand habitats, and significantly lower in seagrass and unvegetated mud. The data also reflected a strong seasonal pattern in predation potential which was correlated with water temperature. Predators contributing to this pattern were identified and assessed using an underwater video-recording system to monitor tethered crabs. While a variety of potential predators appeared and attacked crabs frequently, only two species had a measurable impact on crab survival, adult conspecifics and northern puffers, *Sphoeroides maculatus.* These results were confirmed in large laboratory tanks using untethered crabs as prey. These studies indicate that the mechanisms behind seasonal variation in predation pressure may include both physiologically-linked activity rhythms and seasonal migration of predators. The potential impact of seasonally-varying predation pressure on the life history of blue crabs was explored in a modeling exercise, using concepts of dynamic optimization. The results suggest that the blue crab may exhibit behavioral adaptations which are reflected in optimal biological timing of recruitment and growth, thereby enhancing survival through the juvenile phase.

Moore, K.A., J.L. Goodman, J.C. Stevenson, L. Murray, and K. Sundberg. 1995. Chesapeake Bay nutrients, light, and SAV: Relationships between water quality and SAV growth in field and mesocosm studies. Final Report. U.S. EPA, Chesapeake Bay Program, Annapolis, Maryland. 60pp + appendix.

Pardieck, R.A. 1996. The Influence of Location, Seagrass Species and Water Depth on the Settlement and Distribution of Early Stage Blue Crabs. Master's Thesis. The College of William and Mary, Williamsburg, Virginia. 57pp.

ABSTRACT

Habitat structure, related to seagrass species and water depth, and physical forces, such as currents and winds, can substantially influence organism distributions. Deep and shallow suction samples in monospecific *Zostera marina* and *Ruppia maritima* beds in the York River, VA, indicate that site and seagrass species influence settlement and distribution of early stage *Callinectes sapidus* (postlarvae through ninth instars). In 1994, early stage blue crabs were significantly more abundant in *R. maritima* than in *Z. marina* on the north shore, while crabs were evenly distributed between seagrass species on the south shore. In 1995, postlarvae through 3rd instars were not related to bed type or depth, but were significantly correlated with distance upriver. Later crab instars (>3rd instar), however, were more abundant in *R. maritima* beds, which had significantly higher shoot densities than *Zostera marina* beds. The effect of water depth on all crab stages was nonsignificant. Fourth to seventh instars were also positively correlated with *R. maritima* shoot densities ($p = 0.064$). Habitat use by early stage blue crabs may be related to changes in seagrass shoot density, which occur each summer, resulting in the domination of different seagrass species at different times of the year. An ontogenetic shift in habitat use was found for the earliest blue crab stages: smallest instars were significantly related to site in both 1994 and 1995, which suggests that larval supply and physical forces, such as currents and winds, influence initial crab distributions. Abundance of later instars was significantly related to seagrass species, possibly because of differences in shoot density, which indicates the importance of habitat selection and differential mortality.

Pardieck, R.A., R.J. Orth, R.J. Diaz, and R.N. Lipcius. 1999. Ontogenetic changes in habitat use by postlarvae and young juveniles of the blue crab. *Marine Ecology Progress Series* 186: 227 – 238.

ABSTRACT

Changing habitat requirements are evident during the developmental cycles of many species. In this field investigation, we attempted to distinguish between depth (shallow vs deep), habitat structure (seagrass species), and study site as factors influencing the distribution and abundance of postlarvae and juvenile blue crabs *Callinectes sapidus* in the Chesapeake Bay. Deep (>= 70 cm mean low water [MLW]) and shallow (<= 50 cm MLW) suction samples in monospecific *Zostera marina* and *Ruppia maritima* beds were taken in the York River, a tributary of the Chesapeake Bay. Our studies revealed ontogenetic changes in habitat use, which suggested that blue crabs are influenced differently by physical and biological factors even during the earliest life stages. Postlarvae through 3rd instar distributions were not related to seagrass species, but their densities increased with distance upriver (regression, $p < 0.004$, $n = 36$ to 38, postlarvae: $r^2 = 0.173$, 1st instars: $r^2 = 0.308$, 2nd-3rd instars: $r^2 = 0.231$). This suggests that the smallest instar distributions are related to larval supply and physical forces, such as currents and winds, which determine water-column transport. In contrast, 4th and greater instars were significantly more abundant in *Ruppia* than in *Zostera* (ANOVA, $df = 1$, $p < 0.05$),

possibly because of the high shoot density of *Ruppia* beds. Habitat use by 4th and greater instars may be related to seasonal changes in seagrass shoot density. Water depth did not influence the distribution of any crab stage. We suggest that habitat selection and differential mortality among habitats influence larger instar distributions more strongly than they influence the distribution of postlarvae and the earliest instars of *C. sapidus*.

Parker, J.D. 2001. Does Plant Diversity Control Animal Diversity? An Experimental Approach. Master's Thesis. The College of William and Mary, Williamsburg, Virginia. 74pp.

ABSTRACT

Plant diversity reportedly promotes animal diversity, but there were no experimental tests of the relationship. Faunal diversity may decrease with diminishing plant diversity, potentially compromising ecosystem function. I manipulated plant species diversity and composition and measured animal diversity in a temperate seagrass bed in two experiments during June 1997. Although there was a weak positive relationship between animal species richness and plant diversity (Simpson's index) ($r^2 = 0.08$, $p = 0.035$), most animal diversity indices were more strongly related to the relative biomass of macro algae within plant diversity treatments. Animal diversity and evenness were negatively correlated with the proportion of macro algae within treatments ($r^2 = 0.24$, $p < 0.001$; $r^2 = 0.45$; $P < 0.001$, respectively). Animal density, evenness, and diversity were significantly different among treatments grouped by morphological similarity. Hence, epifaunal diversity was more a function of the species composition and structural characteristics (seaweeds versus seagrasses) of plant communities than of plant diversity.

To assess potential resource specialization, I collected epifauna occupying seagrasses and drift algae on nine dates between August 1996 and August 1997 at the same site. Three crustacean species, the amphipods *Cymadusa compta* and *Gammarus mucronatus,* and the isopod *Erichsonella attenuata,* comprised 77% of total epifauna sampled. There were no clear patterns of host-plant specificity, although the relative abundances of taxa often differed among plant species.

Epifauna responded more strongly to specific plant species and structural attributes than to plant diversity *per se* in the experimental treatments and in undisturbed field situations, supporting the idiosyncratic hypothesis of community responses to diversity. Faunal responses to changes in diversity can be positive, negative, or indeterminate, and depend strongly upon species composition.

Parker, J.D., J.E. Duffy, and R.J. Orth. 2001. Plant species diversity and composition: Experimental effects on marine epifaunal assemblages. *Marine Ecology Progress Series* 224: 55 – 67.

ABSTRACT

Plant diversity is believed to govern animal community structure, yet few studies have tested this relationship. We manipulated plant species diversity and composition (2 seagrasses and 3 seaweeds) and measured the abundance, diversity, and biomass of plant-associated macroinvertebrates in a temperate, estuarine seagrass community. Animal diversity was weakly but positively related to plant diversity (Simpson's $1 - \lambda$). Most indices of animal diversity, however, were more strongly related to total plant surface area than to plant diversity. Epifaunal abundance and biomass increased, whereas epifaunal diversity and evenness decreased with total plant surface area. Both food and habitat covary with plant surface area, providing potential mechanistic explanations for these patterns. Plant species composition had strong effects on epifaunal community structure. After statistically controlling for effects of plant surface area, epifaunal abundance and biomass remained higher, and evenness remained lower, among assemblages composed of branched (mostly seaweeds) relative to unbranched (mostly seagrasses) macrophytes. Multiple regression analyses also revealed differential use of particular plant species by epifauna. For example, amphipods responded particularly strongly to the coarsely branched red alga *Gracilaria verrucosa*. Thus, our experimental results support a strong effect of plant species composition, and little effect of plant diversity per se, on the motile macrofauna that we studied. This conclusion is consistent with results of a concurrent field survey; epifaunal community structure differed among plant species and seasons, with no host-plant specialists. These results support evidence from both terrestrial and aquatic communities; ecosystem structural and functional properties are often more strongly influenced by particular attributes, rather than number of species, in a community.

Pile, A.J., R.N. Lipcius, J. van Montfrans, and R.J. Orth. 1996. Density-dependent settler-juvenile relationships in blue crabs. *Ecological Monograph*s 66(3): 277 – 300.

ABSTRACT

Current theory on the population dynamics of marine species with complex life history patterns posits that a suite of physical and biotic forces (e.g., habitat structure and density-dependent predation or emigration) control survival and abundance in early life history, particularly after settlement. We have conducted a long-term sampling effort accompanied by a series of field and laboratory experiments examining the joint effects of habitat type, body size, and population density upon abundance and survival of early juveniles of the blue crab, *Callinectes sapidus.* In addition, the chance occurrence of a tropical storm during one set of experiments provided an opportunity to assess the impact of a physical disturbance upon newly settled blue crab survival and abundance. In the 10-yr sampling effort, we quantified relationships between sequential life history stages (juvenile crab instars) in seagrass beds, the initial nursery habitat for blue crabs in the lower Chesapeake Bay. Inter-instar relationships were defined as the densities of larger instars as dependent on" the densities of smaller instars. Inter-instar relationships for the youngest instars are described by hyperbolic functions until crabs begin to emigrate to unvegetated habitats at approximately the fifth instar. Inter-instar relationships between crabs larger than the fifth instar and smaller crabs become either parabolic or linear functions and decay as the number of instars between sequential life history stages increases. While both the hyperbolic and parabolic functions are indicative of populations regulated by density-dependent processes, either predation or emigration, the decay in the functions describing the inter-instar relationships for crabs larger than the fifth instar indicates that the suite of processes regulating this segment of the population changes qualitatively.

In laboratory and field experiments, the effects of vegetated and unvegetated habitats and size-specific predation on newly settled juveniles were tested. Tethering was used to quantify relative rates of predation, and a laboratory study was conducted to determine if tethering induced treatment-specific bias. We found no statistically significant interactions between the tethering treatment and the factor treatments of crab size and habitat during the laboratory study, indicating that tethering did not produce treatment-specific bias. Thus, tethering provided a relative measure of predation that allowed comparisons between treatments of habitat and crab size on crab survival. In both laboratory and field experiments, survival was significantly higher in vegetated habitats and with increasing size until the ninth instar, when survival did not differ by habitat. This difference explains the dispersal from vegetated to unvegetated habitats that occurred between the fifth and seventh instars. In addition, survival of all crabs was significantly increased both during and after Tropical Storm Danielle compared to pre-storm conditions.

A model is developed that describes juvenile survival as a function of crab size and habitat type. Survival curves in both habitats are represented by similar sigmoid functions with survival higher in vegetated habitats. Subsequently, the survival of newly settled blue crabs is likely dependent on the availability of complex habitat. Thus, a suite of biotic and physical processes, both density-dependent and density-independent, control the early life history after settlement for the blue crab.

Pile, A.J. 1993. Effects of Habitat and Size-Specific Predation on the Ontogenetic Shift in Habitat Use by Newly Settled Blue Crabs, *Callinectes sapidus*. Master's Thesis. The College of William and Mary, Williamsburg, Virginia. 84pp.

ABSTRACT

Newly settled blue crabs, *Callinectes sapidus,* are found in highest densities in seagrass beds within the Chesapeake Bay. Densities of newly settled blue crabs in seagrass beds were highly variable from 1983-1992 and are regulated by density-dependent processes. The mean annual densities of larger instars were dependent on smaller instars. These inter-instar relationships between the mean annual densities first seven instars were determined to be either hyperbolic or parabolic functions. The inter-instar relationship began to decay at the fifth instar, the size when crabs begin to emigrate to unvegetated habitats. Subsequent laboratory and field tethering experiments were performed to assess the effects of habitat, crab size, and crab density on the relative rates of predator-induced mortality on first, third, fifth, seventh and ninth instar crabs. A full-factorial experimental design laboratory experiment with tethered and untethered prey was conducted and determined that tethering was an unbiased technique for assessing predation-induced mortality on newly settled blue crabs. Crab survival was significantly higher in vegetated habitats (ANOVA, $F_{1,199}$= 16.00, $p < .001$), with increasing crab size (ANOVA, $F_{4,199}$= 61.10, $p < .001$), and in the absence of a tether (ANOVA, $F_{1,199}$= 7.677, $p < .01$). Similarly, the field tethering experiments performed at replicate locations near the mouth of the York River, Virginia indicated that crab survival was significantly higher in vegetated habitats (G-Test, $X^2_1 = 15.75$, $p < .0001$) and with increasing crab G-Test, $X^2_4 = 18.07$, $p < .001$); densities of tethered crabs had no effect on survival (G-Test, $X^2_1 = .24$, $p > .05$). Additionally, the close passage of Tropical Storm Danielle to the field location allowed for the assessment of the effects on relative rates of predation and on habitat utilization by newly settled blue crabs. Crabs had significantly higher survival during and after the tropical storm (G-Test, $X^2_2 = 8.38$, $p < .01$) and significantly higher densities at locations of lower energy regime (ANOVA, $F_{1,40}$= 202.73, $p < .0001$).

Radian International LLC. 1999. Final Toxicity Study: Installation Restoration Program, Langley Air Force Base, Virginia.

Seufzer, W.J. 1994. Measurement of *In Situ* Eelgrass Community Metabolism in Standing and Flowing Waters; Methods and Models. Master's Thesis. The College of William and Mary, Williamsburg, Virginia. 100pp.

ABSTRACT

Five methods were investigated for measuring *Zostera marina* community metabolic rates. Metabolism measurements were based on dissolved oxygen (DO) exchange. The five methods were accomplished under enclosing hemispherical domes and with an array of DO sensors in the water column. Slack, diurnal curve, and two upstream-downstream methods (Eulerian and Lagrangian) were accomplished with the array of DO probes. Data collected from the array were used in computational models to evaluate each of the four open-water methods. Parameters used to compare the methods included gross production, community respiration, and production to respiration ratio (P:R). Comparison of the dome method to the open-water slack method showed each method estimating gross daily production from 8.0 -13.7 g 0_2 m^{-2} day^{-1}, community respiration from 7.4 to 11.0 g 0_2 m^{-2} day^{-1}, and production to respiration ratio from 0.9 to 1.5. Results were numerically similar but lack of sufficient replication did not allow the differences or similarities to be shown as statistically significant. The diurnal, Eulerian, and Lagrangian methods accounted for moving water. In estimating net apparent production vs. water velocity, two of the methods (diurnal and Eulerian) showed a positive relationship but the results at higher velocities could not be shown as different from rates published in the literature studies using small chambers and domes. This study suggests that a slack water method with improved measures of reaeration could be used to replace the dome method and be applied to long-term monitoring. A qualitative relationship between water velocity and production estimates was shown in a comparison of slack (little to no water velocity) and diurnal (higher water velocities) methods. This study was not able to show a statistically significant relationship between water flow and production estimates.

Wyanski, D.M. 1990. Patterns of Habitat Utilization in 0-Age Summer Flounder (*Paralichthys dentatus*). Master's Thesis. The College of William and Mary, Williamsburg, Virginia. 55pp.

ABSTRACT

Patterns of recruitment and habitat utilization were described for 0-age summer flounder, *Paralichthys dentatus* at five estuarine sites in lower Chesapeake Bay and on Virginia's Eastern Shore. At each site, sampling was conducted at three depth ranges (< 1 m, 1-2 m, and 6-11 m), over sand and fine (very fine sand, silt, and clay) substrates. Substrate composition was quantified. A 4.9 m bottom trawl and seines were used to make semi-monthly collections at each site from September 1986 to July 1987.

A total of 671 0-age *P. dentatus,* 13-160 mm TL, were collected. Specimens 13-20 mm TL were considered new recruits. Nearly all of these specimens were completely transformed. They had probably settled out of the water column recently. Recruitment occurred from November through April on both sides of the Eastern Shore compared to February through April on the western side of Chesapeake Bay. Peak recruitment occurred in November and December on the Eastern Shore compared to March and April on the western side of Chesapeake Bay. Eighty-three percent of the new recruits from trawl collections were captured in shallow (< 2 m) habitats.

Shallow, fine-substrate habitat served as the primary nursery of 0-age *P. dentatus* from the time of settlement until they were 60-80 mm total length. This habitat was located in subtidal areas adjacent to salt-marsh vegetation. The substrate was composed of > 50% very fine sand, silt, and clay. At four of the five sites, catch-per-unit-effort was an order of magnitude greater in the shallow, fine-substrate habitat compared to the other habitats sampled. The nursery is limited to only shallow, fine-substrate habitat until late spring (fish length = 60-80 mm). After that time, shallow sand-substrate (includes seagrass beds in Chesapeake Bay), deep sand-substrate, and deep fine-substrate habitats are also utilized as nurseries.

The present study represents the first attempt to define the nursery habitat of 0-age *P. dentatus* in Virginia. Virginia estuaries are important nurseries for *P. dentatus* immediately after settlement. The collection of > 375 0-age specimens on the seaside of the Eastern Shore provides conclusive evidence to support the hypothesis by Poole (1966) that this area is one of the major nurseries for *P. dentatus*.

B. Geological / Chemical / Physical

Moore, K.A., I.C. Anderson, and B.B. Neikirk. 1998. The role of the littoral zone in regulating water quality within an estuary. Final Report. Va. Department of Environmental Quality, Coastal Resources Management Program. Richmond, Virginia. 79pp.

ABSTRACT

Processes which influence water quality within the littoral zone of Virginia's tidal tributaries can be distinctly different from those in channel zones and can vary over short time scales. However, little detail is known about processes responsible for this variability and how the presence of submerged aquatic vegetation (SAV) may affect these rates. Currently the Chesapeake Bay Water Quality model depends upon observations made in deeper, channel areas for calibration. Therefore, the objectives of this study were to provide the information necessary for ongoing testing of the sediment diagenesis and flux sub-model by measuring, in situ, metabolic processes, sediment/water fluxes of inorganic nutrients, and rates of gross mineralization and nitrification in both vegetated and unvegetated sediments within littoral zone areas of the lower Chesapeake Bay.

Sediments vegetated with SAV in the littoral zone were more organic-rich than unvegetated sediments and had distinctly different physico-chemical profiles. Microalgae were generally higher in unvegetated sediments during spring and early summer but by late summer these differences disappeared as the biomass of the SAV overstory declined. Water column concentrations of nutrients in the littoral zone were regulated mainly by high rates of phytoplankton uptake during spring and early summer and by high rates of SAV uptake during fall. During late summer NH_4^+ concentrations in the water column varied sharply over diurnal time scales because of net phytoplankton uptake in the light and net sediment mineralization and release in the dark. High rates of sediment mineralization in late summer followed by high rates of nitrification in surface sediments during fall were responsible for the observed sediment nutrient profiles and for increased DIN in the water column during fall. Decreased production: respiration (P/R) ratios in August, resulting from high temperatures and high rates of sediment mineralization (respiration), were likely responsible for the decreased SAV biomass observed during late summer. Water column uptake of DIN supplied all of the nitrogen required to support growth of SAV and associated epiphytes during fall.

C. Cultural / Socioeconomic

II. CATLETT ISLANDS

A. Biological

Luckenbach, M.W., D.A. Harsh, R. Mann, R.J. Orth, and K.A. Moore. 1995. Filtration by oysters: Interactive effects of water flow, seston composition and filtration rate. Final Report. Virginia Institute of Marine Science, Gloucester Point, Virginia. 106pp.

ABSTRACT

Filtration by suspension-feeding bivalves affects water quality and the postulated impacts include increased light penetration and enhanced benthic primary production. Such system-level predictions are extrapolated from still water experiments which neglect
the effects of flow, seston composition, turbulent mixing and refiltration by oysters within groups. Flume experiments were used to investigate the effects of varying flow speed and seston composition on filtration capacity of oysters. Six groups of 90 oysters were used in treatments which varied concentrations of the algae *Thalassiosira weisflogii* separately and in combination with inorganics; four sets of shell only controls were used to evaluate hydrodynamic effects. The results indicate the importance of morphological differences in bed structure on turbulence and particle redistribution which may obscure biological effects and of the importance of the physiological condition of oysters on filtration capacity. Field transplants of eelgrass, *Zostera marina*, and American oysters, *Crassostrea virginica*, were used to evaluate interactions between oyster filtration, water quality and plant survival in the field. Abnormally poor water quality forced the early termination of these experiments, but in conjunction with the flume results they indicate a strong effect of physical forces on seston distribution against which impacts of suspension feeders must judged.

Rhodes, M.W. and H.I. Kator. 1991. Use of *Salmonella typhimurium* WG49 to enumerate male-specific coliphages in an estuary and watershed subject to nonpoint pollution. *Water Research* 25(11): 1315 – 1323.

ABSTRACT

The occurrence of male-specific RNA (FRNA) coliphages, proposed as indicators of enteric viruses, was determined in an estuary subject to nonpoint pollution that included fecal inputs from livestock. A host originally developed for detecting FRNA phages in sewage was applied to water and sediment samples. Phages were enumerated using the host *Salmonella typhimurium* WG49 containing an *Escherichia coli* plasmid coding for sex pili, and the female parent strain WG45.

FRNA phages and fecal coliforms were enumerated in samples collected seasonally from an estuary and associated feeder streams and densities related to selected environmental parameters. Mean phage densities enumerated on WG49 ranged from <1 to 50 100 ml^{-1} water and <13 to 7200 100 g^{-1} dry sediment. Examination of 300 phages from estuarine and freshwater samples showed that ≥ 99% were RNase-resistant, ≥ 94%were lytic to the female parent salmonella strain (WG45), ≤ 9% were lytic to male *E. coli* C3000, and none were lytic to female *E. coli* C. RNase resistant phages lytic to both salmonella strains were noncontractile flexible tailed phages and those lytic to male salmonella or *E. coli* hosts were filamentous phages. Electron micrographs of the only RNase-sensitive phage recovered that plaqued only male hosts showed cubic phage particles adsorbed to sex pili.

Parallel enumerations of environmental samples on WG45 and WG49 yielded equal or greater phage densities on the former host. Purified phages from these samples were lytic to certain salmonella serovars recovered from the environment but did not cross react with fecal coliform or heterotrophic bacteria isolated from the environment. Although the WG49 host was inappropriate to estuarine and freshwater samples examined because of interference by somatic phages, WG45 and WG49 should be examined as hosts for enumerating salmonella phages. Similarly, the public health significance of somatic phages detected by these hosts should be determined.
FRNA phages, with a single exception (1/187 samples), were not detected in a condemned shellfish growing area subject to nonpoint pollution. This observation questions the application of FRNA phages as indicators of fecal contamination in waters impacted by diffuse fecal inputs.

Seitz, R.D. 1998. Incorporation of soft-sediment systems into a model of marine benthic community regulation. *Marine Freshwater Research* 49: 817 – 826.

ABSTRACT

This review (1) describes important regulating forces in soft-sediment systems, (2) outlines existing models of community regulation, and (3) revises a model of community regulation to incorporate soft-sediment systems. The Menge and Sutherland (MS) model of community regulation and its refinements were developed for hard-bottom habitats, but can be modified for soft-sediment systems. This 'consumer stress model' posits that mobile consumers feed ineffectively in harsh environments, and that the relative importance of physical disturbance, interspecific competition and predation varies predictably with the magnitude of recruitment, environmental conditions, productivity and trophic position. The MS model predicts that interspecific competition for a resource depends directly upon the level of recruitment, though it does not explicitly address the joint effects of recruitment and resource availability, which are important in soft-sediment communities. The model is here revised to incorporate hard-bottom and soft-sediment systems by changing the recruitment axis to a 'recruitment : resource ratio', whereby the effect of a given level of recruitment depends on resource availability. The potential utility of the revised model is illustrated in a hypothetical contrast of the effect of recruitment : resource ratios

on community regulation for a mussel-dominated assemblage in hard-bottom habitats and an infaunal clam-dominated system in soft sediments.

Williams, C.A.H. 1994. Toxicity Resistance in Mummichug (*Fundulus heteroclitus*) from a Chemically Contaminated Environment. Master's Thesis. The College of William and Mary, Williamsburg, Virginia. 120pp.

ABSTRACT

A growing field in toxicity research focuses on acute and chronic health problems in aquatic organisms living in chemically contaminated environments. Fishes exposed to environmental toxicants may suffer adverse effects ranging in severity from relatively minor sublethal changes to death. Certain populations, however, have been shown to develop resistance to these toxicants, either by physiological acclimation or by genetic adaptation.

The highly industrialized Elizabeth River, Virginia, is one of the most polluted waterways in the United States. Studies at the Virginia Institute of Marine Science (VIMS) have focused on a population of mummichog *(Fundulus heteroclitus)* from a contaminated site in the southern branch of this river, which has been shown to contain high sediment concentrations of polycyclic aromatic hydrocarbons, presumably of creosote origin. While these fish exhibit a high prevalence of neoplastic and non-neoplastic tissue lesions, their embryos apparently are resistant to the acute toxicity of the pollutants found at the site; a resistance which does not appear to be shared by mummichog embryos from a population living in a relatively uncontaminated environment. The purpose of this study was to characterize the resistance occurring in these fish embryos.

Short-term sediment exposure tests using mummichog embryos from the contaminated population and from a reference population were conducted to evaluate the differential resistance exhibited by these embryos, to determine if the observed resistance appeared to be due to physiological acclimation or to genetic adaptation, and to document the effects of contaminated sediment on non- resistant embryos. In addition, exposure tests using hybrid embryos from controlled crosses between the two populations were conducted to investigate the nature of the inheritance of the resistance trait. Embryo responses to the various treatments used in these experiments were assayed using mortality and cardiovascular malformation as toxicity end points.

In all experiments, Elizabeth River embryos exposed to contaminated sediment developed and hatched relatively normally, while similarly exposed reference embryos developed cardiovascular abnormalities and died. The cardiac terata most often observed in these experiments were tube hearts of varying severity, accompanied by pericardial edema. Hybrid embryos, for the most part, responded to contaminated sediment in a manner similar to reference embryos. However, hybrids obtained by crossing Elizabeth River females with reference males appeared to be slightly less susceptible to the toxic effects of contaminated sediment than were the reciprocal hybrids.

The results of this study supported the hypothesis that mummichog embryos from a chemically contaminated site in the Elizabeth River, Virginia, are more resistant to the acute toxicity of contaminated sediment than are embryos from an uncontaminated reference site. This resistance was apparent when either mortality or cardiovascular malformation was used as a criterion for toxic effects. The observed resistance was shown to be due to genetic adaptation rather than physiological acclimation. It appears to be inherited as an autosomal recessive trait which may be modified by maternal effects.

B. Geological / Chemical / Physical

Finkelstein, K. and C.S. Hardaway. 1988. Late Holocene sedimentation and erosion of estuarine fringing marshes, York River, Virginia. *Journal of Coastal Research* 4(3): 447 – 456.

ABSTRACT

Eleven vibracores and three ^{14}C dates in conjunction with historical maps and charts were used to determine the late Holocene accretion and erosion of fringing York River estuarine salt marshes. Cyclical stages of marsh accretion and erosion were recognized, hypothetically beginning with an expansive marsh associated with a meandering tidal river. With rapid sea-level rise from the Holocene marine transgression, these marshes were drowned. A reduction in the rate of sea-level rise and low wave energy allowed fringing marshes to develop over the low-energy, estuarine sediments. Subsequent increased rates of sea-level rise along with relatively large storm waves from a large fetch over relatively deeper estuarine waters result in the present erosion of the marshes.

The results from this region are not in agreement with previous studies elsewhere that point to late Holocene and modern-day marsh accretion. The present local rate of sea-level rise may be too great for marsh expansion. However, the exposure to storm-waves was also of significant importance in the maintenance or erosion of the fringing marshes.

C. Cultural / Socioeconomic

Blanton, D.B., C.M. Downing, and D.W. Linebaugh. 1993. A cultural resource overview and preservation plan for the Timberneck Farm Property and Catlett Islands, Gloucester County, Virginia. College of William and Mary Center for Archaeological Research, Williamsburg, Virginia. 54pp + appendices.

III. TASKINAS CREEK

A. Biological

Kator, H. and M. Rhodes. 1996. Identification of pollutant sources contributing to degraded sanitary water quality in Taskinas Creek, National Estuarine Research Reserve, Virginia. Special Report in Applied Marine Science and Ocean Engineering No. 336. The College of William and Mary, School of Marine Science. 46pp + appendix.

Kator, H. and M. Rhodes. 1999. Continued evaluation of pollutant sources contributing to degraded sanitary water quality in Taskinas Creek Reserve, Virginia. Final Report. NOAA Office of Ocean and Coastal Resource Management. 29pp.

ABSTRACT

Objectives of this research were to identify sources of fecal contamination reflected by the observed elevated fecal coliform densities in the Taskinas Creek watershed, to continue evaluation of *Streptococcus bovis* as an animal specific indicator of contamination, and to verify a proposed oligoprobe (JB1) to *S. bovis* 16S RNA to facilitate identification of presumptive isolates. The coincidence of comparatively high levels of *S. bovis* at feeder streams and in Taskinas Creek proper previously observed reflected an active animal community within both reserve and developed portions of the watershed. This conclusion was reinforced this year as well by consistent field observations of animal tracks and fecal deposits at both feeder stream and creek sampling sites. Analyses this year confirmed that fecal samples from dominant animals in the watershed, deer and raccoon, were significant sources of *S. bovis* and *Escherichia coli*. Geometric mean counts for presumptive *S. bovis* were about equivalent in muskrat, deer and raccoon scat. Raccoon scat tended to be somewhat higher in *E. coli* than the other two animal species. Results of weathering experiments, intertidal for muskrat and upland for deer scat, suggested that both are sources of indicator bacteria, and that deer scat may serve as relatively long-term (28 days) reservoirs for the release of fecal bacteria following precipitation events. Muskrat scat tended to break up with tidal incursions but remained sources of *E. coli* for at least 7-14 days, a period of time long enough to influence sanitary water quality. Persistence of *S. bovis* in receiving waters under light and dark conditions showed *S. bovis* was sensitive to sunlight and was reduced from levels found in animal scat to undetectable counts within 3 days. Limited persistence of this indicator continues to support our contention that its presence in the watershed implies fresh contaminant sources that originate from an active animal community. Despite extensive and prolonged testing, peer review of procedures, synthesis of oligoprobes by two different vendors, we were unable to obtain hybridization of the *S. bovis* oligoprobe against *S. bovis* JB1, isolates in our reference library, and presumptive isolates derived from Taskinas Creek samples.

Rhodes, M. and H. Kator. 1999. Sorbitol-fermenting bifidobacteria as indicators of diffuse human faecal pollution in estuarine watersheds. *Journal of Applied Microbiology* 87: 528 – 535.

ABSTRACT

Sorbitol fermenting bifidobacteria were evaluated as indicators of non-point source human faecal pollution to three sub-estuaries with elevated faecal coliform densities. Human-specific bifidobacteria correlated with identifiable human sanitary deficiencies in feeder streams to estuarine creeks in two of three watersheds examined, one rural and one moderately developed. Sorbitol-fermenting bifidobacteria were recovered at densities ranging from 1 to 90 colony-forming-units 100 ml^{-1} in 11 of 258 water samples but were undetected in sediment (n = 68) and scat from resident wildlife (deer, muskrat and raccoon, n = 20). Failure to detect sorbitol-fermenting bifidobacteria in water samples during the summer months was consistent with laboratory microcosm results showing non-recoverability of *Bifidobacterium adolescentis* after 5-9 d in membrane-filtered estuarine water at 23 and 30°C, but persistence for 4 weeks at 10°C. Persistence of sewage-derived bifidobacteria in membrane-filtered freshwater at 15°C was also observed. Recovery of sorbitol-fermenting bifidobacteria was complicated by high background levels of Gram-positive rods and cocci. Use of propionic acid and reduced pH (pH = 5.0), or use of a two-step resuscitation protocol using non-selective and selective media, did not improve recovery. Although human specific bifidobacteria hold promise as indicators of diffuse faecal contamination, methodological constraints now limit its application to situations of gross contamination, or sampling potential sources during environmental conditions conducive to bifid persistence.

B. Geological / Chemical / Physical

Hartenstine, S.A. 1991. Nutrient Standing Stocks and Partitioning in a Forested Coastal Plain Watershed: Groundwater, Stream and Marsh Creek. Master's Thesis. The College of William and Mary, Williamsburg, Virginia. 69pp.

ABSTRACT

This study investigated the nutrient standing stocks in a small, pristine, bottomland hardwood swamp and partitioned the nutrient sources and sinks at the marsh/upland interface. Nutrient concentrations of water samples collected during two hydroperiods in 1990 in the Taskinas Creek watershed of the York River Estuary, Virginia, showed the importance of groundwater as a potential source of nutrients to the system, particularly during the spring hydroperiod. Observed

orthophosphate concentrations were high during both hydroperiods at all sampling stations. Groundwater concentrations ranged from 1.37 to 6.78 µg-at/L during the spring hydroperiod and from 1.44 to 12.52 µg-at/L during the summer hydroperiod. Nitrate + nitrite concentrations were greatest in Taskinas Creek during the spring hydroperiod ranging from 0.87 to 14.90 µg-at/L. During the summer hydroperiod, the stream exhibited the greatest concentrations of nitrate+nitrite ranging from 1.50 to 2.56 µg-at/L. Ammonium concentrations generally were highest in the groundwater during the spring ranging from 0.41 to 4.56 µg-at/L while the highest summer ammonium concentrations fluctuated between the groundwater and stream sampling stations. Groundwater ammonium concentrations ranged from 1.37 to 6.57 µg-at/L and the stream station ranged from 2.22 to 3.50 µg-at/L during the summer hydroperiod. The Taskinas Creek sampling station showed great variation in nutrient concentrations, presumably due to York River influence. The results indicate that during the spring groundwater acts as an ammonium source for the stream. The results indicate that spring groundwater also may be an important source of nitrate+nitrite, while groundwater may serve as a source for orthophosphate in the system in both hydroperiods.

Wenner, E., A.F. Holland, and D. Sanger. 1988. Assessing short-term variability in dissolved oxygen and other water quality variables in shallow estuarine habitats. *In:* Ocean Community Conference '98 Proceedings, Vol. 2, Nov 16-19, 1998. pp. 802 – 806.

ABSTRACT

Water quality data collected from 1995 to 1996 at National Estuarine Research Reserves (NERR) and during 1994 from 24 tidal creeks in Charleston Harbor, SC were analyzed to: (1) characterize spatial and temporal variability; and (2) determine if water quality in shallow estuarine habitats was related to the degree and type of coastal watershed development. The periodicity, degree, and amplitude of dissolved oxygen (DO) levels varied with geographical location, habitat type, land cover, time of day, lunar phase, season, and among years. Lowest DO levels consistently occurred during summer at early morning low tides. Statistically significant tidal (12.5 h) and diel (24 h) periodicity in DO was found at all sites. Tidal periodicity was greatest at SC sites, which represented the largest tidal ranges (2 m) evaluated. Developed watersheds had more frequent low DO events than forested watersheds. Many of the low DO events identified would not have been detected by daily (or less frequent) sampling. Tidal creeks with developed watersheds were also characterized by significantly greater variability in salinity than creeks located in forested watersheds, suggesting that coastal development substantially altered the rate and volume of freshwater flow into estuaries. Short-term fluctuations in salinity may be an efficient, understandable indicator of the hydrodynamic impacts of coastal development. Characterizing the variability in estuarine water quality and determining when fluctuations are related to anthropogenic activities and when they are natural is a difficult problem. Resolution of this problem will require reliable long-term monitoring information that is collected in a near-continuous manner.

C. Cultural / Socioeconomic

IV. SWEETHALL MARSH

A. Biological

Campana, M.L. 1998. The Effect of *Phragmites australis* Invasion on Community Processes in a Tidal Freshwater Marsh. Master's Thesis. The College of William and Mary, Williamsburg, Virginia. 88pp.

ABSTRACT

Nutrient flux, sedimentation, and plant community structure and species diversity within 3 paired *Phragmites australis* (Cav.) Trin. ex Steud. and *Spartina cynosuroides* (L.) Roth wetland plant communities were compared to investigate the effect of *P. australis* invasion on tidal freshwater marsh processes at Sweet Hall Marsh, Virginia. Nutrient flux (PO_4^{-3}, NH_4^+, NO_3^-+NO_2^-, DIN) was measured 3 times during the growing season using a benthic chamber method. Net annual inorganic mass flux and ion rates were measured using depth of peak ^{137}Cs deposition. Vascular plant species richness, species diversity, species evenness, and community structure were investigated using ground cover, stem density, and frequency of occurrence measurements taken 3 times during the growing season. The invasive *P. australis* communities exhibited lower PO_4^{-3} release to tidal waters late in the growing season (-3.9 μmol m^{-2} h^{-1} and 28.3 μmol m^{-2} h^{-1} respectively), lower NO_3^-+NO_2^- uptake from tidal waters throughout the growing season (-58 μmol m^{-2} h^{-1} and -159. μmol m^{-2} h^{-1} respectively), and slightly higher values of species richness (14.3 and 11.7 respectively) and diversity (1.937 and 1.683 respectively) mid-season than the native *S. cynosuroides* communities. No differences in inorganic mass flux or accretion rates between the two communities were detected. Results indicate that predicting the effect of changes in species composition on community, and potentially ecosystem processes, is dependent on the species' role in the system and the type of process. In addition, invasive *P. australis* communities do not appear to be devoid of water quality (nutrient/sediment buffering) or habitat (richness/diversity) value compared to native communities in this marsh. Recognition of this potential ecological value in other ecosystems should be incorporated into the resource management decision-making process.

Davies, S. 2004. Vegetation Dynamics of a Tidal Freshwater Marsh: Long-term and Inter-annual Variability and their Relation to Salinity. Master's Thesis. The College of William and Mary, Williamsburg, Virginia. 75pp.

ABSTRACT

Tidal freshwater marshes (TFMs) support diverse plant communities and provide valuable habitat for commercially important fish and wildfowl populations. Relative sea level rise (RSLR) may cause declines in this diversity due to increased salinity and altered hydroperiod, but little research has focused on the community level response of TFM plants to RSLR. Sweet Hall Marsh, a component of the Chesapeake Bay National Estuarine Research Reserve in Virginia, is a model system for studying long-term variation in vegetation dynamics of a TFM. Studies completed in 1974 and 1987 provided historical vegetation data. The second of the two studies quantitatively documented a change in vegetation from the first study, suggesting a shift towards an oligohaline marsh. In 2003, previous study areas were re-sampled using the same methods as the previous studies. Percent cover, stem density, and frequency were measured at each of 76 1- m^2 plots throughout the growing season. Dominant species, based on aboveground biomass collected in August 2003, were *Zizania aquatica* (266g/ m^2) and *Peltandra virginica* (71.3g/ m^2). Comparison with previous studies found an increase in the importance of salt-tolerant perennial species (including *S. alterniflora* and *E. palustris*) and a decrease in freshwater perennials (including *P. virginica* and *C. stricta*). Highly variable river salinities, while only tentatively supporting our hypothesis that relative sea level rise may be affecting the plant community, did suggest that salinity stress might be contributing to the plant community change. A limited follow-up study in July 2004 showed the relative importance of salt-tolerant species had decreased while the importance of some freshwater species increased from July 2003 to July 2004. Implications are that both the perennial and annual components of the vegetation community of this TFM may be highly variable from year to year. Therefore, the increase in salt-tolerant perennials observed in 2003 may have been a response to short-term climatic factors rather than long-term salinity increases. Results support the hypothesis that TFMs may remain vegetated with rising sea levels and highlight the need for yearly monitoring of vegetation community.

Doumlele, D.G. 1976. Primary Production and Plant Community Structure in a Tidal Freshwater Marsh. Master's Thesis. The College of William and Mary, Williamsburg, Virginia. 59pp.

ABSTRACT

Annual net primary production and indices of community structure for Sweet Hall Marsh, a tidal freshwater marsh in Virginia, were determined. The total marsh community sampled produced approximately 755.16 g m^{-2} yr^{-1}, with *Peltandra virginica.* accounting for over half the amount. Other major producers were *Leersia oryzoides*, P*olygonum punctatum*, *Pontederia cordata*, and *Aneilema keisak*. Species diversity was highest in August. Both diversity and the species distribution pattern were strongly influenced by elevation and the effects of the presence of shrubs and trees. The community was found to be largely dominated by *Peltandra* from spring through midsummer, but consequent die-back of this species allowed other species, namely *Leersia*, to increase in importance toward the end of the growing season.

Loesch, J.G., R.L. Huggett, and E.J. Foell. 1982. Kepone concentration in juvenile anadromous fishes. *Estuaries* 5(3): 175 – 181.

ABSTRACT

Young-of-the-year alewife, American shad, blueback herring. and striped bass where analyzed for Kepone contamination. Samples were collected from the Potomac, Rappahannock, Pamunkey, Mattaponi, Chickahominy, and James rivers during the period 1977-79. Concentrations of Kepone ≥ 0.3 ppm occurred in all four species collected in the James River nursery zone between km 65 and l20, and in the lower Chickahominy River. Concentrations of Kepone < 0.3 ppm where also present in samples from the Mattaponi and Pamunkey rivers. Four possible explanations for the occurrence of Kepone in these samples from the upper York River system (Mattaponi and Pamunkey rivers) were evaluated. Kepone was not detectable in samples from the Rappahannock and Potomac rivers.

Massmann, W.H. 1952. A Preliminary Study of Shad, *Alosa sapidissima* (Wilson), Spawning in some Virginia Rivers. Master's Thesis. The College of William and Mary, Williamsburg, Virginia. 24pp.

ABSTRACT

In 1949 and 1950 shad spawning was studied in six Tidewater Rivers. The major spawning areas were located in three of these, while on the others, areas where some spawning took place were located. The spawning areas in each river were located in freshwater subject to tidal influence. A few shad eggs were collected at water temperature of 9.2°C, but more were taken after the temperature was 14.0°C. Eggs were still being taken at a temperature of 21.9°C when sampling was discontinued. There appeared to be little evidence that turbidity was a factor in determining the spawning areas. Tidal current velocities from 0 to > 3 ft s^{-1} were observed on the spawning grounds. Bottom topography appeared to be an important factor in the location of spawning areas; those sections of rivers dominated by widespread flats were most extensively utilized. Fewer than five shad eggs hr^{-1} were collected from the most productive rivers; almost two-thirds of these were dead. On the Pamunkey River spawning took place during all hours of the day but was more intense in the period from noon to midnight.

Perry, J.E. 1991. Analysis of Vegetation Patterns in a Tidal Freshwater Marsh. Ph.D. Dissertation. The College of William and Mary, Williamsburg, Virginia. 204pp + appendices.

ABSTRACT

Tidal freshwater wetlands represent a transitional wetland between tidal salt marshes and non-tidal wetlands. As such, they exhibit some of the vegetation characteristics of both systems. If the changes in the vegetation pattern favor the characteristics of one system over the other, the changes may be an indication of changes in the environmental conditions of the estuarine ecosystem that favors that system. Unfortunately, little is known of the temporal and spatial changes that occur in the vegetation patterns of tidal freshwater marshes of the mid-Atlantic coastal region.

In 1987 a vegetation analysis was done on a 60 hectare section of Sweet Hall Marsh, a tidal freshwater marsh of Chesapeake Bay. The data was compared with that of a similar study completed in 1974 to determine the changes that may have occurred in the vegetation pattern of the marsh. The results found that there was no significant difference in the species diversity of the two studies. However, further analysis showed that there was a change in the plant species contributing to the diversity. *Spartina cvnosuroides,* an oligohaline species that was not important in the 1974 study, had the fourth highest importance value in this study. The shift in species composition of Sweet Hall Marsh may reflect a shift in the marsh's environment from being historically that of tidal fresh water to one of being more transitional between oligohaline and tidal fresh water.

Perry, J.E. and C.H. Hershner. 1999. Temporal changes in the vegetation pattern in a tidal freshwater marsh. *Wetlands* 19(1): 90 – 99.

ABSTRACT

Temporal changes in vegetation patterns of Chesapeake Bay wetlands have been poorly documented. Data from a 1987 vegetation analysis of a Chesapeake Bay tidal freshwater marsh were compared to those of a vegetation study completed in 1974. Changes in the vegetation pattern were calculated using species importance values and a species diversity index. Comparison of the 1987 and 1974 results shows no significant difference in species diversity index. However, there was a significant difference in species contribution to the index. *Spartina cynosuroides,* an oligohaline species that was not among the dominant species listed in the 1974 study, had the fourth highest importance value in this study. The change in dominant species composition of the marsh may reflect a directional shift from tidal freshwater toward oligohaline conditions.

Rheinhardt, R. 1992. A multivariate analysis of vegetation patterns in tidal freshwater swamps of lower Chesapeake Bay, U.S.A. *Bulletin of the Torrey Botanical Club* 119(2): 192 – 207.

ABSTRACT

The woody and herbaceous vegetation of 23 tidal freshwater swamps was sampled along the Pamunkey River, a tributary of the York River (a subestuary of Chesapeake Bay). Tidally driven water level fluctuations were monitored and recorded in selected swamps. Four vegetative life-forms were examined and ordinated with Detrended Correspondence Analysis: trees (canopy and sapling sized), woody subcanopy (shrubs and understory trees), vines, and herbs. Species distribution patterns were compared in relation to edaphic factors, a flooding index, and duration of flooding in the root zone.

On the basis of the canopy composition, two tidal swamp communities were found, both subjected to a tidally forced hydroperiod regime within the upper 15 cm of their root zones, the approximate height of the hummocks. *Nyssa biflora-Fraxinus* spp. dominated swamps are best developed toward the more downriver reaches in the wetter sites, which contain more hollows, a higher organic matter content, and higher calcium levels. In contrast, *Acer rubrum- Liquidambar styraciflua- Nyssa biflora* dominated swamps are more common throughout the mid- to upriver reaches at less wet sites

with lower organic matter and calcium levels. *Taxodium distichum* was found to co-dominate in two swamps that may represent relic conditions for the wetter sites.

Although low in canopy diversity, the tidal swamps are floristically rich in herbaceous and subcanopy species, ranking them among the most speciose in temperate North America. The microtopographic complexity (the hummocks vs. hollows pattern) appeared to be strongly related to species distribution patterns in the canopy, vine, and herbaceous strata. Although the ordinations segregated canopy and herbaceous strata similarly, the woody subcanopy did not segregate into the same two communities established by the canopy and herb strata, suggesting that the canopy may be partitioning different resources than the woody subcanopy.

Rheinhardt, R.D. and C. Hershner. 1992. The relationship of belowground hydrology to canopy composition in five tidal freshwater swamps. *Wetlands* 12: 208 – 216.

ABSTRACT

The relationship between ground-water fluctuations and the canopy compositions of five tidal freshwater swamps were examined. Tide gauge data were compared with measured ground-water fluctuations to assess the role of tides in driving the hydrologic regimes of tidal swamps. Flooding in tidal swamps was found to be closely associated with high tides. As the tides dropped through the hummock zone (elevated area, about 15 cm high, to which the trees are restricted), drainage of the hollows (low areas between hummocks) occurred at the same rate as the falling tides. After the tides dropped below the elevation of the hollows, the lowering of the water table became much slower than that of the falling tides, presumably because peat in the root zone inhibited drainage. When the subsequent rising tides reached the elevation of the water table, the water table rose vertically with the tides. Flooding recurred in the hollows as the tides rose above the surface of the ground. The composition of the canopy was found to be related to the mean water-table depth (WTD) (i.e., the depth in relation to the hummock elevation at which the soil was flooded 50% of the time) and not to the duration, depth, or frequency of flooding. Tidal swamps dominated by *Fraxinus* spp. and *Nyssa sylvatica* var. *biflora* occurred in the wetter sites (mean WTD = 17 cm), whereas swamps dominated by *Acer rubrum* and *Liquidambar styraciflua* occurred in less wet sites (mean WTD = 21 to 30 cm). Tidal freshwater swamps are precariously positioned at the upper portion of the tidal range where they seem to keep pace with a rising sea level by accumulating biomass (logs and roots). Potential threats to the distribution and areal extent of tidal freshwater swamps include any abrupt changes in the rate of sea-level rise, periodic logging, or blockage of their upriver migration due to incompatible land use.

Rheinhardt, R.D. 1992. Disparate distribution patterns between canopy and subcanopy life-forms in two temperate North American forests. *Vegetatio* 103: 67 – 77.

ABSTRACT

Quantitative vegetational data of canopy and woody subcanopy species (two life-forms adapted to occupy different strata at maturity) were compared with data collected in two temperate forest ecosystems to determine whether they exhibit a similar pattern of distribution. Tidal freshwater swamps (21 stands) and southern Appalachian forests (19 stands) were examined from data obtained using identical sampling methods. Separate structural analyses of the canopy, sapling, and subcanopy species were compared using the indirect ordination algorithm Detrended Correspondence Analysis. Environmental measurements collected in each stand were assessed for their relationship to the distribution of stands depicted by the ordination diagrams.

Canopy trees and saplings showed a similar pattern of distribution, suggesting that the resource requirements of saplings and canopy-statured adults are similar .In contrast, the subcanopy species (species genetically adapted to an understory existence, i.e., shrubs and small understory trees) of neither ecosystem showed any discern able distributional relationship to the canopy or sapling layers (in tidal swamps, there was no clear way to even segregate subcanopy stands into communities). Environmental gradients associated with the subcanopy ordinations differed from those of the canopy and sapling strata in both forest systems, suggesting that subcanopy species partition different resources than do canopy species.

If a lack of similarity in distribution patterns between canopy and subcanopy species is universal in temperate forests, then the common practice of combining sapling and subcanopy species in structural analyses may hinder our understanding of subcanopy structural patterns in forests.

Rinaldo, R.G. 1971. Analysis of *Morone saxatalis* and *Morone americanus* Spawning and Nursery Area in the York-Pamunkey River, Virginia. Master's Thesis. The College of William and Mary, Williamsburg, Virginia. 55pp.

ABSTRACT

Spawning and nursery areas in the York-Pamunkey River for striped bass, *Morone saxatilis* (walbaum), and white perch, *M. americanus* (Gmelin), are described. Abundance and distribution of prolarvae, larvae and juveniles were investigated by meter net sampling. Both species utilized the main stream of the Pamunkey River 35 to 55 miles up- stream from the mouth of the York River as spawning and nursery areas. Movements of early stages within the nursery ground are also described.

Associated physical and biological data for spring 1966 are related to the early life history of both species. Water temperature was 16 C during striped bass spawning, while white perch spawned when temperatures were 11-16 C. Both species spawned in fresh water and utilized low salinity areas as a nursery ground. Growth rates for both species were essentially the same during the first two months; after which striped bass grew much more rapidly than white perch. Gut content analyses of larvae and recently transformed juveniles indicated a similar diet in the two species. Food of older juveniles differed between the two species. Striped bass became piscivorous at an early age.

Schaffner, L.C. and I.C. Anderson. 2006. An integrated approach to understand relationships between shallow water benthic community structure and ecosystem function (CS 1335). 2005 Annual Report, Strategic Environmental Research and Development Program (SERDP), Washington, D.C. 94pp.

ABSTRACT

Military activities along estuarine shorelines present both unique and common stressors that impact ecosystem sustainability. Biocriteria-based methods, such as the multimetric Benthic Index of Biotic Integrity (B-IBI), have been successfully applied by the Chesapeake Bay Program and others to elucidate regional and local water- and sediment-quality impairments and physical habitat disturbance in the Chesapeake Bay. Although such methods serve as good indicators of anthropogenic disturbance, their relationship to key functional attributes of aquatic ecosystems is unknown. The overall objective of this project is to couple the B-IBI approach with detailed investigations of benthic community structure and function to better understand relationships among military activities, integrity of benthic communities, and ecosystem function within the shallow waters of the Chesapeake Bay. From 2003 to 2005, detailed field investigations of benthic community structure and ecosystem function were conducted at 11 sites located along salinity and disturbance gradients in the Chesapeake Bay. Military sites included in this study were Langley Air Force Base, Fort Eustis, Patuxent River Naval Air Station, Quantico Marine Corps Base, and Aberdeen Proving Grounds. Non-military sites were selected to represent both reference ("pristine") and degraded end-member conditions in order to improve our ability to detect stress within each salinity regime using the B-IBI and measures of ecosystem function.

Specifically in 2005, we conducted comprehensive field studies at Aberdeen Proving Grounds, Quantico Marine Corps Base, Sweet Hall Marsh, a relatively pristine reference site on the Pamunkey River (a subtributary of the York River), and the Anacostia River, a disturbed site, in the oligohaline (historic salinity 0-5 psu) areas of the Chesapeake Bay. Site characterizations and preliminary results from completed laboratory analyses of the 2005 samples are presented in this report. Statistical analyses are in progress to identify relationships among B-IBI metrics, food web structure, and biogeochemical processes along gradients of impairment based on available 2003-2005 data. Preliminary results demonstrate that: (1) B-IBI metrics (abundance, biomass, taxa richness, and diversity) varied with disturbance as predicted based on historical environmental data; (2) near-field sites demonstrated a greater range of environmental impact than did far-field sites; (3) food web structure and secondary production were strongly related to ecosystem health at near but not far sites; (4) benthic microalgae played a critical role in regulating ecosystem function and services; and (5) metrics of ecosystem structure were closely related to those of function.

Wohlgemuth, M. 1988. Estimation of Net Aerial Primary Production of *Peltandra virginica* (L.) Kunth using Harvest and Tagging Techniques. Master's Thesis. The College of William and Mary, Williamsburg, Virginia. 63pp.

ABSTRACT

Bimonthly measurements of individual tagged shoots in permanent plots and harvests of shoots in nearby plots were used to make four estimates of net annual aboveground primary production (NAAP) for *Peltandra virginica*. The tagging data were used to estimate production from the summation of mortality and the Allen curve. Peak biomass and Smalley (1958) estimates were made from harvest data. The four estimates were evaluated and compared. Life history characteristics including: recruitment, mortality, turnover, and life span were estimated from tagged shoot data. The production estimates from the mortality (789.44 g m^{-2} yr^{-1}) and Allen curve (823.10 g m^{-2} yr^{-1}) methods were more than twice the peak biomass (352.64 g m^{-2} yr^{-1}) and Smalley (375.44 g m^{-2} yr^{-1}) method estimates. The two estimates from the tagged shoots incorporated seasonal recruitment, mortality, and turnover. These factors are especially important to include in estimating production for *Peltandra*, a fleshy tidal freshwater wetland plant with high turnover. Recruitment occurred throughout the season with a peak in May. Mortality occurred on all sampling dates with a peak in August. The mean life span was 53 days. Turnover was estimated from three methods NAAP/peak biomass (2.24), NAAP/mean biomass (6.83), and growing season/mean life span (3.6). Based on the findings of the life history patterns the mortality and Allen curve estimates represented true net production better than the harvest methods.

B. Geological

Ledwin, J.M. 1988. Sedimentation and its Role in the Nutrient Dynamics of a Tidal Freshwater Marsh. Master's Thesis. The College of William and Mary, Williamsburg, Virginia. 89pp.

ABSTRACT

This study describes sedimentation and its role in the introduction of nutrients to a tidal freshwater marsh. Three vegetation zones were sampled over a 14 month period to compare sedimentation and nutrient differences among both the plant zones and the seasons. Sediment accumulation was measured using sediment traps for gross deposition, and stake observations and a marker bed technique to record net elevation changes of the marsh surface. Nutrient concentrations of trapped sediment and marsh cores were measured to quantify the amount of nitrogen, phosphorous, and organic matter associated with the incoming sediments, as well as the nutrient concentrations as they were buried. Using sediment accumulation rates based on gross deposition and selected short-term net rates, fluxes of nitrogen, phosphorous, and organic matter to the marsh were estimated. The estimates varied greatly depending on the accumulation rate chosen. For a given rate, estimated fluxes differed 4 to 10 fold between sites and showed distinct seasonal patterns.

Neubauer, S.C., I.C. Anderson, J.A. Constantine, and S.A. Kuehl. 2002. Sediment deposition and accretion in a Mid-Atlantic (U.S.A.) tidal freshwater marsh. *Estuarine, Coastal and Shelf Science* 54: 713 – 727.

ABSTRACT

Sediment deposition and accretion rates in a Virginia tidal freshwater marsh were measured to provide insight to the processes and time scales that are important for maintaining marsh surface elevation. Short-term sediment deposition rates (biweekly to monthly) measured using sediment collection tiles were spatially and temporally variable. Rates were greatest near a tidal creak and decreased along a transect extending toward the marsh interior. When integrated across the entire marsh, annual sediment deposition (as organic carbon) averaged 517 ± 353 g C m^{-2} y^{-1} and was sufficient to balance the effects of existing relative sea level rise and marsh respiration rates. At the creekbank, the highest deposition rates were measured during summer although rates were relatively constant over time at the interior sites. Similar spatial and temporal patterns were obtained when deposition rates were calculated from ^{7}Be inventories (monthly time scale). Sediment inventories of ^{7}Be were greater than those supported atmospherically, indicating that the spatial patterns of sedimentation were not due to sediment erosion and redistribution within the marsh. Accretion rates calculated from ^{137}Cs (decadal scale) and ^{14}C dating (centuries to millennia) were substantially less than annual deposition rates, with a decrease in accretion rate with increasing time scale. Mineralization rates of recently deposited sediments (measured as O_2 consumption) indicated that sediment metabolism could potentially remove ~ 30% of recently deposited carbon within one month of deposition. The metabolism of a labile sediment fraction could explain a portion of the observed decrease in accretion rate with increasing time scale, with the remainder due to periodic storm-induced erosion and historical variability in sediment deposition rates.

Reay, W.G. 1989. Subsurface Hydrodynamics and Nutrient Exchange within an Extensive Tidal Freshwater Wetland. Master's Thesis. The College of William and Mary, Williamsburg, Virginia. 118pp.

ABSTRACT

Located between upland and riverine systems, extensive tidal freshwater wetlands are influenced by a variety of recharging water sources and their respective nutrient contents. Conversely, tidal wetlands discharge interstitial waters and solutes to surface waters during periods of aerial exposure. Geohydrologic and model simulation methodology were utilized in order to aid in the understanding of wetland subsurface flow dynamics, its influence upon pore water nutrient chemistry, and its role in nutrient exchange with adjacent surface waters. Interstitial water nutrient chemistry was monitored along three transects extending from the uplands to the creekbank edge. Surface waters were also monitored throughout the 13 month study period.

Measurements of soil dry bulk density, percent organic matter, fiber content, and horizontal hydraulic conductivity were conducted along a 118 meter transect from the creekbank edge to the high marsh/upland interface. Results indicate vertical and lateral heterogeneity of these physical and hydraulic soil properties within the upper one meter soil profile. Multivariate statistical techniques best described the transect as four separate soil types. General regions of soil types followed wetland elevational regions, these include: the creekbank, levee, low marsh flat, and high marsh regions. Fiber content was identified as the measured parameter which best explained variations in wetland soil permeability.

Vertical and horizontal hydraulic head fluctuations were monitored utilizing piezometer/well arrays along the 118 meter transect. Direct measurement of interstitial water seepage flow from the subaquaeous portion of the creekbank to adjacent surface water was determined. Model simulation of subsurface hydrodynamics were made in order to provide water table fluctuations, estimates of horizontal seepage, and pore water budgets along the transect. Field measurements of marsh surface elevations and hydraulic soil properties were incorporated into the model to allow for comparison between simulated and observed results.

Spatial variations in soil properties and subsurface hydrodynamics indicate that an extensive tidal freshwater wetland cannot be considered as a homogeneous unit. It may be described more accurately as three distinct, yet interactive regions (creekbank, low marsh, flat, and high marsh), with varying potentials for surface and interstitial water exchange. The creekbank, experiencing large water table oscillations and hydraulic gradients, was the most dynamic and tidally influenced region. These hydrodynamic characteristics resulted in substantial subsurface water transport and dilution of interstitial waters by recharging surface waters within the creekbank region. Due to extremely low hydraulic gradients and ponding of water, horizontal seepage was minimal within the low marsh flat. Moderate hydraulic gradients in conjunction with highly permeable soils were conducive for significant horizontal seepage within the high marsh. Hydrologic evidence indicates a potential for nutrient rich shallow groundwater recharge within the high marsh region. Sensitivity analysis within the creekbank region indicates that aquifer depth exhibits the largest influence on interstitial water discharge followed by soil permeability and specific yield properties of the aquifer respectively. Inverted results, as those found within the creekbank region, were obtained for the high marsh region.

Interstitial water nitrogen and total phosphorus levels were variable and a function of depth, location, and time. However, several generalities and patterns appeared relatively consistent. Creekbank pore waters were relatively enriched with oxidized inorganic forms of nitrogen relative to low and high marsh regions. Creekbank ammonium, total nitrogen and phosphorus interstitial pools were intermediate, whereas, dissolved organic nitrogen levels was the lowest of the three regions sampled. The low marsh flat was inorganic nitrogen poor, and intermediate with respect to dissolved organic nitrogen, relative to creekbank and high marsh regions. Pore waters within the low marsh were significantly enriched with dissolved total phosphorus as compared to the creekbank and high marsh regions. High marsh interstitial waters displayed reduced levels of nitrate and nitrite, while levels of ammonium, dissolved organic and total nitrogen were elevated in relation to the creekbank and low marsh flat. Interstitial total phosphorus levels within the high marsh were significantly lower than the low marsh and approximately equal to the creekbank region. The role and influence of subsurface hydrodynamics upon pore water nutrient concentrations and spatial variations are discussed.

Spatial and temporal potential patterns of nutrient exchange between surface water and pore waters of various wetland regions are identified. Dissolved oxidized inorganic forms of nitrogen were imported throughout the sampling period by the creekbank, low marsh flat, and high marsh regions. Ammonium flux, due to seepage, was predominantly from the wetland to surface waters; the high marsh exhibited a greatest potential for ammonium export. The high marsh was a source of dissolved organic nitrogen throughout the study, while the low marsh flat and creekbank regions may best be characterized as sources during winter, spring, and summer months, and potential sinks during the fall. The high marsh exhibited the potential to export dissolved total nitrogen throughout the year, whereas, the low marsh flat and creekbank exhibit export potential during spring and summer months. Patterns of total phosphorus exchange were from high marsh, and low marsh regions throughout the year, while exchange between creekbank and surface waters was minimal and temporally variable. Hydrodynamics within each wetland region must be considered in conjunction with pore water chemistry, in order to fully understand nutrient and solute transport potentials.

C. Chemical / Physical

Anderson, I.C., S.C. Neubauer, B.B. Neikirk, and R.L. Wetzel. 1998. Exchanges of carbon and nitrogen between tidal freshwater wetlands and adjacent tributaries. Final Report. Va. Department of Environmental Quality, Coastal resources Management Program. Richmond, Virginia.

ABSTRACT

Tidal freshwater marshes are hypothesized to export materials and energy that support primary and secondary production in estuaries, yet there are few data available to test this hypothesis. A major objective of our study was to measure net exchange of carbon between marsh and atmosphere to determine whether biogenic carbon inputs are in excess of those required to produce observed biomass, satisfy the measured accretion rate, and keep pace with the historical rate of sea level rise. To determine whether the marsh exports materials and energy we measured exchanges of nutrients between marsh sediments and overlying water and of nutrients, total suspended solids, and chlorophyll *a* between the adjacent tidal creek and river. Studies were performed in Sweet Hall Marsh, a National Estuarine Research Reserve, located on the Pamunkey River in Virginia. A gaseous carbon flux model was developed to calculate annual net CO_2 and CH_4 fluxes between the atmosphere and marsh. In addition, we performed seasonal measurements of macrophyte diversity and biomass, sediment microalgal biomass, standing stocks of porewater nutrients, %C and %N in sediments and macrophytes, and sediment gross mineralization and nitrification. Based upon two years of measurements of net ecosystem metabolism, the marsh is net heterotrophic. Estimates of sediment respiration based on net sediment metabolism greatly underestimated the true respiration rate. When gross N-mineralization, expressed in units of carbon, was used as a surrogate for sediment respiration, net autotrophic fixation accounted for estimated biomass production. A process-based carbon mass balance model for Sweet Hall Marsh was constructed to determine whether calculations of carbon exchange using the gaseous carbon flux model and results of exchange studies were reasonable and to guide future research at Sweet Hall Marsh. Results of mass balance analysis showed that inputs and exports of carbon to or from the marsh are reasonably in balance. While additional information on sediment and chlorophyll exchanges would strengthen our model, it appears that on an annual basis Sweet Hall Marsh imports sediments and exports chlorophyll. In addition, the marsh is a sink for NO_3^- throughout the year. NH_4^+ produced by organic matter mineralization appears to be removed by coupled nitrification-denitrification so that there is little, if any, export of dissolved inorganic nitrogen from the marsh. These conclusions indicate that tidal freshwater marshes may export materials (chlorophyll) to adjacent waters, but the ultimate fate of these materials and their effects on estuarine primary and secondary production are still unknown.

Neubauer, S.C. 2000. Carbon Dynamics in a Tidal Freshwater Marsh. PhD. Dissertation, College of William and Mary, Williamsburg, Virginia. 220pp.

ABSTRACT

The sources and fates of carbon in a mid-Atlantic tidal freshwater marsh (Sweet Hall marsh; Pamunkey River, Virginia) were determined to understand the role that tidal freshwater marshes play with respect to estuarine carbon cycling. A carbon gas flux model, based on measured field fluxes of carbon dioxide and methane, was developed to calculate annual rates of macrophyte and microalgal photosynthesis and community and below ground respiration. Because gaseous carbon fluxes out of marsh sediments may underestimate true belowground respiration if sediment-produced gases are transported through plant tissues, gross nitrogen mineralization was used as a proxy for belowground carbon respiration. A mass-balance model of macrophyte-influenced carbon cycling indicated that translocation was critical in controlling seasonal biomass patterns. Annual community respiration exceeded gross photosynthesis, suggesting an allochthonous input of organic carbon to the marsh.

Sediment deposition during tidal flooding was measured as a potential exogenous carbon source. Short term deposition rates (biweekly to monthly) were spatially and temporally variable, with highest rates measured near a tidal creek during summer. Annual deposition on the marsh was sufficient to balance the effects of relative sea level rise and measured respiration. Sediment inventories of ^{7}Be indicated that spatial patterns of sedimentation were not due to sediment redistribution within the marsh. Accretion rates calculated from ^{137}Cs (decadal scale) and ^{14}C (centuries to millennia) were substantially less than annual deposition rates.

The concentration and isotopic composition ($\delta^{13}C$ and $\delta^{18}0$) of dissolved inorganic carbon (DIC) were measured in a marsh creek which drained the study site. Seasonal isotopic variations in DIC were explained by marsh porewater drainage and decomposition of marsh-derived carbon. A model linking DIC concentrations and water transport showed that DIC inputs from the marsh occurred throughout the tidal cycle and, when exported from the marsh, could explain a significant portion of excess DIC production in the York River estuary.

Similarly, the role of the marsh as a source or sink for dissolved and particulate organic carbon (DOC and POC) was assessed. Isotopic mass mixing models indicated seasonal variability in the importance of phytoplankton as a source of dissolved and particulate carbon to a marsh tidal creek. However, due to an overlap in concentration and $\delta^{13}C$ values for marsh and riverine DOC and POC, there was no evidence for a flux of these materials between the marsh and estuary. On an annual basis, the marsh carbon budget was closely balanced, with carbon sources exceeding sinks by approximately 5 percent. This similarity suggests that those processes which were not quantified (DOC and POC export, losses due to consumption by riverine and marsh fauna) were quantitatively unimportant with respect to the entire marsh carbon budget. When integrated over thousands of years, a slight imbalance between sources and sinks can result in significant carbon sequestration under the marsh.

Neubauer, S.C., W.D. Miller, and I.C. Anderson. 2000. Carbon cycling in a tidal freshwater marsh ecosystem: A carbon gas flux study. *Marine Ecology Progress Series* 199: 13 – 30.

ABSTRACT

A process-based carbon gas flux model was developed to calculate total macrophyte and microalgal production, and community and belowground respiration, for a *Peltandra virginica* dominated tidal freshwater marsh in Virginia. The model was based on measured field fluxes of CO_2 and CH_4, scaled to monthly and annual rates using empirically derived photosynthesis versus irradiance, and respiration versus temperature relationships. Because the gas exchange technique measures whole system gas fluxes and therefore includes turnover and seasonal translocation, estimates of total macrophyte production will be more accurate than those calculated from biomass harvests. One limitation of the gas flux method is that gaseous carbon fluxes out of the sediment may underestimate true below ground respiration if sediment-produced gases are transported through plant tissues to the atmosphere. Therefore we measured gross nitrogen mineralization (converted to carbon units using sediment C/N ratios and estimates of bacterial growth efficiency) as a proxy for below ground carbon respiration. We estimated a total net macrophyte production of 536 to 715 g C m^{-2} yr^{-1}, with an additional 59 g C m^{-2} yr^{-1} fixed by sediment microalgae. Below ground respiration calculated from nitrogen mineralization was estimated to range from 516 to 723 g C m^{-2} yr^{-1} versus 75 g C m^{-2} yr^{-1} measured directly with sediment chambers. Methane flux (72 g C m^{-2} yr^{-1}) accounted for 11 to 13% of total belowground respiration. Gas flux results were combined with biomass harvest and literature data to create a conceptual mass balance model of macrophyte-influenced carbon cycling. Spring and autumn translocation and re-translocation are critical in controlling observed seasonal patterns of above and below ground biomass accumulation. Annually, a total of 270 to 477 g C m^{-2} of macrophyte tissue is available for deposition on the marsh surface as detritus or export from the marsh as particulate or dissolved carbon.

Neubauer, S.C. and I.C. Anderson. 2003. Transport of dissolved inorganic carbon from a tidal freshwater marsh to the York River estuary. *Limnology and Oceanography* 48(1): 299 – 307.

ABSTRACT

The cycling of dissolved inorganic carbon (DIC) and the role of tidal marshes in estuarine DIC dynamics were studied in a Virginia tidal freshwater marsh and adjacent estuary. DIC was measured over diurnal cycles in different seasons in a marsh tidal creek and at the junction of the creek with the adjacent Pamunkey River. In the creek, DIC concentrations around high tide were controlled by the same processes affecting whole-estuary DIC gradients. Near low tide, DIC concentrations were 1.5–5-fold enriched relative to high tide concentrations, indicating an input of DIC from the marsh. Similar patterns (although dampened in magnitude) were observed at the creek mouth and indicated that DIC was exported from the marsh. Marsh pore-water DIC concentrations were up to 5 mmol L^{-1} greater than those in the creek and suggested a significant input of sediment pore water to the creek. A model of tidal marsh DIC export showed that, on a seasonal basis, DIC export rates were influenced by water temperature. The composition of exported DIC averaged 19% dissolved CO_2 and 81% HCO_3^- and CO_3^{2-}. Although CO_2 can be lost to the atmosphere during transit through the estuary, DIC in the form of carbonate alkalinity is subject to export from the estuary to the coastal ocean. When extrapolated to an estuarywide scale, the export of marsh-derived DIC to the York River estuary explained a significant portion (47 ± 23%) of excess DIC production (i.e., DIC in excess of that expected from conservative mixing between seawater and freshwater and equilibrium with the atmosphere) in this system. Therefore, CO_2 supersaturation, by itself, does not indicate that an estuary is net heterotrophic.

D. Cultural / Socioeconomic

V. YORK RIVER - MULTIPLE SITES

A. Biological

Batiuk, R., R.J. Orth, K. Moore, P. Heasley, W. Dennison, J.C. Stevenson, L. Staver, V. Carter, N. Rybicki, S. Kollar, R.E. Hickman, and S. Bieber. l992. Submerged aquatic vegetation habitat requirements and restoration goals: A technical synthesis. USEPA Final Report. CBP/TRS 83/92.

Burrell, V.G. 1968. The Ecological Significance of a Ctenophore, *Mnemiopsis leidyi* (A. Agassiz), in a Fish Nursery Ground. Master's Thesis. The College of William and Mary, Williamsburg, Virginia. 62pp.

ABSTRACT

The tentaculate ctenophore, *Mnemiopsis leidyi*, occurred all months of the year in the York River estuary, Virginia. It was present only in higher salinity water (15 ‰ and above) in winter, but in less than 6 ‰ in late summer. Numbers of small plankton, such as copepods and the larvae of annelids, mollusks and barnacles, varied inversely with the volume of ctenophores present at each sampling site. Stomodaeum analyses and feeding experiments confirmed *M. leidyi* as a predator of these plankters. Other feeding experiments indicated that the ctenophore was responsible for 3/4 of the total predation by plankton forms. Plankters exceeding 6 mm in length were not preyed upon.

Most of the fish using this estuary as a nursery ground were large enough before entering infested waters to avoid predation. Young fish in the area subsisted chiefly on items not preyed on by this ctenophore. Another ctenophore, *Beroe ovata*, preyed on the tentaculate form in the summer and fall to such an extent that the tentaculate ctenophores were restricted to areas outside the range of the beroid. The medusa *Chrysaora quinquecirrha* also preyed on the tentaculate form but did not significantly reduce its numbers.

Burton, W.H. 1982. Comparitive Ecology of Two Sympatric Species of Atherinids, *Menidia menidia* and *Membras martinica*. Master's Thesis. The College of William and Mary, Williamsburg, Virginia. 83pp.

ABSTRACT

The trophic interactions, spatial and temporal distributions of *Menidia menidia* and *Membras martinica* in the lower Chesapeake Bay were determined through feeding and vertical distribution experiments, gut content analyses, neuston collections, and beach seining techniques. Feeding experiments and gut content and analyses indicated that *Menidia* > 61 mm ate epibenthic prey and zooplankton, while *Membras* fed exclusively on zooplankton. *Membras* adults and juveniles were abundant in surface mid-bay waters. *Menidia* never occurred offshore, but concentrated in shallow inshore zones at or near the bottom. *Membras* juveniles > 5 mm occurred in large numbers offshore from June through August, 1981. Mid-bay surface waters are believed to be an important nursery area for juvenile *Membras*. Juvenile *Menidia* were absent mid-bay, and appear to inhabit inshore environments. *Membras* catches were much greater in the James than in the York or the Rappahannock drainages. *Menidia* and *Membras* were found to be ecologically separated with respect to food selection, vertical and geographic distribution, and salinity preference.

Causey, M.H. 1984. The Effect of Beaver (*Castor Canadensis*) Dams on the Vegetation of Tidal Marshes. Master's Thesis. The College of William and Mary, Williamsburg, Virginia. 46pp.

ABSTRACT

Beaver (Castor *canadensis*) populations have expanded into Virginia tidal marshes since their reintroduction in the state. The effect that beaver dams have on Virginia's wetland jurisdiction and the change in vegetation found at the dams was investigated. The dams do not alter the jurisdiction of Virginia under the Virginia Wetlands Act, although the dam itself appears to be included in the protection provided wetlands by the Virginia Wetlands Act. The observed vegetation changes coinciding with one dam in a tidal freshwater marsh (Unicorn Creek) and two dams on a brackish marsh (Ware Creek) on the Pamunkey and York Rivers, Virginia, were studied utilizing net production, diversity and species composition. Net production decreased significantly at the 1% level on both brackish and freshwater impounded marshes. Diversity, as measured by the Shannon Weaver diversity index, decreased significantly at the 1% level in the freshwater marsh. In the brackish water marsh the decrease was significant at the 1% level when the vegetation on the second dam was considered the result of beaver activity, rather than the presence of the first dam. Species composition changed in both fresh and brackish water marshes. There is a dearth of conclusive evidence that the dam is the cause of this vegetation change, however, the change in vegetation coinciding with the dam, the data collected from 1939 aerial photographs and comparisons with 1979 inventories of the area empirically lead one to conclude that the dam does cpuse the decrease in diversity, net production and the change in species composition found at the beaver dam.

Cerco, C. and K.A. Moore. 2001. System-wide submerged aquatic vegetation model for Chesapeake Bay. *Estuaries* 24(4): 522 – 534.

ABSTRACT

A predictive model of submerged aquatic vegetation (SAV) biomass is coupled to an eutrophication model of Chesapeake Bay. Domain of the model includes the mainstem of the bay as well as tidal portions of major embayments and tributaries. Three SAV communities are modeled: ZOSTERA, RUPPIA, and FRESHWATER. The model successfully

computes the spatial distribution and abundance of SAV for the period 1985–1994. Spatial distribution is primarily determined by computed light attenuation. Sensitivity analysis to reductions in nutrient and solids loads indicates nutrient controls will enhance abundance primarily in areas that presently support SAV. Restoration of SAV to areas in which it does not presently exist requires solids controls, alone or in combination with nutrient controls. For regions in which SAV populations exist at the refuge level or greater, improvements in SAV abundance are expected within 2 to 10 years of load reductions. For regions in which no refuge population exists, recovery time is unpredictable and will depend on propagule supply.

Dancy, L.M. 1997. Targeting Wetland Preservation Areas for Compensatory Mitigation Utilizing a GIS Protocol. Master's Thesis. The College of William and Mary, Williamsburg, Virginia. 119pp.

ABSTRACT

Compensatory mitigation for unavoidable impacts to wetlands has been met through four methods: creation, restoration, enhancement, and preservation of existing wetlands. While creation, restoration, and enhancement are predominantly permitted due to greater adherence with "no net loss" policies, these options continue to pose questions of equivalency and success. Thus, an increased interest in preservation as a compensatory mitigation option, coupled with a shift in environmental decision-making to a watershed approach, warranted a protocol to target preservation areas within a watershed for compensatory mitigation.

In order to accommodate a decision-making protocol on a watershed scale, a geographic information system (GIS) was utilized for its capability to map and analyze a large geographical area and numerous factors. In addition, GIS provides the means to develop this protocol as an exportable model for applications to other coastal watersheds. Thus, data resources were selected to reflect those accessible to local and statewide decision- makers. The York River watershed in central Eastern Virginia was selected as a case study due to the availability of data resources, its proximity for the field component, and three sites previously preserved through the National Estuarine Research Reserves System (NERRS) with which the protocol could be tested due to similar site-selection criteria.

In an effort to address compensation of wetland functions lost or impaired, the protocol focused on three functions important to society for their environmental and economic benefits-water quality improvement, flood mitigation, and habitat. The opportunity to perform or provide these wetland functions was evaluated by specific landscape attributes such as position in the watershed, the presence or absence of RTE species, and anthropogenic influences, namely point discharge sites, roads, and surrounding land use. A wetland's effectiveness at performing or providing these functions was evaluated by its biological, chemical, and physical properties using wetland type and size. The protocol then allowed for further prioritization of the targeted areas based on the degree of threat. Field visits of priority sites were conducted in October 1997 in order to verify the GIS data where possible and assess additional site characteristics currently unavailable in a GIS format.

With six GIS data coverages, it was possible to develop a protocol with which to target a small number of sites within a watershed for preservation. No sites met the land use criteria due to the York River watershed's undeveloped character. Fourteen of the twenty sites which met all other criteria and closest matched the land use criteria were visited; GIS data were verified and additional site characteristics were noted. While none of the three NERRS sites were identified by the protocol, a close examination of their original selection revealed the emphasis on research potential, which was not a priority for this preservation protocol. In addition, the NERRS sites are predominantly wetland types which were not prioritized through this protocol.

Dennison, W.C., R.J. Orth, K.A. Moore, J.C. Stevenson, V. Carter, S. Kollar, P. Bergstrom, and R.A. Batiuk. 1993. Assessing water quality with submersed aquatic vegetation. *BioScience* 43: 86 – 94.

Feeley, J.B. 1967. The Distribution and Ecology of the Gammaridea (Crustacea: Amphipoda) of the Lower Chesapeake Estuaries. Master's Thesis. The College of William and Mary, Williamsburg, Virginia. 75pp.

ABSTRACT

Investigations were conducted from September 1966 to June 1967 to determine the distribution and ecology of the Gammaridea found in the lower Chesapeake Bay estuaries, emphasis being placed on the James, York, and Rappahannock rivers. A total of 36 species in 27 genera, of which 28 species were personally sampled, is reported on. For six species the area is a southern limit. These are *Cerapus tubularis*, *Leptocheirus plumulosus*, *Listriella barnardi*, *Lysianopsis alba*, *Parametopella cypris*, and *Sympleustes glaber*. This area represents the northernmost known limit for only one species, *Melita fresneli*. A recent literature citation is provided for each species.

Epifaunal species were shown to move up or down the river with changes in salinity resulting from the seasonal oscillation of river discharge. Limiting factors most likely to affect local distribution were found (in decreasing order) to be: salinity, substrate, water temperature, dissolved oxygen concentration, and pollution.

Harsh, D.A. 1995. Filtration of Oysters in Patches: Effects of Water Flow and Seston Composition. Master's Thesis. The College of William and Mary, Williamsburg, Virginia. 101pp.

ABSTRACT

There is increasing evidence that benthic, filter feeding bivalves may control water quality in shallow water, estuarine systems. Small-scale filtration experiments have been used to extrapolate the system level effects of *Crassostrea virginica* on water quality in the Chesapeake Bay. Small-scale experiments do not account for the complex interactions of flow and

seston composition on the filtration rates and feeding behavior of *Crassostrea virginica*. Flume experiments were designed to incorporate variation in flow speed and seston composition over a bed of oysters.

Regularly arrayed patches of 90 oysters were placed within a flume; control arrays were constructed similarly using sealed oyster shells. The diatom, *Thalassiosira weisflogii*, and the diatom with kaolinite were added to a 5-m long recirculating flume. Vertically arrayed seston samplers collected water samples upstream and downstream of the oyster bed. At eight flow velocities (U_∞ ranging from 0.65 to 22 cm sec^{-1}), changes in particle counts between upstream and downstream samplers were used to determine particle removal rates. Samples were analyses for particle concentration and in vivo fluorescence.

Significant differences in filtration rates between experiments were attributed to variation in hydrodynamic and biotic factors. Although there were not significant differences between the filtration rates and the control rates, the filtration rates were greater than the control rates at low flow speeds. Abundant fecal production by the oysters indicated that large amounts of particles were being removed from the water column. It appears that the biotic factors were not of sufficient strength to produce filtration rates that would be significantly greater than flow mediated factors.

Using feces production and shell gape as indicators of feeding activity, there was a positive relationship between oyster feeding behavior and increasing flow speed up to 22 cm sec^{-1}. The feeding behavior of the oysters may also be affected by the health of the oysters within the bed.

Differences in oyster feeding activity between experiments and differences in the flow-mediated effects on particle distribution between replicate control experiments indicate that the effects of oysters in patches on seston dynamics may vary considerable. Improved system-level ecological models, which taken into account flow, particle concentration, particle composition, seston depletion, refiltration, vertical exchange of particles, and the actual number of oyster filtering at anyone time, can yield improved understanding of the materials processing capabilities of oyster reefs.

Hovel, K.A. 1999. The Effect of Seagrass Habitat Fragmentation on Juvenile Blue Crab Survival. PhD. Dissertation, College of William and Mary, Williamsburg, Virginia. 151pp.

ABSTRACT

Habitat fragmentation is increasingly common on land and in the sea) leading to small) isolated habitat patches in which ecological processes may differ substantially from those in larger) continuous habitats. Seagrass is a structurally complex but fragmented subtidal habitat that provides food and serves as a refuge from predation for juveniles of the blue crab) *Callinectes sapidus* Rathbun. The influence of seagrass habitat fragmentation (e.g. patch size) on crab survival is unknown, and is difficult to quantify because seagrass complexity (e.g. shoot density)' and patch size are often confounded and vary temporally: In this study, I compared the effects of eelgrass (*Zostera marina* L.) patch size and shoot density on juvenile blue crab survival and abundance both before (June) and after (September) shoot defoliation and cownose ray disturbance changed eelgrass habitat) and used artificial seagrass to determine the influence of eelgrass patch size on juvenile blue crab survival in the absence of covarying shoot density. I then used the results of these experiments to model the effect of eelgrass fragmentation and loss on juvenile blue crab survival.

Crab survival was inversely correlated with eelgrass patch size in the absence of covarying shoot density) in contrast to patterns typically observed in fragmented terrestrial landscapes; this was likely due to low predator abundance in small patches. Under natural conditions) eelgrass patch size and shoot density both influenced juvenile blue crab survival, but crab survival patterns varied temporally. In June, the effect of fragmentation was non-linear: crab survival, crab density and seagrass shoot density all were lowest in large (3000 m^2), spatially-isolated patches and in unvegetated sediment) and were higher in smaller patches (0.25 and 8 m^2) and in the largest patch (i.e. continuous seagrass: 30,000 m^2). In September) crab survival was low and did not differ among patch sizes. Crab density increased witl1 seagrass shoot density at both times and was greater in September than in June. Crab survival declined from June to September) probably due to density-dependent cannibalism, decreased eelgrass shoot density due to defoliation, or increased habitat fragmentation caused by cownose ray bioturbation. Density-dependent cannibalism likely caused crab survival to decrease with shoot density in September.

The inverse relationship between crab survival and eelgrass patch size suggests that juvenile blue crab survival may be maximized at an intermediate level of seagrass fragmentation, where the negative effects of large patch size and low proportional seagrass cover both are reduced. I tested this hypothesis by modeling the joint effects of patch size and proportional cover on juvenile blue crab survival. When I assumed predation on crabs to be independent of crab density, maximal crab survival (ca. 34%) occurred at intermediate values of seagrass percent cover, However, under the more realistic scenario of density-dependent survival, about 18% of crabs survived irrespective of the proportion of the landscape covered by seagrass.

My findings indicate that (i) effects of habitat fragmentation on survival may differ between seagrass and terrestrial landscapes, (ii) seagrass habitat fragmentation has a significant but not overriding influence on faunal survival, and (iii) seagrass patch size, seagrass complexity, and blue crab density all influence juvenile blue crab survival, but their effects vary temporally. Habitat fragmentation studies should incorporate multiple scales of space and time, as well as potentially confounding environmental variables.

Hypes, S.R. 1999. Sub-Lethal Effects of Hypoxia/Hypercapnia on *Callinectes Sapidus* in the York River Estuary, Virginia. Master's Thesis. Virginia Commonwealth University, Virginia. 52pp.

ABSTRACT

This research examined effects of hypoxic environments on blue crabs, *Callinectes sapidus* in an estuarine environment. Hypoxic conditions were treated as a multiple stressor involving low dissolved oxygen (D.O.), increased carbon dioxide (hypercapnia), and low pH concurrently. The objectives were to: 1) identify hypoxia/hypercapnia by monitoring D.O. and pH as an indicator of hypercapnia in shallow regions of the York River, 2) measure blue crab abundance, and 3) describe blue crab responses to hypoxia/hypercapnia via field work at Taskinas Creek and lab

measurements of respiration. Ambient D.O. and pH were positively correlated in the Taskinas Creek and York River sites (r= .73). Crab abundance (CPUE) was not significantly different among D.O. and pH ranges. It was concluded that hemolymph blood lactate concentration was not considered a good *in situ* biomarker for exposure to hypoxic/hypercapnic conditions. Oxygen uptake was not significantly different between normoxic and hypoxic conditions but was significantly affected by pH.

Kemp, W.M., R. Batiuk, R. Bartleson, P. Bergstrom, V. Carter, C. Gallegos, W. Hunley, L. Karrh, E.W. Koch, J. Landwehr, K. Moore, L. Murray, M. Naylor, N. Rybicki, J.C. Stevenson, and D. Wilcox. 2004. Habitat requirements for submerged aquatic vegetation in Chesapeake Bay: Water quality, light regime, and physical-chemical factors. *Estuaries* 27(3): 363-377.

ABSTRACT

In this paper, we describe an algorithm for calculating habitat suitability for submerged aquatic vegetation (SAV) at any Chesapeake Bay site where monitoring data are available for five water quality variables that govern light availability at the leaf surface. We developed independent estimates of the minimum light required for SAV survival both as a % of surface light passing through water column to the depth of SAV growth, PLWmin, and as a % light reaching leaves through the epiphyte layer, PLLmin. These estimates were obtained by applying, as inputs to this algorithm, statistically derived values for water quality variables that correspond to thresholds for SAV presence. These estimates of PLWmin and PLLmin compared well with the values established from a review of the published literature. Calculations account for tidal range and partition total light attenuation into water column and epiphyte contributions. Water column attenuation is further partitioned into effects of chlorophyll-a, total suspended solids (TSS) and colored dissolved organics. For all water quality monitoring sites in the Bay, we used this algorithm to predict potential SAV presence in areas where calculated light available at plant leaves exceeded PLLmin. In general, these predictions closely matched results of aerial monitoring surveys of SAV distribution. This correspondence between predictions and observations was particularly strong in the mesohaline and polyhaline regions, which contain 75-80 % of all potential SAV sites in the Bay. This SAV habitat assessment algorithm, thus, offers a quantitative tool that uses monitoring data to define recent changes in suitability of sites for supporting SAV growth. Although physical and chemical factors other than light can also limit SAV distribution in both pristine and perturbed coastal sites, the approach described here represents a major improvement in our ability to use water quality monitoring data for quantitative assessment of SAV habitat conditions. This approach has played a central role in the derivation of "water clarity criteria" used for resource management in Chesapeake Bay.

Libelo, E.L. and W.G. MacIntyre. 1992. Groundwater monitoring studies at components of the Chesapeake Bay National Estuarine Research Reserve in Virginia. *In:* [M.P. Lynch and B. Crowder, eds.] Organizing for the Coast. Proceedings of the 13th International Conference of the Coastal Society. Washington, D.C. pp. 629 – 644.

ABSTRACT

The sites of the Chesapeake Bay National Estuarine Research Reserve in Virginia provide a unique opportunity for research on groundwater quality and quantity in shallow aquifers adjacent to the Chesapeake Bay. The ensured availability, protection and relatively undisturbed nature of these sites make them ideal locations for collecting baseline data, and establishing monitoring well networks to provide long-term monitoring of groundwater. Data from these sites can be used to study regional changes in groundwater quality due to acid precipitation, sea level rise and other natural and anthropogenic processes, and for investigation of localized impacts of human activity on groundwater quality throughout the Chesapeake Bay region. Data collected from these sites can also be used to help elucidate the role of groundwater in determining the abundance and distribution of terrestrial and submerged aquatic vegetation, and to estimate the sensitivity of this flora to future perturbations.

Monitoring well networks have been installed at the Goodwin Islands Reserve site at the mouth of the York river subestuary, and at the Catlett Islands Reserve site 19 nautical miles upstream in the mesohaline region. Groundwater samples were collected monthly over one year from Goodwin Islands and over six months from Catlett Islands and analyzed for dissolved nutrients, pH and salinity. Groundwater from Goodwin Islands was also analyzed to determine the possible presence of organic pollutants. Groundwater nutrient loadings at both Goodwin Islands and Catlett Islands were found to be well below those observed at agricultural or residential land use locations in the region. Nitrate, nitrite, ammonium and phosphate concentrations were below 3.0 mg/L and generally below 0.5 mg/L. Salinity of groundwater was highly variable between wells at each site, and showed considerable temporal variation. Observed salinity ranged from 0 to 14 parts per thousand (ppt). The groundwater pH varied between wells from 3.5 to 8. No chlorinated organic compounds were detected at concentrations greater than one part per billion.

Lipcius, R.N., R.D. Seitz, M.S. Seebo, and D. Colón-Carrión. 2005. Density, abundance and survival of the blue crab in seagrass and unstructured salt marsh nurseries of Chesapeake Bay. *Journal of Experimental Marine Biology and Ecology* 319: 69–80.

ABSTRACT

Structured benthic habitats such as salt marshes, seagrass beds and oyster reefs are recognized as critical nurseries for fish, crustaceans and mollusks in coastal and estuarine systems. Yet most estuaries and coastal habitats have extensive, relatively unstructured shallow-water habitats such as subtidal mud and sand flats, which are generally viewed as inconsequential nursery grounds. We tested this paradigm with the blue crab, *Callinectes sapidus* Rathbun, in shallow and deep benthic habitats of the York River, Chesapeake Bay. Juvenile blue crabs (b100 mm carapace width) were sampled quantitatively in deep channel muds (DCM, >2 m depth), in shallow unstructured subtidal mud flats (SMF) and sand flats (SSF) adjoining salt marshes, and in beds of submerged aquatic vegetation (SAV—eelgrass, *Zostera marina*, and

widgeongrass, *Ruppia maritime*) in three river zones (Upriver, Downriver, Mouth) across 60 km of the river axis. Survival of juveniles 25–55 mm carapace width was examined experimentally in all shallow habitats. SAV habitats were examined only at the Mouth zone; SAV did not occur in the Downriver and Upriver zones. Juvenile blue crab density was nearly an order of magnitude lower in SMF and SSF than in SAV habitats; density was lowest in DCM. Density in Upriver SMF and SSF habitats was 4- to 10-fold higher than that in Mouth and Downriver SMF and SSF, and DCM. Consequently, the two areas harboring the greatest fractions of York River juveniles were shallow: Mouth SAV (~50%) and Upriver SMF and SSF (~40%). Upriver expanses of SMF and SSF adjoining extensive salt marshes near the turbidity maximum harbored an approximately equal abundance of juvenile crabs as the downriver SAV beds, despite the density difference. Survival of tethered juveniles was significantly higher in Upriver SMF and SSF habitats than in Mouth SAV, SMF and SSF habitats, despite the lack of structural refuge in SMF and SSF; crabs in Upriver SMF and SSF survived four times as long as crabs in SAV, Mouth SMF and Mouth SSF. We conclude that shallow subtidal mud and sand flats near upriver salt marshes and in marsh coves are vital nursery grounds for the blue crab, and thus warrant conservation and restoration efforts at the level provided to SAV. The production potential of the blue crab and other estuarine species that utilize salt marshes has likely been severely reduced due not only to direct salt marsh destruction, but also due to indirect degradation of shallow subtidal mud and sand flats fringing salt marshes.

Luckenbach, M.W., D.A. Harsh, R. Mann, R.J. Orth, and K.A. Moore. 1995. Filtration by oysters: Interactive effects of water flow, seston composition and filtration rate. VIMS Report. Gloucester Point, Va. 105pp.

McGovern, J.C., and J.E. Olney. 1988. Potential predation by fish and invertebrates on early life history stages of striped bass in the Pamunkey River, Virginia. *Transactions of the American Fisheries Society* 117: 152 – 161.

ABSTRACT

Field surveys in the Pamunkey River, Virginia, indicated that numerous fish and invertebrate predators varied in their spatiotemporal coincidence with eggs and larvae of striped bass *Morone saxatilis* on spawning grounds. In the laboratory, the cyclopoid copepod *Acanthocyclops vernalis* was observed to attack and kill striped bass larvae. In addition, juveniles or adults of satinfin shiner *Notropis analostanus*, spot tail shiner *N. hudsonius*, tessellated darter *Etheostoma olmstedi*, white perch *Morone americana*, striped bass, bluegill *Lepomis macrochirus*, pumpkinseed *Lepomis gibbosus*, channel catfish *Ictalurus punctatus*, and white catfish *I. catus* ate yolk-sac larvae under laboratory conditions. Consumption of larvae by spot tail shiners and satin fin shiners increased with increasing prey density to a maximum observed ingestion of 150 and 81 larvae per predator per hour, respectively. At prey concentrations simulating ambient Pamunkey River conditions (20-100 larvae/m^3), consumption by both species ranged from 0 to 5 larvae/h, but these estimates were considered to be lower limits because prey densities were not maintained during the experiment. In contrast to these laboratory results, neither eggs nor larvae of striped bass were positively identified in guts of field-collected fishes, although various fish species consumed many eggs of the white perch.

McGovern, J.C. and J.E. Olney. 1996. Factors affecting survival of early life stages and subsequent recruitment of striped bass on the Pamunkey River, Virginia. *Canadian Journal of Fisheries and Aquatic* Sciences 53: 1713 – 1726.

ABSTRACT

The relationship between patterns of survival inferred from the back-calculation of juvenile hatch dates was compared with predator densities, egg production, food abundance, and changing environmental conditions during the 1988 and 1989 spawning seasons of striped bass. In 1988, a year of average recruitment, only 22% of the hatch dates occurred during the week of peak spawning when over 65% of eggs were produced. Most of the juveniles hatched late in the spawning season when egg production was declining. In 1989, a year of high recruitment, the temporal distribution of hatch dates more closely followed that of egg abundance, with 34% of the juveniles hatched during the week of peak spawning when 35% of the eggs were produced. Potential fish predators were more numerous during peak spawning in 1988 (61/100 m^3) than during the same period in 1989 (12/100 m^3). Water temperatures were lower during peak spawning in 1988 (16°C) than in 1989 (19°C). Also, prey items for first-feeding larvae decreased the week following peak spawning in 1988. Lower water temperatures and reduced food densities in 1988 may have combined to prolong development of striped bass eggs and larvae, thereby making them more susceptible to elevated predator densities.

Moore, K.A. and J.L. Goodman. 1995. Effects of a polyhaline SAV bed on spatial and temporal variability in water quality. *In:* Toward a Sustainable Coastal Watershed: The Chesapeake Experiment. 1994 Chesapeake Research Conference. pp. 615 – 628.

Moore, K.A., H.A. Neckles, and R.J. Orth. 1996. *Zostera marina* (eelgrass) growth and survival along a gradient of nutrients and turbidity in the lower Chesapeake Bay. *Marine Ecology Progress Series* 142: 247 – 259.

ABSTRACT

Survival of transplanted *Zostera marina* L. (eelgrass), *Z. marina* growth, and environmental conditions were studied concurrently at a number of sites in a southwestern tributary of the Chesapeake Bay to elucidate the factors limiting macrophyte distribution in this region. Consistent differences in survival of the transplants were observed, with no long-term survival at any of the sites that were formerly vegetated with this species but that currently remain unvegetated.

Therefore, the current distribution of *Z. marina* likely represents the extent of suitable environmental conditions in the region, and the lack of recovery into historically vegetated sites is not solely due to lack of propagules. Poor long-term survival was related to seasonally high levels of water column light attenuation. Fall transplants died by the end of summer following exposure to levels of high spring turbidity ($K_d > 3.0$). Accumulation of an epiphyte matrix during the late spring (0.36 to 1.14 g g^{-1} dry wt) may also have contributed to this stress. Differences in water column nutrient levels among sites during the fall and winter (10 to 15 µM dissolved inorganic nitrogen and 1 µM dissolved inorganic phosphates) had no observable effect on epiphyte accumulation or macrophyte growth. Salinity effects were minor and there were no symptoms of disease. Although summertime conditions resulted in depressions in growth, they did not alone limit long-term survival. It is suggested that water quality conditions enhancing adequate seagrass growth during the spring may be key to long-term *Z. marina* survival and successful recolonization in this region.

Moore, K.A., J.L. Goodman, J.C. Stevenson, L. Murray, and K. Sundberg. 1996. Chesapeake Bay nutrients, light and SAV: Relations between variable water quality and SAV recovery in field and mesocosm studies. CB003909-02. 120pp.

Moore, K.A., R.L. Wetzel, and R.J. Orth. 1997. Seasonal pulses of turbidity and their relations to eelgrass (*Zostera marina* L.) survival in an estuary. *Journal of Experimental Marine Biology and Ecology* 215: 115 – 134.

ABSTRACT

The light environment of one Chesapeake Bay tributary where seagrasses have decreased in abundance was described using both continuous and discrete measures of irradiance and related to the growth and survival of transplanted eelgrass *(Zostera marina* L.). After 8 months of continuous growth at an upriver site, a decline and eventual complete loss of eelgrass transplants began during a month long (May-June) period of increased turbidity ($K_d > 3.0$). Transplant loss continued even after light conditions improved *(*$K_d < 2.0$). At a downriver site where there has been some natural seagrass regrowth, the pulse of high turbidity was not as evident and transplants survived. Other than this spring period of high turbidity at the upriver site, the light environments of the two areas were similar with minimum turbidity in January and maximum in the spring and summer. Annual median daily attenuation coefficients (K_d) at the upriver and downriver sites were 1.77 and 1.96, respectively, and were not significantly different ($P = 0.49$). Total downwelling quantum flux at transplant depths of 0.8 m below mean sea level were 2618 and 2556 mol m^{-2} yr^{-1}, or approximately 24.9 and 24.3% of annual solar PAR. The high spring turbidity pulse corresponded to an increase in non-chlorophyll particulate matter. Chlorophyll specific attenuation (K_c) accounted for 6.7-9.0% of K_d in June. Differences in attenuation were greatest in the 400-500 nm spectral region. Therefore, measures of total PAR attenuation can overestimate the usable irradiance available to the macrophytes. Scalar quantum fluxes during the period of elevated turbidity were 2.7 and 13.4 mol m^{-2} d^{-1} at the upriver and downriver sites. The duration and intensity of total PAR measured upriver during this period were insufficient to support eelgrass growth and survival, and below literature estimates for eelgrass community light compensation at in situ temperatures (20-25°C). Therefore late spring, month-long pulses in turbidity, such as measured here can account for the loss of transplanted vegetation and, potentially, explain lack of successful recruitment into formerly vegetated upriver sites.

Moore, K.A., D.J. Wilcox, and R.J. Orth. 1997. Biomass of submerged aquatic vegetation in the Chesapake Bay. EPA/CBP, Annapolis, MD. CB993267-02. 78pp.

Moore, K.A., D. Wilcox, and R.J. Orth. 1998. Analysis of biomass of submersed aquatic vegetation in the Chesapeake Bay 1985-1997. US EPA/CBP. Annapolis, MD. CB993267-02. 57pp.

Moore, K.A., I. Anderson, and B.B. Neikirk. 1998. The role of the littoral zone in regulating water quality within an estuary. Virginia Coastal Resources Managemant Program. Richmond ,Virginia. NA570Z561-01/NA670Z0360-01. 59pp.

Moore, K.A., D.L. Wilcox, and R.J. Orth. 2000. Analysis of abundance of submersed aquatic vegetation communities in the Chesapeake Bay. *Estuaries* 23(1): 115 – 127.

ABSTRACT

A procedure was developed using aboveground field biomass measurements of Chesapeake Bay submersed aquatic vegetation (SAV), yearly species identification surveys, annual photographic mapping at 1:24,000 scale, and geographic information system (GIS) analyses to determine the SAV community type, biomass, and area of each mapped SAV bed in the bay and its tidal tributaries for the period of 1985 through 1996. Using species identifications provided through over 10,000 SAV ground survey observations, the 17 most abundant SAV species found in the bay were clustered into four species associations: ZOSTERA, RUPPIA, POTAMOGETON, and FRESHWATER MIXED. Monthly aboveground biomass values were then assigned to each bed or bed section based upon monthly biomass models developed for each community. High salinity communities (ZOSTERA) were found to dominate total bay SAV aboveground biomass during winter, spring, and summer. Lower salinity communities (RUPPIA, POTAMOGETON, and FRESHWATER MIXED) dominated in the fall. In 1996, total bay SAV standing stock was nearly 22,800 metric tons at annual maximum biomass in July encompassing an area of approximately 25,670 hectares. Minimum biomass in December and January of that year was less than 5,000 metric tons. SAV annual maximum biomass increased baywide from lows of less than 15,000 metric tons in 1985 and 1986 to nearly 25,000 metric tons during the 1991 to 1993 period, while area increased from approximately 20,000 to nearly 30,000 hectares during that same period. Year-to-year comparisons of maximum annual community

abundance from 1985 to 1996 indicated that regrowth of SAV in the Chesapeake Bay from 1985–1993 occurred principally in the ZOSTERA community, with 85% of the baywide increase in biomass and 71% of the increase in area occurring in that community. Maximum biomass of FRESHWATER MIXED SAV beds also increased from a low of 3,200 metric tons in 1985 to a high of 6,650 metric tons in 1993, while maximum biomass of both RUPPIA and POTAMOGETON beds fluctuated between 2,450 and 4,600 metric tons and 60 and 600 metric tons, respectively, during that same period with net declines of 7% and 43%, respectively, between 1985 and 1996. During the July period of annual, baywide, maximum SAV biomass, SAV beds in the Chesapeake Bay typically averaged approximately 0.86 metric tons of aboveground dry mass per hectare of bed area.

Moore, K.A., B. Anderson, and D. Wilcox. 2003. Intensive water quality mapping of nearshore and mid-channel regions of the James River relative to SAV growth and survival using the DATAFLOW surface water quality mapping system. Special Report No. 385 in Applied Marine Science and Ocean Engineering, Gloucester Point, Va. 55p.

Moore, K.A. 2004. Influence of seagrasses on water quality in shallow regions of the lower Chesapeake Bay. *Journal of Coastal Research* 45: 162 – 178.

ABSTRACT

The influence of seagrasses on water quality was investigated seasonally from permanent stations located along transects across vegetated and formerly vegetated sites in shoal regions of the Chesapeake Bay National Estuarine Research Reserve in Virginia. The effect of the seagrass bed on conditions inside compared to outside the bed varied seasonally and could be related to bed biomass and development. During spring (April-June) the rapidly growing seagrass bed was a sink for nutrients, suspended inorganic particles, and phytoplankton, while during the summer, as bed dieback progressed, resuspension and release of nutrients were observed. Reductions in suspended particle concentrations and light attenuation were generally not measurable until bed biomass exceeded 50-100 gdm m^{-2} or 25-50% vegetative cover. During April when nitrate levels in adjacent channel waters were observed to be highest (>10 FM), rapid uptake, equivalent to 48% of nitrogen requirements for seagrass growth, reduced inorganic nitrogen standing stocks 73% within the bed compared to outside of it. An unvegetated site that previously supported seagrass demonstrated little capacity to reduce measurable levels of suspended particles or nutrients, and re-suspension of bottom sediments contributed to higher levels of suspended particle concentrations and turbidity in the unvegetated shallows compared to adjacent waters. The capacity of seagrass beds to improve local water quality conditions, such as turbidity and nutrients, during the spring when suspended particle concentrations are highest may be key to their continued long-term survival in this lower bay region. High levels of spring turbidity, which have been related to seagrass declines in this area, can be mediated by dense seagrass structure, while largely unvegetated areas are unlikely to modify conditions to permit survival of first year recruits or transplants through the summer. Therefore, water quality conditions that are suitable for recovery are likely greater than those required for continued survival of existing seagrass beds. Given this, statistically derived estimates of water quality conditions or habitat requirements that are usually obtained from measurements in areas adjacent to existing seagrass beds should be used with caution. While suitable for predicting the maintenance of existing beds with adequate biomass and structure, they may underestimate the levels needed for restoration and recovery of many currently unvegetated sites.

Moore, K.A., D.J. Wilcox, B. Anderson, T.A. Parham, and M.D. Naylor. 2004. Historical analysis of submerged aquatic vegetation (SAV) in the Potomac River and analysis of bay-wide SAV data to establish a new acreage goal. Final Report for the Chesapeake Bay Program (CB983627-01) 23p.

Moore, K.A. 2004. Development of enhanced water quality mapping systems in the York River. February 2004. Final Report submitted to the Virginia Department of Environmental Quality. VIMS Report.

Olney, J.E., J.D. Field, and J.C. McGovern. 1991. Striped bass egg mortality, production, and female biomass in Virginia Rivers, 1980 – 1989. *Transactions of the American Fisheries Society* 120: 354 – 367.

ABSTRACT

A Lagrangian time-series study of egg abundances of striped bass *Morone saxatilius* in the Pamunkey River in 1987 yielded mortality estimates of 10-91 %/d. Mean daily mortality (68%/d) was incorporated into a model used to estimate annual egg production and female biomass from results of ichthyoplankton surveys conducted on Virginia spawning grounds in the Mattaponi River (1980), Pamunkey River (1980, 1983-1985, 1988-1989), Rappahannock River (1982-1983), and James River (1981, 1983). Annual egg production varied from 2.77 x 10^8 eggs in the Mattapolli River in 1980 to 2.69 x 10^9 eggs in the Pamunkey River in 1988. Results of contemporaneous surveys in 1983 indicated that egg production and biomass estimates were greatest on the Rappahannock and James rivers. Egg production estimates in Virginia are comparable to estimates for the upper Chesapeake Bay region and North Carolina. Our results indicate that an order-of-magnitude increase in female biomass was required to deposit the number of eggs observed during the 10-year period. The occurrence of peaks in juvenile abundance appears unrelated to stock size, because above-average recruitment was observed during years of high and low egg production. A substantial increase in spawning activity on Pamunkey River spawning grounds in 1987-1989 is attributed, in part, to the entry of 1982-1984 year-class females into the spawning population. We conclude that successful 1982-1984 year-classes and the implementation of more stringent fishing regulations have combined to increase present striped bass stocks in Virginia.

Orth, R.J., J.F. Nowak, G.F. Anderson, and J.R. Whiting. 1993. Distribution of submerged aquatic vegetation in the Chesapeake Bay and tributaries and Chincoteague Bay – 1992. Final Report to U.S. EPA, Chesapeake Bay Program, Annapolis, MD. Grant No. CB003909-01. 268 pp.

Orth, R.J., R.A. Batiuk, and J.F. Nowak. 1994. Trends in the distribution, abundance, and habitat quality of submerged aquatic vegetation in Chesapeake Bay and its tidal tributaries: 1971 – 1991. Chesapeake Bay Program, Annapolis, MD. CBP/TRS 137/95. EPA 903-R-95-009. 216 pp.

Orth, R.J., J.F. Nowak, G.F. Anderson, and J.R. Whiting. 1994. Distribution of submerged aquatic vegetation in the Chesapeake Bay and tributaries and Chincoteague Bay – 1993. Final Report to U.S. EPA, Chesapeake Bay Program, Annapolis, MD. Grant No. CB003909-02. 262 pp.

Orth, R.J., M. Luckenbach, and K.A. Moore. 1994. Seed dispersal in a marine macrophyte: Implications for colonization and restoration. *Ecology* 75(7): 1927 – 1939.
ABSTRACT

Seagrasses rely on both vegetative (rhizome elongation) and sexual (seeds) propagation for maintenance of existing beds and colonization of new areas. Yet mechanisms of seed dispersal and survival of seeds in new areas remain poorly described. We conducted seed dispersal experiments in the field and laboratory to better describe seed dispersal characteristics in one species, Zostera marina L. (eelgrass), the dominant seagrass species in the temperate zone of the United States, Japan, and Europe. Seeds were broadcast by hand into unvegetated 5 m diameter plots at three locations over 3 yr (1989—1991) in the York River, Virginia (Chesapeake Bay). These sites had been previously vegetated but were devoid of any vegetation prior to (since 1972) and during the course of the experiments. Resultant seedling distributions closely matched broadcast patterns, with 80% of all seedlings found within the 5 m diameter plots, despite the fact that geophysical processes would appear sufficient to transport seeds greater distances. Wind records for the 2—mo period between seed broadcasting and germination revealed time—averaged wind speeds in excess of 40 km/h on > 12 d in each of the 3 yr and galeforce winds (17 km/h) in 2 of 3 yr. A three—dimensional hydrographic computer simulation model of the York River provided instantaneous current velocity estimates from which maximum bottom shear velocities (u*) in the study area were approximated (flood tide: 1.26 cm/s, ebb tide: 1.20 cm/s). These estimates exceeded the critical erosion threshold (U^*_{crit} = 0.7 cm/s) for Z. marina seeds determined from laboratory flume experiments. We postulate that small—scale topographic features on the bottom (burrows, pits, mounds, ripples) shield the seeds from the flow. Our results suggest that seeds settle rapidly, dispersing only up to a few metres under the influence of currents and become rapidly incorporated into the sediment. The limited dispersal capabilities of seeds underscore the need to address restoration goals and questions of seagrass ecology in the context of landscape—scale distributional patterns and metapopulation analyses.

Orth, R.J., J.F. Nowak, G.F. Anderson, D.J. Wilcox, J.R. Whiting, and L.S. Nagey. 1995. Distribution of submerged aquatic vegetation in the Chesapeake Bay and tributaries and Chincoteague Bay – 1994. Final Report. U.S. EPA. Chesapeake Bay Office, Annapolis MD. 277pp.
ABSTRACT

The distribution of submerged aquatic vegetation (SAV), principally rooted vascular macrophytes, in the Chesapeake Bay, its tributaries, and Chincoteague Bay, was mapped from black-and-white aerial photographs taken during May to October 1994 at a scale of 1:24,000. SAV bed perimeter information was digitized and stored in a computerized database. Ground-truth information was obtained from the United States Geological Survey (USGS) National Center; United States Environmental Protection Agency (USEPA); Maryland Department of Natural Resources (MD-DNR); United States Fish and Wildlife Service (USFWS); Harford Community College, Maryland; Essex Community College, Maryland; Maryland-National Capital Parks and Planning Commission, Patuxent River Park; Ocean Pines Boat Club, Berlin, Maryland; and the School of Marine Science, Virginia Institute of Marine Science, The College of William and Mary. Citizen support via the U. S. Fish and Wildlife Service and the Chesapeake Bay Foundation provided additional ground-truth information.

In a change from previous SAV distribution and abundance reports in this series, SAV distribution data in this report are presented and discussed based on the segmentation scheme adopted by the Chesapeake Bay Program (U.S. EPA, 1983) and described briefly in the Methods section of this report. A new zonation scheme (Upper, Middle, and Lower zones) for Chesapeake Bay, which accommodates the Chesapeake Bay Program segmentation boundaries, was adapted from that used in previous SAV distribution reports (i.e., Orth et al., 1994) and established by Orth and Moore (1982), then modified by Orth et al., (1989). SAV distribution data for the years 1991-1994 are presented using the Chesapeake Bay Program segmentation scheme in order to consistently follow up the recently published EPA report on trends in SAV (Orth et al., 1995), which covers the years 1971-1991 using the same scheme.

The 1991-1993 data were edgematched using ARC/INFO GIS software, as were the 1994 data, in order to bring separately digitized USGS 7.5 minute topographic quadrangle SAV coverages into one unified coverage for the entire Chesapeake Bay (see Methods). Therefore, 1991-1993 SAV distribution data presented in this report reflect edgematching adjustments, and differ from previously published data for these years derived from separate coverages which were not edgematched (i.e., Orth et al., 1992, 1993, and 1994).

Orth, R.J., J.F. Nowak, G.F. Anderson, D.J. Wilcox, J.R. Whiting, and L.S. Nagey. 1996. Distribution of submerged aquatic vegetation in the Chesapeake Bay and tributaries and Chincoteague Bay – 1995. Final Report. U.S. EPA. Chesapeake Bay Office, Annapolis MD. 293pp.

ABSTRACT

The distribution of submerged aquatic vegetation (SAV), principally rooted vascular macrophytes, in the Chesapeake Bay, its tributaries, and the Chincoteague Bay section, was mapped from black-and-white aerial photographs taken during May to October 1995 at a scale of 1:24,000. SAV bed perimeter information was digitized and stored in a computerized database.

SAV distribution data in this report are presented and discussed based on the segmentation scheme adopted by the Chesapeake Bay Program (Flemer et al., 1983) and described briefly in the Methods section of this report. This zonation scheme (Upper, Middle, and Lower zones) for Chesapeake Bay, which accommodates the Chesapeake Bay Program segmentation boundaries, was adapted from that used in previous SAV distribution reports (i.e., Orth et al., 1994) and established by Orth and Moore (1982), then modified by Orth et al., (1989). The 1995 data were edgematched using ARC/INFO GIS software, as were all the historical SAV bed data, in order to bring separately digitized USGS 7.5 minute topographic quadrangle SAV coverages into one unified coverage for the entire Chesapeake Bay (see Methods). Therefore, SAV distribution data presented in this report reflect edgematching adjustments, and differ from previously published data for these years derived from separate coverages which were not edgematched (i.e., Orth et al., 1992, 1993, and 1994).

Orth, R.J., J.F. Nowak, D.J. Wilcox, J.R. Whiting, and L.S. Nagey. 1997. Distribution of submerged aquatic vegetation in the Chesapeake Bay and tributaries and the coastal bays – 1996. Final Report to U.S. EPA, Chesapeake Bay Program, Annapolis, MD. 300 pp.

ABSTRACT

Orth, R.J., J.F. Nowak, D.J. Wilcox, J.R. Whiting, and L.S. Nagey. 1997. Distribution of submerged aquatic vegetation in the Chesapeake Bay and tributaries and the coastal bays – 1997. Final Report. U.S. EPA. Chesapeake Bay Office, Annapolis MD. 351pp.

ABSTRACT

The distribution of submerged aquatic vegetation (SAV), principally rooted vascular macrophytes in the Chesapeake Bay, its tributaries, and the coastal bays of the Delmarva Peninsula, was mapped from 1,728 black and white aerial photographs. These were taken between May and October 1997, at a scale of 1:24,000, encompassing 141 flight lines covering 1,808 miles of shoreline.

Orth, R.J., J.F. Nowak, D.J. Wilcox, J.R. Whiting, and L.S. Nagey. 1998. Distribution of submerged aquatic vegetation in the Chesapeake Bay and tributaries and the coastal bays – 1998. Final Report. U.S. EPA. Chesapeake Bay Office, Annapolis MD. 370pp.

ABSTRACT

The distribution of submerged aquatic vegetation (SAV), principally rooted vascular macrophytes in Chesapeake Bay, its tributaries, and the coastal bays of the Delmarva Peninsula, was mapped from 1,987 black and white aerial photographs. These were taken between May and October 1998, at a scale of 1:24,000, encompassing 169 flight lines covering 2,290 miles of shoreline.

Orth, R.J., D.J. Wilcox, L.S. Nagey, J.R. Whiting, and J.R. Fishman. 2000. 1999 Distribution of submerged aquatic vegetation in the Chesapeake Bay and coastal bays. Final Report. U.S. EPA. Chesapeake Bay Office, Annapolis MD. http://www.vims.edu/bio/sav/sav99.

ABSTRACT

The distribution of submerged aquatic vegetation (SAV) in Chesapeake Bay, its tributaries, and the coastal bays of the Delmarva Peninsula, was mapped from 1,857 black and white aerial photographs. These were taken between May and October 1999, at a scale of 1:24,000, encompassing 160 flight lines covering 2,135 miles of shoreline.

Orth, R.J., D.J. Wilcox, L.S. Nagey, J.R. Whiting, and J.R. Fishman. 2001. 2000 Distribution of submerged aquatic vegetation in the Chesapeake Bay and coastal bays. Final Report. U.S. EPA. Chesapeake Bay Office, Annapolis MD. http://www.vims.edu/bio/sav/sav00.

ABSTRACT

The distribution of submerged aquatic vegetation (SAV) in Chesapeake Bay, its tributaries, and the coastal bays of the Delmarva Peninsula, was mapped from 2,033 black and white aerial photographs. These were taken between May and October 2000, at a scale of 1:24,000, encompassing 173 flight lines covering 2,340 flightline miles of shoreline.

Orth, R.J., J.R. Fishman, A. Tillman, S. Everett, and K.A. Moore. 2001. Boat scar effects on SAV in Virginia (Year 1). Final Report VMRC. http://vims.edu/bio/sav/Boat_scarring Year_1_final_report.pdf.

Orth, R.J., D.J. Wilcox, L.S. Nagey, A.L. Tillman, and J.R. Whiting. 2002. 2001 Distribution of submerged aquatic vegetation in the Chesapeake Bay and coastal bays. Final Report. U.S. EPA. Chesapeake Bay Office, Annapolis MD. http://www.vims.edu/bio/sav/sav01.

ABSTRACT

The distribution of submerged aquatic vegetation (SAV) in Chesapeake Bay, its tributaries, and the coastal bays of the Delmarva Peninsula, was mapped from 1,820 black and white aerial photographs. These were taken between May and October 2001, at a scale of 1:24,000, encompassing 159 flight lines covering 3,343 flight line kilometers.

Orth, R.J., D.J. Wilcox, J.R. Fishman and K.A. Moore. 2002. Quality assurance project plan for the 2001 submerged aquatic vegetation distribution and abundance survey of Chesapeake Bay, its tributaries and the Delmarva Coastal Bays. VIMS Report.

Orth, R.J., D.J. Wilcox, L.S. Nagey, A.L. Owens, J.R. Whiting, and A. Serio. 2003. 2002 Distribution of submerged aquatic vegetation in the Chesapeake Bay and coastal bays. Final Report. U.S. EPA. Chesapeake Bay Office, Annapolis MD. http://www.vims.edu/bio/sav/sav02.

ABSTRACT

The distribution of submerged aquatic vegetation (SAV) in Chesapeake Bay, its tributaries, and the coastal bays of the Delmarva Peninsula, was mapped from 2,324 black and white aerial photographs. These were taken between June and November 2002, at a scale of 1:24,000, encompassing 193 flight lines covering 4,318 flight line kilometers.

Orth, R.J., D.J. Wilcox, L.S. Nagey, A.L. Owens, J.R. Whiting, and A. Serio. 2004. 2003 Distribution of submerged aquatic vegetation in the Chesapeake Bay and coastal bays. Final Report. U.S. EPA. Chesapeake Bay Office, Annapolis MD. http://www.vims.edu/bio/sav/sav03.

ABSTRACT

The distribution of submerged aquatic vegetation (SAV) in Chesapeake Bay, its tributaries, and the coastal bays of the Delmarva Peninsula, was mapped from black and white aerial photographs. These were taken between May and November 2003, at a scale of 1:24,000, encompassing 193 flight lines. In addition, color aerial photography acquired by St. Mary's County, Maryland and the Metro Washington Council of Governments provided coverage for sections of the lower Potomac River.

Orth, R.J. and K.A. Moore. 2004. Restoration of seagrasses in Virginia Coastal Bays. Final Report to the Virginia Coastal Program. Virginia Department of Environmental Quality, Richmond Va. February 13, 2004. 14p.

Orth, R.J., J. Bieri, J.R. Fishman, M.C. Harwell, S.R. Marion, K.A. Moore, J.F. Nowak, J. van Montfrans. 2005. A review of techniques using adult plants and seeds to transplant eelgrass (*Zostera marina* L.) in Chesapeake Bay and the Virginia Coastal Bays. Proc. Conf. Seagrass Restoration: Success, Failure, and the Costs of Both. March 11, 2003. Sarasota, Florida.

ABSTRACT

In many areas of the Chesapeake Bay region, including the coastal bays of the Delmarva Peninsula, eelgrass (*Zostera marina* L.) is much less widespread today than in the past due to the eelgrass wasting disease in the 1930s and the more general seagrass population decline in the 1970s in Chesapeake Bay resulting from increasing nutrients and sediments entering the bays' watershed. In 1978, an experimental eelgrass restoration program was initiated in lower Chesapeake Bay as part of a larger research effort on the biology and ecology of eelgrass beds. In this paper we provide an overview of both manual and mechanized techniques we have used in efforts to restore eelgrass at a number of different locations using either adult plants or seeds, highlighting the importance of the timing of transplanting, use of fertilizer, labor requirements, and initial success. Much of the earliest transplant work was conducted in a variety of locations with different vegetation histories and water quality characteristics to facilitate addressing questions related to growth and habitat requirements.

We found that planting eelgrass in fall rather than spring was optimal because plants had a longer growing period to become established. Addition of fertilizer to transplants increased plant density but did not enhance the long-term survival. Techniques utilizing adult plants (e.g., mesh mats with bare rooted shoots, sods and cores of seagrass and sediment, bundles of bare root shoots with anchors, single shoots without anchors) were generally successful, with the manually planted single shoot method being both successful and requiring the least time. Mechanized planting with a planting boat had lower initial planting unit survivorship and did not result in significant savings of time. Techniques using seeds (e.g., peat pots, seed broadcasting, burlap bags to protect seeds) rather than adult plants had varying degrees of success with highest seedling establishment noted where seeds were protected in burlap bags. Current issues with seeds deal primarily with the low survival rate of seeds (generally between 5 and 10% of seeds establishing as seedlings in field experiments). However, broadcast of seeds is one of the least labor-intensive techniques used to date in our program and is currently proving successful in restoring eelgrass to Virginia's seaside coastal bays that have been unvegetated since the 1930s pandemic wasting disease.

Orth, R.J., D.J. Wilcox, L.S. Nagey, A.L. Owens, J.R. Whiting, and A.K. Kenne. 2005. 2004 Distribution of submerged aquatic vegetation in the Chesapeake Bay and coastal bays. Final Report. U.S. EPA. Chesapeake Bay Office, Annapolis MD. http://www.vims.edu/bio/sav/sav04.

ABSTRACT

The distribution of submerged aquatic vegetation (SAV) in Chesapeake Bay, its tributaries, and the Maryland and Virginia coastal bays of the Delmarva Peninsula, was mapped from black and white aerial photographs. These were taken between May and December 2004, at a scale of 1:24,000, encompassing 173 flight lines. In addition, color aerial photography acquired by Air Survey Inc. provided coverage for sections of the upper Potomac River.

Perry, J.E. 1992. Temporal and spatial changes in plant diversity in Chesapeake Bay tidal wetlands: Management implications. *In:* [M.P. Lynch and B. Crowder, eds.] Organizing for the Coast. Proceedings of the 13th International Conference of the Coastal Society. Washington, D.C. pp. 619 – 625.

ABSTRACT

Vegetation composition of tidal marshes plays an important role in Chesapeake Bay wetlands. In general, plants provide wildlife habitat, help water quality, provide erosion and flood control, and are important as a carbon-based food source. Since different plants may provide different functions, change in the composition of the vegetation may alter the function that a particular wetland may provide an estuarine ecosystem. Management objectives of wetlands are oriented toward protecting the functions of a wetland valuable to our society. Since little is known of the probability of occurrence, cause or extent of these vegetation changes, or the role they may play in estuarine wetland functions, management planning for these areas becomes difficult. A long-term study is underway to quantitatively assess changes in vegetation patterns in the tidal wetlands of the Chesapeake Bay. Changes in each site can then be quantified and used to indicate long-term trends by comparing year-to-year data. By better understanding long-term vegetation trends, long-term management planning may become possible.

Perry, J.E. and R.B. Atkinson. 1997. Plant diversity along a salinity gradient of four marshes on the York and Pamunkey Rivers in Virginia. *Castanea* 62(2): 112 – 118.

ABSTRACT

Diversity of emergent wetland plant species was measured in four tidal marshes on the York and Pamunkey Rivers, Virginia. Each marsh represented a different salinity regime (polyhaline, mesohaline, oligohaline, or tidal freshwater). The tidal freshwater marsh had the highest species diversity index of the sites. However, the next highest diversity index was seen in the marsh with the highest salinity, possibly due to an obligate halophytic component absent from the other sample plots. Facultative halophytes dominated the polyhaline, mesohaline, and oligohaline marshes. No similarity existed between the dominant flora of the tidal freshwater marsh and that of the other three marshes.

Ralph, P.J., S.M. Polk, K.A. Moore, R.J. Orth, and W.O. Smith. 2002. Operation of the xanthophyll cycle in the seagrass *Zostera marina* in response to variable irradiance. *Journal of Experimental Marine Biology and Ecology* 271: 189 – 207.

ABSTRACT

Changes in the photobiology and photosynthetic pigments of the seagrass *Zostera marina* from Chesapeake Bay (USA) were examined under a range of natural and manipulated irradiance regimes. Photosynthetic activity was assessed using chlorophyll-a fluorescence, and photosynthetic pigments were measured by HPLC. Large changes in the violaxanthin, zeaxanthin, and antheraxanthin content were concomitant with the modulation of non-photochemical quenching (NPQ). Photokinetics (Fv/Fm, rapid light curves (RLC), and non-photochemical quenching) varied as a result of oscillating irradiance and were highly correlated to xanthophyll pigment content. Zeaxanthin and antheraxanthin concentrations increased under elevated light conditions, while violaxanthin increased in darkened conditions. Unusually high concentrations of antheraxanthin were found in *Z. marina* under a wide range of light conditions, and this was associated with the partial conversion of violaxanthin to zeaxanthin. These results support the idea that xanthophyll intermediate pigments induce a photoprotective response during exposure to high irradiances in this seagrass.

Schultz, G.E. 1999. Bacterial Dynamics and Community Structure in the York River Estuary. PhD. Dissertation, College of William and Mary, Williamsburg, Virginia. 171pp.

ABSTRACT

Bacterial community dynamics were investigated over seasonal and basin scales within the York River, VA estuary. Various parameters characterizing bacterioplankton dynamics were measured weekly at a single station (March 1996 through May 1997) and monthly at six stations June 1996 through May 1997) spanning the entire salinity gradient (0- ca. 20 psu over 60 km). Bacterial abundance and production were found to be high throughout the estuary. Bacterial abundance ranged from 4.4×10^8 to 1.3×10^{10} cells-liter^{-1}. Incorporation of ^{3}H-thymidine ranged from 10 to 863 pmol-liter^{-1}–h^{-1} while ^{3}H-leucine incorporation rates ranged from 25 to 1963 pmol-liter^{-1}–h^{-1}. Clear seasonal trends were apparent. The highest values of abundance and incorporation were found during the summer warm-water months. On a basin scale, bacterial properties were strongly related to changes in salinity. Bacterial properties were not related to phytoplankton biomass or production.

Although there is a great deal of variability from month to month, two opposing trends were consistently found: bacterial abundance increased from freshwater to the mouth of the river, while incorporation rates decreased from freshwater to the mouth. These patterns imply a strong landward gradient in specific growth rates. Growth rates determined

by a two-dimensional box model were indeed higher upstream, but net growth rates were highest near the mouth. This explains how biomass can accumulate downstream even though production decreases.

We also used the box-model to investigate the role of physical dispersion in the distribution of bacterial cells. Growth and removal rates were generally greater than dispersion rates, indicating the relative importance of biological processes in the distribution of bacterial cells within the estuary. BIOLOG plates were used to determine if differences in bacterial community structure or metabolic capabilities occurred over time or space. Two distinct bacterial communities separated by temperature were found over the course of a year at the VIMS pier. Four distinct communities separated by temperature and salinity were found over the course of a year along the salinity gradient.

Thus, temperature, salinity and removal processes are the dominant processes controlling bacterial dynamics in the York River estuary.

Schwarzschild, A.C., W.G. MacIntyre, K.A. Moore, and E.L. Libelo. 1994. *Zostera marina* L. growth response to atrazine in root-rhizome and whole plant exposure experiments. *Journal of Experimental Marine Biology and Ecology* 183: 77 – 89.

ABSTRACT

Atrazine (2-chloro-4-[ethylamino]-6-[isopropylamino-]-s-triazine), a triazine herbicide, is one of the most widely used herbicides in the Chesapeake Bay watershed. Increased use of atrazine in the 1970s coincided with a decline in the abundance of *Zostera marina* L. (eelgrass). Ground-water surveys have found atrazine in concentrations that may affect eelgrass growth and survival. The effects of atrazine in groundwater discharges on the growth of eelgrass through root-rhizome exposure were examined in laboratory systems. A long term, dynamic, groundwater simulation study was conducted with atrazine concentrations ranging from 0.0 to 2.5 $mg \cdot l^{-1}$. No significant effects on chlorophyll content, growth or survival were detected. A static root-rhizome exposure experiment was conducted using split chamber exposure systems to verify these results, atrazine concentrations were increased by an order of magnitude. Neither mortality nor significant effects on plant growth were detected (maximum atrazine concentration 7.6 $mg \cdot l^{-1}$). A static, whole plant exposure experiment was conducted, and mortality was observed at atrazine concentrations of 1.9 $mg \cdot l^{-1}$ and above. This work suggests that eelgrass is not susceptible to atrazine through root-rhizome uptake, and that atrazine exposure via groundwater seepage did not cause the declines in eelgrass abundance and distribution.

Seitz, R.D., R.N. Lipcius, and M.S. Seebo. 2005. Food availability and growth of the blue crab in seagrass and unvegetated nurseries of Chesapeake Bay. *Journal of Experimental Marine Biology and Ecology* 319: 57 – 68.

ABSTRACT

Variation in habitat quality and resource availability can affect the distribution and growth of animals. Thin-shelled clams dominate many benthic communities in Chesapeake Bay, both in numbers and in biomass, and they can comprise up to 50% of the blue crab (*Callinectes sapidus*) diet. Our objective was to determine which habitats were optimal for juvenile crab growth and how growth related to food availability. We experimentally examined benthic infaunal food availability (primarily bivalves) and concurrent growth of juvenile blue crabs at 30–40 sites along 50 km of the York River during fall 2000 and spring 2001. Each year, 4–10 replicate sites along the York River were established in each of five habitats: (1) Seagrass, (2) Mud at the river mouth, (3) Sand at the river mouth, (4) Mud upriver, and (5) Sand upriver. Food availability inside and outside of 0.43-m2 crab growth cages was examined, along with crab growth after 3–6 months inside cages. In both years, after 3–6 months, the Baltic clam, *Macoma balthica*, was abundant inside and outside the cages, whereas the soft-shell clam, *Mya arenaria*, was only abundant inside cages. Densities of *Macoma* were greatest in upriver mud and sand, while those of *Mya* were greatest in upriver sand. Crab growth was significantly greater in spring-summer than fall-winter and was significantly higher in upriver mud and sand, where clam densities were highest, than at the river mouth. The upriver region was near the turbidity maximum, which may enhance pelagic and benthic productivity and thereby provide more food for clams and therefore for blue crabs. Crab growth in seagrass was intermediate between that upriver and at the mouth, suggesting that upriver, unvegetated, subtidal habitats adjacent to salt marshes serve as valuable nursery habitats rivaling seagrass beds.

Virginia Institute of Marine Science. 1997. York River Colloquy. 55pp.

ABSTRACT

The York River watershed extends from the piedmont across the coastal plain of Virginia, covering approximately 2,661 square miles. Over the 120 mile distance from headwaters in Orange County to the mouth at Chesapeake Bay, surface waters pass through a wide variety of landuses dominated by forestry and agriculture. The York River itself is formed by the convergence of the Mattaponi and Pamunkey Rivers at West Point, Virginia.

The Virginia Institute of Marine Science/School of Marine Science of the College of William and Mary is situated on the shore of the York River at Gloucester Point. From this vantage it logical that VIMS would make the York River system the focus of much of its research effort to understand coastal and estuarine systems. Over its 57 year history, VIMS has grown from a fisheries laboratory into a multi-disciplinary institution which today is the largest laboratory in the country focused on coastal and estuarine sciences.

The 1997 York River Colloquy is intended to provide an overview of some of the ongoing activities conducted by VIMS scientists in the York River system. This collection of project summaries in not exhaustive, but it does provide a means to identify the interests of various investigators. This snapshot of the longer-term effort is intended to convey both the breadth and depth of VIMS' interests in the York system, and to provide a stimulus to future collaboration among researchers.

Watts, B.D. and M.A. Byrd. 1994. Status and distribution of colonial waterbirds in Coastal Virginia. Submitted manuscript. 17pp. + appendix.

ABSTRACT

During the breeding season of 1993, we coordinated a survey of Virginia's Coastal Plain for all colonial waterbird species. A combination of both aerial and ground counts were used to locate and survey active colonies. Twenty-four species were encountered distributed among 446 colonies. An estimated 94,947 breeding pairs were surveyed. Laughing Gulls were the most abundant species (>45,000) followed by Great Blue Herons (>9,000), Herring Gulls (>8,800), Common Terns (>6,700), and Royal Terns (> 6,200). All of the remaining 19 species combined accounted for less than 20% of the total. The barrier island/lagoon system of the Eastern Shore was found to be the most significant geographic region for colonial species, accounting for >50% of all colonies and >70% of all breeding pairs. This region was the dominant area for 75% of all species detected. Other regions were of importance to specific species or species groups. Comparison to broad surveys of the mid 1970's shows a greater than 70% increase in collective population estimates and 100% increase in the number of colonies detected. Differences are likely due to a combination of greater survey coverage, selected population increases, and recent colonization events. Recent population trends for individual species varied from negative to positive to relatively stable depending on the species.

Wesson, J.A., R.J. Orth, J. van Montfrans, K.A. Moore, and M.W. Luckenbach. 2000. Seagrass and oyster habitat restoration: Implications for enhancement of water quality and abundance of commercially and recreationally important finfish and shellfish. Final Report. The Virginia Coastal Resources Management Program, Va. Department of Environmental Quality. Richmond, VA.

Zacherle, A.W. 1984. A Method for Evaluating the Long-term, Cumulative Impacts of Tidal Marsh Alterations: The York River System – A Case Study. Master's Thesis. The College of William and Mary, Williamsburg, Virginia. 197pp.

ABSTRACT

This study describes a methodology for evaluating the long-term, cumulative impacts of alterations to the marshes of Virginia's tidal river systems. The methodology is designed to quantitatively evaluate the tidal marshes along a given river system for the five valuable properties or "functions" of marshes recognized in the Virginia Wetlands Guidelines: production and detritus availability; waterfowl and wildlife utilization; erosion protection; flood protection; and water quality. Each marsh is evaluated based on specific criteria which determine its ability to perform each function, and is assigned quality points which reflect its relative value for each function. The quality points assigned for each function for each marsh are added together to arrive at a total value for the functions of the marshes in each county along the river system and the river system itself. This number will be used as a baseline from which the impacts of all future tidal marsh alterations can be determined. As an example of the application of this methodology, the tidal marshes along the York River System were evaluated. The potential loss in value of the functions available to the system caused by the construction of the proposed Ware Creek Reservoir were then determined.

B. Geological

Dellapenna, T.M. 1998. Fine-scale Formation in Biologically and Physically Dominated Estuarine Systems within the Lower Chesapeake and York River Subestuary. PhD. Dissertation, College of William and Mary, Williamsburg, Virginia. 273pp.

ABSTRACT

To investigate the relationship between biological and physical mixing in forming strata, two systems have been used for comparison, the lower mainstem of Chesapeake Bay and the York River Subestuary. Within the lower Chesapeake Bay two sites were selected as biologically dominated, both are located within the bay stem plains and are characterized by muddy sand and an abundance of large, deep-dwelling organisms. X-radiographs indicate extensive biological reworking of sediments, with no long-term preservation of physical stratification. ^{210}Pb profiles reveal low sediment accumulation rates within the mainstem sites (<0.1 cm y^{-1}), but significant differences in biological mixing depths (25 vs 40 cm) and biodiffusivity (>80 vs 6-30 cm^3 y^{-1}).

Within the upper York River, transient, longitudinal erosional furrows regularly form within a broad flat portion of the river which comprises a partially filled paleochannel. Varying furrow morphologies were observed depending on tidal flow, ranging from: 1) no furrows during the higher flow conditions of spring tide; to 2) large patches of meandering furrows as the mean f1ow decreases; to 3) large, widely spaced (5- 7 m), linear furrows with smaller furrows filling the space between the larger furrows, within a day of neap tide; to 4) uniform, linear, closely spaced (-0.7 m) furrows during the lowest mean current conditions of neap tide. A 35 month time series using kasten cores reveals that although the furrows produce mixing on the 25 cm depth scale on a fortnightly time frame, a signal of mixing exists on the 100 cm depth scale on the annual to interannual time frame which is unrelated to the formation of erosional furrows.

The seabed throughout most of the energetic, microtidal York River is characterized by deep mixing with depths ranging from 25-200cm. Throughout the entire river, one side, including the channel, flank and shoal, is dominated by high rates of short-term deposition and physical mixing, the other flank and shoal is dominated by biological mixing and is primarily either non-depositional or erosional. Below Gloucester Point, the north side of the river is dominated by physical processes, above Gloucester Point, the south side is physically dominated. Within the physically dominated side of the river, the mixed layer is characterized by ^{210}Pb profiles with one or more segments of nearly uniform excess activity. X-

radiographs reveal that although bioturbation exists, much of the mixed layer is comprised of centimeter to decimeter-scale units of finely to coarsely laminated strata bounded by hiatal surfaces, demonstrating that mixing results primarily from erosion, resuspension, and deposition, The benthos in the York River are generally comprised of a depauperate community of small opportunistic species, there is a paucity of larger macrofuuna. As a result, mixing in the biologically dominated side of the river is generally restricted to depths <40 cm, ^{210}Pb geochronologies yield low biodiffusion rates (1-3 cm^2y^{-1}) and x-radiographs reveal the presence of some laminations suggesting that although the mixing is controlled by biological process the mixing intensity is low relative to the lower Bay sites.

Based on ^{210}Pb geochronologies, residence time estimates for particles within the York River mixed layer are on the order of centuries. The volume and mass of sediments in the physically mixed layer is equivalent to 70 years of river sediment yield. This is consistent with the century scale residence times from core data, suggesting that the sediment within the upper seabed are cycled through the environment on the century time frame.

Herman, J.D. 2001. Sediment Budgets, Estuarine Sediment Loads, and Wetland Sediment Storage at Watershed Scales, York River Watershed, Virginia. PhD. Dissertation. The College of William and Mary, Williamsburg, Virginia. 158pp + appendices.

ABSTRACT

Three separate but related aspects of sediment allocation in a river/estuarine system were examined. The main purpose was to compare sediment budgets for a series of eleven nested sub-watersheds as a function of watershed size, ranging from 65 to 6,900 km^2. The approach quantified six budget components: upland erosion; stream bank erosion; colluvial storage; wetland storage; stream channel erosion and storage; and sediment flux at the outlets. Three budgets were developed for each sub-watershed to examine the relative proportions of budget components, budget sensitivity (the influence of individual components on the overall budget), and the uncertainty of budget components. The study area was the rural, forested, low relief York River watershed in southeastern Virginia.

The relative proportions of budget components do not change with a 10^2 increase in sub-watershed size. Budgets are more influenced by the tributary system than by the sub-watershed size. The budget is sensitive to most components because they are large in size and are highly variable. The uncertainties of budget components are proportional to the size of the best estimates. Management efforts should focus on locally-derived material to improve water quality because little sediment from the upper parts of the watershed reaches the estuary.

Sediment loads were needed in the sediment budgets for three estuarine sampling stations. The loads were estimated by separating the gravitational circulation, tidal pumping, and river input components of the long-term total suspended solids data. The load for the station closest to the river mouth was somewhat larger than literature values. The contribution to the estuary of the two tributary stations was previously unknown. Tidal pumping, rather than gravitational circulation, is the dominant process moving suspended sediment up the estuary.

The potential supply and storage of sediment in wetlands at the watershed level was examined by quantifying the areal extent of wetland type and location in the watershed, and surrounding land use, slope, and soil type. Results showed that these landscape characteristics are unevenly distributed within the York River watershed and its subdivisions. The differences in landscape characteristics between subdivisions support the hypothesis that wetland performance and its impact on water quality may vary within a watershed. The results also identify regions where research and management strategies should focus. Separate management approaches may be needed to accommodate the differences in subdivisions.

C. Chemical / Physical

Raymond, P.A. and J.E. Bauer. 2000. Bacterial consumption of DOC during transport through a temperate estuary. *Aquatic Microbial Ecology* 22: 1 – 12.

ABSTRACT

Bacterial utilization of natural levels of dissolved organic carbon (DOC) was measured in the York River estuary, a sub-estuary of the Chesapeake Bay. This study was undertaken in order to elucidate spatial and temporal changes in bacterial carbon utilization and to evaluate its importance as a pathway for organic matter transformation in estuaries. Multiple pools of DOC were defined based on decomposition kinetics. The first pool (G_1) made up a mean of 2.8% of total DOC and had turnover times of ≤5 d. The second pool (G_2) comprised an average of 4.9% of total DOC and had turnover times of ~1 mo. Our data indicate that although the total amount of DOC utilized was low, there was a continual supply of both the G_l and G_2 fractions within the estuary. Bacterial growth efficiency on the G_l pool averaged 28%. The production of CO_2 through bacterial respiration of the G_l pool could not balance CO_2 evasion for the majority of the estuary. Bacterial DOC degradation in the York River estuary was limited by temperature for the majority of the year. This temperature constraint coupled with relatively short hydrologic residence times resulted in the export of labile DOC from the estuary prior to complete bacterial decomposition. We estimate that ~10% of the riverine DOC exported annually from estuaries to the mid-Atlantic Bight (MAB) is a labile fraction of DOC that is not utilized within the estuaries due to temperature constraints on estuarine bacteria. This DOC is not inherently recalcitrant and is an allochthonous source of labile DOC for the coastal Mid-Atlantic Ocean.

Raymond, P.A. and J.E. Bauer. 2000. Atmospheric CO_2 evasion, dissolved inorganic carbon production, and net heterotrophy in the York River estuary. *Limnology and Oceanography* 45: 1707 – 1717.

ABSTRACT

Direct measurements of the partial pressure of CO_2 (pCO_2) and dissolved inorganic carbon (DIC) were made over a 2-yr period in surface waters of the York River estuary in Virginia. The pCO_2 in surface waters exceeded that in the

overlying atmosphere, indicating that the estuary was a net source of CO_2 to the atmosphere at most times and locations. Salinity-based DIC mixing curves indicate there was also an internal source of both DIC and alkalinity, implying net alkalinity generation within the estuary. The DIC and alkalinity source displayed seasonal patterns similar to that of pCO_2 and were reproducible over a 2-yr study period.

We propose that the source of inorganic carbon necessary for both the sustained CO_2 evasion to the atmosphere and the advective export of DIC is respiration in excess of primary production (e.g.. net heterotrophy). The rates of CO_2 evasion and DIC export were estimated to provide an annual rate of net heterotrophy of ~100 g C m^{-2} yr^{-1}. Approximately 40% of this excess inorganic carbon production was exported as DIC to the coastal ocean, whereas 60% was lost as CO_2 evasion to the atmosphere. The alkalinity generation needed to sustain the export of inorganic carbon, as HCO_3^- is most likely provided by net sulfate reduction in sediments. Accumulation of sulfide in the sediments of a representative site directly adjacent to the York River estuary is sufficient to account for the net export of alkalinity. The seasonality of net heterotrophy causes large variations in annual CO_2 and DIC concentrations, and it stresses the need for comprehensive temporal data sets when reporting annual rates of CO_2 evasion, DIC advection, and net heterotrophy.

Raymond, P.A. and J.E. Bauer. 2001. Use of ^{14}C and ^{13}C natural abundances for evaluating riverine, estuarine, and coastal DOC and POC sources and cycling: A review and synthesis. *Organic Geochemistry* 32: 469 – 485.

ABSTRACT

Though not typically regarded as "biomarkers" in the traditional sense of the word, the radioactive and stable isotopes of carbon (^{14}C and ^{13}C, respectively) can serve as powerful tools for identifying sources and estimating turnover times of organic matter in aquatic systems. Paired ^{14}C and ^{13}C measurements of carbon pools can provide an additional degree of specificity for studies of organic matter cycling as a result of: (1) the lower susceptibility of natural isotopes to diagenetic effects that can alter organic biomolecules; (2) the "dual" isotopic nature of the approach; (3) the unique input functions for each isotope; and (4) the greater dynamic range in $\Delta^{14}C$ (-1000 to ~ + 200‰) compared to $\delta^{13}C$ (~-32 to –12‰). Relatively few geochemical studies in rivers, estuaries and the coastal ocean waters have employed ^{14}C and ^{13}C analyses of organic matter. In this paper we summarize the available data on ^{14}C and ^{13}C measurements in dissolved and particulate organic carbon (DOC and POC, respectively) in these systems. A brief review is presented of current methods for the separation and oxidation of DOC and POC from water samples, for subsequent $\Delta^{14}C$ and $\delta^{13}C$ analyses. We also compile the existing data sets on paired ^{14}C and ^{13}C measurements across the riverine to coastal marine continuum in order to elucidate sources, ages, and transformations of organic matter within each system, and during transport from rivers to the coastal ocean. The natural range in the $\Delta^{14}C$ values of both DOC and POC across similar system types was 500 and 1000‰, respectively. In general, riverine DOC was enriched in ^{14}C relative to POC in rivers and estuaries, but the opposite generally held for coastal marine waters. This is indicative of the different sources and transport mechanisms for DOC and POC within and across these three general types of systems. During river and estuarine transport, DOC generally becomes enriched in ^{13}C and depleted in ^{14}C due to simultaneous additions from autochthonous production and removals from heterotrophic bacteria and abiotic processes. Bacterial utilization experiments indicate that bacteria preferentially utilize a ^{14}C enriched (i.e. young) DOC fraction and, therefore, DOC utilization is a partial explanation for the ^{14}C-depeleted riverine and estuarine DOC. It is concluded that through the use of paired ^{14}C and ^{13}C measurements in DOC and POC, a more robust interpretation of sources, sinks, and residence times of organic matter may be attained than by using either isotope separately.

Raymond, P.A. and J.E. Bauer. 2001. Riverine export of aged terrestrial organic matter to the North Atlantic Ocean. *Nature* 409: 497 – 500.

ABSTRACT

Global riverine discharge of organic matter represents a substantial source of terrestrial dissolved and particulate organic carbon to the oceans. This input from rivers is, by itself, more than large enough to account for the apparent steady-state replacement times of 4,00-6,000yr for oceanic dissolved organic carbon. But paradoxically, terrestrial organic matter, derived from land plants, is not detected in seawater and sediments in quantities that correspond to its inputs. Here we present natural ^{14}C and ^{13}C data from four rivers that discharge to the western North Atlantic Ocean and find that these rivers are sources of old (^{14}C-depleted) and young (^{14}C-enriched) terrestrial dissolved organic carbon, and of predominantly old terrestrial particulate organic carbon. These findings contrast with limited earlier data' that suggested terrestrial organic matter transported by rivers might be generally enriched in HC from nuclear testing, and hence newly produced. We also find that much of the young dissolved organic carbon can be selectively degraded over the residence times of river and coastal waters, leaving an even older and more refractory component for oceanic export. Thus, pre-ageing and degradation may alter significantly the structure, distributions and quantities of terrestrial organic matter before its delivery to the oceans.

Raymond, P.A. and J.E. Bauer. 2001. DOC cycling in a temperate estuary: A mass balance approach using natural $^{14}C$and ^{13}C isotopes. *Limnology and Oceanography* 46: 655 – 667.

ABSTRACT

We measured dissolved organic carbon (DOC), dissolved inorganic carbon (DIC), and their corresponding $\Delta^{14}C$ and $\delta^{13}C$ values in order to study the sources and fates of DOC in the York River Estuary (Virginia, U.S.A.). The $\Delta^{14}C$ and $\delta^{13}C$ values of DOC and DlC at the freshwater end-member indicate that during periods of moderate to high flow, riverine DOC entering the York was composed of decadal-aged terrestrially organic matter. In nearly all cases, DOC concentrations exceeded conservative mixing lines and were therefore indicative of a net DOC input flux from within the estuary that averaged 1.2 μM $L^{-1}d^{-1}$.

The nonconservative behavior of DOC in the York River Estuary was also apparent in carbon isotopic mixing curves and the application of an isotopic mixing model. The model predicted that 20-38% of the DOC at the mouth of the estuary was of riverine (terrestrial + freshwater) origin, while 38-56% was added internally, depending on the isotopic values assigned to the internally added DOC. Measurements of $\Delta^{14}C$ and $\delta^{13}C$ of DOC and DlC and marsh organic matter suggest that the internal sources originated from estuarine phytoplankton and marshes. The isotopic mixing model also indicates a significant concomitant loss (27-45%) of riverine DOC within the estuary.

Changes in DOC concentration, $\Delta^{14}C$-DOC, and $\delta^{13}C$-DOC were also measured during incubation experiments designed to quantify the amounts, sources, and ages of DOC supporting the carbon demands of estuarine bacteria. Results of these experiments were consistent with an estuarine source of phytoplankton and marsh DOC and the preferential utilization of young (^{14}C-enriched) DOC in the low-salinity reaches of the York. However, the average removal of riverine DOC by bacteria accounts for only ~4-19% of the riverine pool; therefore, other significant sinks for DOC exist within the estuary.

Reay W. and K.A. Moore. 2005. Impacts of Tropical Cyclone Isabel on shallow water quality of the York River Estuary. *In:* Proceedings, Hurricane Isabel in Perspective: Developing an Understanding of How Storm Events affect the Chesapeake Bay Region. CRC Press. November 14-17, 2004. Maritime Institute. Linthicum Heights, Maryland.

ABSTRACT

Water quality impacts from Tropical Cyclone Isabel on the York River estuary were assessed based on long-term, near continuous, shallow water monitoring stations located along the York River proper (poly and mesohaline regimes) and its two tidal tributaries, the Mattaponi and Pamunkey Rivers (oligohaline and tidal freshwater regimes). Regional rainfall from September 18 to 19, 2003, ranged from 5.8 to 11.7 cm. Peak mean daily stream flow occurred on September 21, 2003 and represented a 20 and 30 fold increase over pre-storm conditions on the Mattaponi and Pamunkey Rivers, respectively. Isabel produced a storm surge of 1.7 m near the mouth of the estuary and 2.0 m the upper tidal freshwater regions. The tidal surge resulted in a short-term (12 to 36 hours) pulse of high salinity water, approximately 10 ppt greater than pre-storm conditions, within the oligohaline portion of the estuary. In comparison, salinity levels within the upper tidal freshwater and down river poly and mesohaline regions remained relatively unchanged. Following the storm surge, salinity levels within lower portions of the estuary declined 2 to 4 ppt for an extended period in response to freshwater runoff. Elevated turbidity, in some cases extreme, was in direct response to Tropical Cyclone Isabel. With exception of a single station, maximum storm-associated turbidity levels varied between 200 and >1000 NTUs. Turbidity levels returned to pre-storm conditions (range: 10 to 20 NTUs) within a 24 to 30 hour period. Perhaps the most significant environmental impact associated with the passage of Isabel was the persistent low dissolved oxygen levels, 3 to 4 mg L^{-1}, that occurred within some tidal freshwater regions. Low dissolved oxygen at these sites was correlated to increased freshwater inflow suggesting augmented loadings of readily degradable organic material from the watershed. It took approximately two weeks for mean daily dissolved oxygen levels to return to pre-storm DO levels at these sites. Dissolved oxygen levels at the poly and mesohaline stations within York River proper remained at or above 5 mg L^{-1} prior to, during and after the storms passage.

Wetzel, R.L., S.K. Dailey, G.J. Lackey, B.E. Berry, and R.R. Christian. 1993. Sediment-water nutrient exchange in estuarine sediments of differing trophic status. Applied Marine Science and Ocean Engineering Special Report No. 328 (SRAMSOE #328). College of William and Mary, Virginia Institute of Marine Science, Gloucester Point, Virginia. 46pp + appendix.

ABSTRACT

The National Estuarine Research Reserve (NERR) system offers unique opportunities to carry out research in a variety of estuarine habitats. In both Virginia and North Carolina, NERR sites include both low salinity areas (Sweethall Marsh and Currituck Banks, respectively) and high salinity sites (Goodwin Islands and Masonboro Island, respectively) containing habitats with varied sediment types, light and nutrient conditions.

Eutrophication poses a threat to many estuaries. Among other impacts, increases in turbidity and nutrient concentrations may effect changes in estuarine autotrophic and heterotrophic processes. We investigated sediment community oxygen and carbon dioxide metabolism, and sediment-water exchange of nutrients (NH_4^+, nitrate + nitrite (NO_x^-), and filterable reactive phosphate (FRP)) and assessed potential eutrophication-related impacts on benthic environments along natural light/depth gradients. Field studies provided baseline information on these processes, and the comparison between areas of high and low irradiance indicated potential changes attributable to turbidity increases in the water column. Field studies were conducted at the NERR sites listed above, in both sand and mud dominated areas.

Overall, significant effects of short-term light conditions were common for fluxes of O_2, CO_2, and NH_4^+, but less so for NO_x^- and FRP. The greatest frequency of depth (long-term light) effects across all variables was at Goodwin Islands. Other sites had significant effects for one half or less of the analyses. "Mud" sites tended to demonstrate effects more often and with greater significance than sand sites. With the exception of Goodwin Islands, shallow (1 m) depths tended to be more "autotrophic" than 2 m deep sediments. In 1992 at Goodwin Islands, numerous effects differences among sites in combination with factors associated with date of sampling confound any pattern. Highly significant differences associated with salinity regime were only noted twice: O_2 at Pmax and NO_x^- at Pmax. But in both cases there was also significant interaction with the date/depth treatment. For O_2 there was a trend for fluxes in high salinity to exceed paired fluxes in low salinity .but no trend was discernible for NO_x^-. $C0_2$ fluxes at Pmax demonstrated a less significant effect but no interaction. In this case low salinity regimes demonstrated greater autotrophy. Lastly, no discernible trends between regions (Virginia vs. North Carolina sites) could be noted with the exception of benthic respiration. Uptake of O_2 in the dark for our North Carolina samplings tended to be higher than those for Virginia.

The patterns of flux direction vary among sites and chemical species. Masonboro and Goodwin Islands have sediments that are most likely to be autotrophic. Both are also potential sinks for NO_x^-; but whereas Masonboro Island is also a sink for NH_4^+ and FRP, Goodwin Islands are more likely to be a source for both. Sweethall and Currituck Banks have sediments which tend to be heterotrophic even though the one is largely "mud" and the other sand. NH_4^+ and NO_x^- tend to be taken up by the sediments at Currituck Banks with FRP concentrations being too low to measure. At Sweethall NO_x^- is consistently effluxed, whereas the directions of NH_4^+ and FRP fluxes are less predictable.

D. Cultural / Socioeconomic