NEERS FALL 2004 ABSTRACTS

BLOCK ISLAND, RI

Abdelrhman, M. A.

THE LOCAL EFFECT TIME (LET)AND HOW IT INCORPORATES ECOLOGY INTO RESIDENCE TIME

A clear and direct connection between constituent/water residence times and ecological effects is necessary to quantitatively relate these time scales to ecology. The concept of “local effect time” (LET) is proposed here as a time scale with adequate spatial resolution to relate ecological components to spatial distributions of various water column constituents within an embayment. The LET can be used to predict the susceptibility of real-world ecological components to changes in water column conditions. Further, it can provide an efficient way to allow managers and agencies to evaluate the degree of stress or relief from current or projected changes in the loading of contaminants or nutrients. The methodology for calculating LET and defining its correlation with the existing ecological components and processes of an embayment will be presented along with an illustrative application to loading from riverine inflow in New Bedford Harbor, MA. The LET successfully identified the areas within the harbor that could be prone to ecological changes due to the loading rate of freshwater and its constituents.

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DEVELOPING A COMPREHENSIVE MONITORING PLAN FOR NARRAGANSETT BAY AND WATERSHED

The Coastal Institute chairs the Rhode Island Environmental Monitoring Collaborative that was established by the RI General Assembly in the 2004 session. The charge to the Collaborative is to develop a comprehensive environmental monitoring plan for Narragansett Bay and its watershed. The Plan must include a process for data integration, synthesis, and distribution to resource managers, scientists, citizens, and decision-makers. The monitoring program and a budget for monitoring activities are to be presented to the Governor and General Assembly in January 2005. The Monitoring Collaborative is also a component of the RI Bays, Rivers, and Watersheds Coordination Team that was also established this last legislative session. The Coordination Team is charged with developing a systems-level plan for the management, preservation, and restoration of the state's bays, rivers, and watersheds. I will review the work of these organizations and how they can contribute to monitoring nutrients in Narragansett Bay and coastal Rhode Island.

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PREDICTING LIGHT ATTENUATION IN SHALLOW COASTAL WATERS

The availability of underwater light is a critical factor in the growth and abundance of aquatic primary

producers. The goal of this study was to examine the relative importance of factors influencing light availability in shallow estuaries. Although many model formulations predict light attenuation from chlorophyll or phytoplankton stock, no significant relationship was found to exist between chlorophyll and the diffuse attenuation coefficient in the sites studied here. Colored dissolved organic matter (CDOM), can strongly influence the availability of light to aquatic primary producers. This study demonstrated that over 70 percent of the variability in the diffuse attenuation coefficient can be attributed to CDOM in the shallow estuaries of Southern New England. This illustrates the need for improved model formulations that include CDOM in the prediction of light attenuation for shallow coastal systems. A new regression model predicting light attenuation from chlorophyll, CDOM, and turbidity, has been developed. This empirical equation has the potential to improve ecological modeling of coastal systems.

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WILL A DECREASE IN ANTHROPOGENIC NUTRIENTS AFFECT THE MACROBENTHIC COMMUNITY OF NARRAGANSETT BAY, RHODE ISLAND?

Recent legislation calls for a 50 percent reduction in nutrient pollution entering Narragansett Bay from wastewater treatment facilities by 2008. It is not currently known what effects a nutrient reduction of this magnitude will have on bay's benthic community. In temperate coastal systems such as Narragansett Bay benthic fauna depend on the organic deposition of water column production as a major source of food. Further, springtime peaks of macrofaunal abundance have been linked to the accumulation of phytodetritus within the sediment following the winter-spring diatom bloom. With phytoplankton playing an important role as a food source for benthic macrofauna and the sensitivity of these organisms to nutrient limitation; it follows that the proposed reduction of anthropogenic nutrients may result in a decrease in benthic productivity. Using the natural north-to-south gradient of decreasing levels of available nutrients as a proxy for the proposed reduction in nutrient input from wastewater treatment, this study considers the patterns of variability in faunal abundance and biomass which currently characterize the macrobenthic community of Narragansett Bay.

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EUTROPHICATION ASSESSMENT IN NORTHEAST COASTAL PARKS

In an effort to quantify terrestrial nitrogen inputs to its northeast coastal parks, the National Park Service implemented a computer-based modeling effort in 2002. The status of eutrophication at parks in the Northeast Corridor (Acadia National Seashore, ME; Cape Cod National Seashore, MA; Fire Island National Seashore, NY; Gateway National Recreation Area, NY/NJ; Assateague Island National Seashore, MD; Colonial National Historical Park, VA) was measured using a field reconnaissance and GIS-based approach. Data from the US Census Bureau, US Department of Agriculture, US Geologic Survey, National Atmospheric Deposition Program, and state and local sources were compiled for inputs to a nitrogen loading model. The Waquoit Bay Nitrogen Loading Model, developed by Valiela et al. (1997) was extended to account for agricultural outputs (animal and vegetative) and wastewater treatment plant outputs. The accuracy of this model and its extensions is to be evaluated in the future with field measurements of

nitrogen loading.

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USE OF A STABLE ISOTOPIC METHOD IN A HABITAT RESTORATION CONTEXT

In a tidally restricted salt marsh in coastal Rhode Island, a macroalgal bloom has grown in size and duration in the last decade. The goal of this assessment is to determine whether or not restoring tidal flow alone will reduce the macroalgal bloom. The cause of the bloom remains to be determined, but two nutrient sources seem possible. Nitrogen stable isotopes have been used to identify the contribution of wastewater N to the land-derived nitrogen load to receiving waters. Here, we apply this relatively new technique to a salt marsh restoration project. Contrary to our hypothesis, nitrogen stable isotopic values in Gooseneck Cove were not indicative of a wastewater source. This result suggests another nutrient source for the macroalgal bloom. We suggest that nutrient release from the subsiding salt marsh may be that source. Gooseneck Cove has been restricted since at least 1939, but subsidence of part of the marsh started after 1981. It has been shown that salt marsh peats have high concentrations of nutrients, and decomposition of marsh peat, and subsequent nutrient release, could stimulate primary productivity in the watercolumn. Continuing research will assess whether or not subsiding marsh peat is the source of nutrients for the algal bloom.

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APPLICATION OF 2&3D COMPUTER-AIDED TOMOGRAPHY (CT) FOR THE VISUALIZATION AND QUANTIFICATION OF THE ANTHROPOGENIC IMPACT ON MARINE SEDIMENT AND MARSH COMMUNITIES

We have applied two and three dimensional Computer-Aided Tomography (2&3D-CT) to quantify the response of marine benthic communities within pollution gradients. Now we are turning our attention to marsh habitats in order to examine the potential application of 2&3D-CT to determine anthropogenic influences.

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THE FUTURE OF NARRAGANSETT BAY : IT'S TOUGH PREDICTING NEW ENGLAND WEATHER

Narragansett Bay has experienced many environmental insults over the last 300 years. Today most toxics have decreased due to environmental laws and economic shifts, but nutrients have slowly increased following a rapid rise in the population in the late 1800's. Signs of impacts have been slowly uncovered, partly due to poor baseline information and partly due to erroneous assumptions about the Bay's physical mixing energies. Evidence now exists for nutrient-related impacts in terms of historical eelgrass loss and present hypoxia formation in summer neap tides. Because of the confounding effects of water temperature and weather-related runoff, we still lack the ability to adequately predict the response of this system to changing nutrient loads. An adaptive management approach to nutrient control using cost-effective

technological efforts has begun. Present plans to control point source nutrient (nitrogen) loads have the potential to alter total loads by 20-30%. It will be difficult to predict the true response of the system because nutrient impacts can be exacerbated by warming trends and changes in weather patterns for rainfall and winds, not to mention the possibility of changes in phytoplankton responses to CO_2 increases. In addition, sea level changes could possibly alter tidal currents to some extent (although likely minor for the foreseeable future). The only long term steady physical limit seems to be seasonal photoperiod length (based on latitude), which hopefully won't change in the near-geological time period. However, it does seem clear that present plans will not lead to such drastic nutrient reductions that Narragansett Bay would face a nutrient crisis for secondary production.

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EXPANSION OF BIG CORDGRASS ALONG THE SEEKONK RIVER

One shovel-full of the Big Cordgrass, *Spartina cynosuroides*, was transplanted from Dennis, MA, to Swan Point, on the Seekonk River in Providence, RI, in 1939. Field notes made in 1955 and in 1958 indicate that a few slender stalks of Big Cordgrass were recognizable within some colonies of *S. alterniflora*, the Smooth Cordgrass, at Swan Point. Today, robust colonies of Big Cordgrass grow on both sides of this urban river. Notes from the 1980s suggest that Phragmites colonies were replaced through overgrowth of Big Cordgrass. In the Goose Point area, Big Cordgrass has infiltrated the remaining Phragmites colony of the west shore. In recent decades, Seekonk River sediment has shown a yearly reduction of heavy metals; and, thanks to a major landslide event, an increase in clean sand. This combination of factors probably accounts for the current rapid expansionn of the Big Cordgrass. Large seeds, heavy seed set, stout rhizomes, and the ability to overgrow Phragmites suggest that Big Cordgrass might have a positive impact in selected salt marsh restorations in New England.

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A SYSTEMATIC ASSESSMENT OF NEW ENGLAND COASTAL WETLANDS

US Environmental Protection Agency's Atlantic Ecology Division and Massachusetts Office of Coastal Zone Management have begun work on a comprehensive coastal wetlands assessment in Rhode Island, Connecticut, and Massachusetts. The method includes a landscape analysis followed by an on-site rapid assessment. The landscape analysis uses NWI mapped inter-tidal emergent and associated shrub wetlands, aerial photography, and GIS data to assess the condition of coastal wetlands at a coarse scale. Using a random probabilistic design, selected sites are characterized using the following metrics: landscape position, size, shape, exposure, aquatic edge, tidal flushing and associated habitat. The geomorphology and hydrology data will be used to classify and stratify the wetlands in later analyses. Disturbances that can be detected using remote data, such as ditching/draining, fill/fragmentation and land use in the buffer, are also assessed. In the second phase, a rapid assessment protocol is conducted on-site to verify the landscape analysis and determine the condition and disturbances of the marsh. The condition of the marsh is described by measures

of hydrology, plants and soils. The plant metrics include large scale descriptions of plant communities as well as species composition and percent cover. Soil metrics include estimates of sediment resistance and plant fragments. In addition, anthropogenic disturbances such as tidal restrictions, outfalls and invasive species are observed on-site. Metrics from both the landscape and rapid assessment will be calibrated and verified to determine the condition of New England coastal wetlands.

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THE MAPPING PARTNERSHIP FOR COASTAL SOILS AND SEDIMENT (MAPCOAST)

An integrated and scientific understanding of most of the world's seabed bathymetry, sediment and habitat types, biological communities, and underwater archaeological resources is woefully inadequate. We currently have a comprehensive understanding for only a few scattered areas of specific interest to either government or industry. This is a problem that critically limits effective management and protection of coastal ecosystems. The MapCoast Partnership began during the spring of 2004 with the stated goal of developing the institutional framework necessary to map, inventory, describe, and classify soil and sediment data for coastal marshes, dunes, inter-tidal flats, and shallow water habitats (to approximately 5 m of water). The Mapping Partnership for Coastal Soils and Sediment (MapCoast) brings together groups and individuals who recognize the importance and need to collect more detailed data for these vital coastal resources. Further, MapCoast strives to develop a readily accessible database of soils and sediment in coastal Rhode Island that meets the variety of needs of the user community. The first pilot project for this parternship is underway in the Ninigret Pond coastal lagoon, Charlestown, Rhode Island. This poster highlights the organizational outline, methodology, and preliminary results of the study.

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A DIFFERENT KIND OF DAM: TERRESTRIAL VEGETATION AND THE ANNUAL FLUX OF SILICA TO LITTLE NARRAGANSETT BAY

The Pawcatuck Watershed (797 km ^{2}) is located in southern Rhode Island and northeastern Connecticut. As past of a larger study of nutrient and sediment exports from the watershed to Little Narragansett Bay, we measured dissolved silica(SiO_2) concentrations at the Pawcatuck River mouth over seventy times from 1/14/02 to 11/29/02. Annual export of dissolved silica was 40 x 10^{6} mol yr^{-1} or 50 kmol km^{-2} yr^{-1}. River dissolved silica concentrations exhibited a strong seasonal signal that did not vary in a regular way with water discharge or water temperature. Dissolved silica and dissolved inorganic nitrogen concentrations were significantly related over the annual cycle ($p < 0.0001$) and both decreased substantially during the spring. It does not seem likely that in-stream biological uptake was responsible for the silica decline as phosphorus did not covary with nitrogen or silica at anytime. Our hypothesis is that the spring decline in river silica concentrations is due to silica uptake by terrestrial vegetation. We estimate a net forest silica accretion rate of 41 kmol km^{-2} y^{-1}, a value that is stoichiometrically consistent with other measurements of net carbon accretion in nearby forests. Terrestrial vegetation decreases the silica flux to Little Narragansett Bay by 30%

and changes the Si:N ratio from 10 to 6.

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SALINITY EFFECTS ON THE NITROGEN CYCLE IN ESTUARIES

The oligohaline zone of estuaries experience changes in salinity on inter-annual, seasonal, and daily time scales. In oligohaline subtidal sediments we have documented how changes in salinity alter ammonium release from sediments, and alter rates of nitrification and denitrification. In the Parker River, MA, we saw highest rates of denitrification in the spring and fall, when salinities are low. Rates were much lower during summer when salinity was high. We are now investigating some of the reasons behind these seasonal differences. We measured potential nitrification at several sites along the estuary during both spring and fall in lab incubations. These measurements suggested that rapid salinity changes may be suppressing sediment nitrification. There were also differences in the microbial community along the salinity transect. An examination of the microbial community using TLRF revealed that the most likely microbes responsible for nitrification, the ammonium oxidizing bacteria, showed distinct differences in diversity along the estuary. The AOB community at the high salinity site had the much lower diversity than the upper estuarine sites and was the most stable, showing little variability over three years. Finally, we also measured strong seasonal differences in the dissimilatory nitrate reduction to ammonium (DNRA) pathway. DNRA appeared to follow the opposite pattern of denitrification, DNRA. rates where highest in summer when salinity was high and low in spring and fall. The implication of these finding for estuarine N cycling under changing hydrologic regimes will be discussed.

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STATUS OF AN OYSTER REMOTE SET PROGRAM IN RHODE ISLAND COASTAL WATERS

Eastern oyster (*Crassostrea virginica*) were selected by state and federal trustee agencies as one of several target species for release and restoration in Rhode Island coastal waters to address shellfish injuries resulting from the 1996 *North Cape* oil spill. The program plan consists of a multi-year, phased-project approach with the goal of restoring lost shellfish tissue biomass. The project components included a desktop screening to identify historic beds and site conditions, field reconnaissance to assess and select seeding sites, setting of hatchery-raised eyed larvae on shell bags in tanks, placement and grow-out of oyster spat in nursery trays, and release of oysters to and assessment of seeding sites. In 2003, a total of 31 areas were screened as potential release sites, 16 were field assessed, 53 field sites were assessed within these areas, 5 sites were selected for remote sets with one site eliminated due to oyster disease prevalence. In fall 2003, we released ~465,000 set oysters averaging 32 mm to the ~1000 m2 remote set sites: three in Narragansett Bay embayments (Bissel Cove, Potter Cove, and Spectacle Cove) and one in Pt. Judith Pond (Smelt Brook Cove). We also released ~10,000 50+- mm single-shell oysters, donated by Moonstone Oysters, to upper Pt. Judith Pond (Saugatucket River). In summer 2004, we conducted follow-up monitoring to assess survivorship and growth. Survivorship of oysters in the four remote set sites ranged from 11-21% with shell

length increasing 39-55% over the 10-month period, while 84% of the larger oysters survived and shell length increased 49%. Length-weight relationships from the literature were applied to extrapolate progress toward the biomass goal. This labor-intensive program was accomplished with a dedicated project staff of eight, plus hundreds of labor hours contributed by local volunteers.

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MODELING GROWTH AND RESOURCE ALLOCATION OF *ZOSTERA MARINA*; A COMPARISON OF PREVIOUS MODELS AND A NEW APPROACH

Several simulation models have been designed for seagrass systems that emphasize the prediction of standing biomass or shoot density. These variables are typically calculated in response to light and water temperature using the traditional "Eppley curve" modeling approach first devised for phytoplankton communities. Recent examination of this approach in plankton systems by other researchers has led to an emphasis on accurate prediction of production rates, in addition to standing stocks. These efforts motivated comparisons of specific growth rates predicted by several existing models of *Zostera marina* that will be presented along with a new, empirically based formulation that includes sediment and nutrient responses in addition to the effects of light and water temperature. Results from these efforts reinforce the importance of accurately modeling various morphological aspects of *Z. marina* resource allocation to belowground versus aboveground production and asexual production of lateral shoots.

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ASSESSMENT OF OPEN MARSH WATER MANAGEMENT (OMWM) ON SALT MARSH COMMUNITIES ALONG THE ATLANTIC COAST

We evaluated the initial responses of salt marsh communities to open marsh water management (OMWM) at 5 National Wildlife Refuges (21 sites) from Massachusetts to Delaware using a Before, After, Control, Impact (BACI) design. At each Refuge we selected pairs of sites that included treatment (OMWM manipulated) marsh and a control marsh. All pairs were monitored prior to OMWM and for 2 years following OMWM. OMWM is a common practice on coastal Refuges and is primarily used to increase open water for habitat enhancement. Various OMWM techniques were used including the creation of pools and ditch plugging. We monitored vegetation community, soil salinity, water table level, nekton (fish and crustaceans) community, mosquito larva, and bird use (bird data will not discussed in this presentation). OMWM did increase open water habitat at those refuges where mapping data were available, thus accomplishing the goal of habitat enhancement. Other responses to OMWM were variable among Refuges and monitoring parameters, and indicated no clear short-term trends in community or physical parameters. Detectable responses were observed and included a shift from high to low marsh vegetation (1 site), decrease in soil salinity (1 site), increase in water table level (4 sites), and changes in nekton species abundance (2 sites).

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BOSTON HARBOR SEDIMENT IMPROVING WITH REDUCED SEWAGE LOADING

For years, large amounts of pollution from sewage and industrial waste have caused severe degradation of Boston Harbor. In the past 12 years significant improvements in water and sediment quality have been achieved with the discontinuation of sewage sludge disposal, primary and secondary treatment of effluent and eventual relocation of the effluent offshore. Sediment from four harbor stations has been repeatedly sampled seasonally since 1991. Results indicate both the rate and variability of sediment-water exchange have decreased with time. The two northern harbor stations, where the impact of sludge dumping was more severe, generally show large reductions in fluxes whereas changes in the less impacted southern stations have been smaller. We report a reduction in sediment total organic carbon (TOC) and sediment oxygen demand (SOD). As the organic loading decreased, microbial processes oxidized the labile carbon. TOC loss is further facilitated by amphipods that burrow into the sediment and allow deeper oxygen penetration. Sediment fluxes of DIN, PO_4^{3-} and silica are lower than in the early nineties and less variable with the exception of silica. The decrease in magnitude and variability of fluxes indicate the harbor benthic community is recovering. In some cases the rates are approaching those measured offshore in less impacted areas. With the reduction of total nutrient inputs to Boston harbor the effects of local climate on year-to-year nutrient loading may become evident.

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HOW USEFUL ARE OPTICAL COUNTING METHODS FOR ESTIMATING ZOOPLANKTON ABUNDANCES?

Zooplankton count data from net tows were compared with Optical Plankton Counter (OPC) data from a towed, undulating platform to assess the suitability of the OPC data for use in a modeling program aimed at understanding interactions between ctenophores and larval fish in Narragansett Bay, RI. A two-year series (October 2001-October 2003) of weekly zooplankton data from two sites in the West Passage of the bay was compared with OPC data from the NOAA/NMFS NuShuttle cruises chosen to correspond with the count data in space and time. Numerical modeling efforts require large data sets to support the state variables included in the model. For the best modeling results these data sets need to be spatially and temporally detailed, but acquiring these types of data sets can involve large amounts of time, equipment and expense. New technologies may help in obtaining suitable data sets, such as the use of Optical Plankton Counters for producing detailed patterns of zooplankton abundance, biomass and distribution.

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COMPLEMENTARY APPROACHES TO WATERSHED ASSESSMENT

Anthropogenic activities in watersheds affect aquatic organisms, riparian vegetation, and their ability to support avian populations. Our objective was to compare indicators of stream and riparian condition with the composition of breeding bird populations in six Rhode Island subwatersheds along a range of residential land use. We used the Rapid Bioassessment Protocol to measure biological, physicochemical, and habitat effects at stream sites. Field transects were used to measure riparian vegetation structure and species richness, and a Geographic Information System was used to document land cover attributes. Bird surveys were conducted in the riparian zone at each stream site. By plotting bird attributes such as species richness, intolerance to human disturbance, and vegetation preference against riparian vegetation metrics, we found changes in the patterns of breeding bird distribution. Results of graphical comparisons showed no difference in species richness with residential land use, but a pronounced effect on species diversity. Intolerant species declined significantly at 20% development and 5% impervious surface, while tolerant species increased. The abundance of aquatic insects decreased at similar levels of land use. The combination of stream, riparian, and avian metrics offer a more complete assessment of effects from altered habitat at the reach and subwatershed scales.

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PROJECTING RATES OF SPREAD FOR INVADING SPECIES

A fundamental characteristic of any biological invasion is the speed at which the geographic range of the population expands. This invasion speed is determined by both population growth and dispersal. I will show how to construct a discrete-time model for biological invasions which couples matrix population models (for population growth) with integrodifference equations for dispersal). This model captures the important facts that individuals differ both in their vital rates and in their dispersal abilities, and that these differences are often determined by age, size, or developmental stage. For an important class of these equations, I will demonstrate how to calculate the population's asymptotic invasion speed. I will also present formulae for the sensitivity and elasticity of the invasion speed to changes in demographic and dispersal parameters. These results are directly comparable to the familiar sensitivity and elasticity of population growth rate. I will show that when dispersal contains both long- and short-distance components it is the long-distance component that governs the invasion speed, even when long-distance dispersal is rare.

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CHANGING PERSPECTIVES ON NUTRIENTS IN ESTUARIES

Eutrophication of the coastal marine environment first emerged as an issue of environmental concern in the northeast U.S. in the 1950's. Prior to that time, marine ecologists focused on the positive role of nutrients in stimulating primary and secondary production in the sea. Work in this region in the 1950's and 1960's showed that N rather than P was the nutrient most limiting to primary production in coastal waters. Studies of nitrogen in estuaries and lagoons increased rapidly during the past 40 years and a general perception has emerged that estuaries are “overenriched” with nitrogen, often leading to lower bottom water oxygen concentrations and, in some cases, to mass mortalities of animals. On a more subtle level, secondary production may be impacted by physiological stress and habitat loss due to low oxygen. This concern has led to regulatory pressure to denitrify sewage effluents, a major source of N in the urban estuaries of the

northeast. But N reduction and consequent “oligotrophication” of estuaries may lead to food stress and reduced secondary production. Will clear waters show us empty nets? Narragansett Bay is a coming great experiment that should be used to learn about links between N reductions and ecosystem responses at all scales. Eutrophication of the Bay occurred over 50 years from 1880 to 1930 with virtually no documentation. Oligotrophication will be much faster, and fascinating to study. But we need to get started now.

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WATER QUALITY ASSESSMENT AND DIATOM ASSEMBLAGE OF CHINCOTEAGUE BAY, VA

Four intertidal locations around Chincoteague Bay, VA were sampled in Oct 2003, Feb 2004 and Apr 2004 to determine the diatom assemblage and nutrient composition of the estuary. Chlorophyll a concentrations were measured fluorometrically and water quality was assessed by measuring NO_3^- and PO_4^- concentrations, D.O., pH, temperature and salinity. Results showed that nutrient concentrations were generally three times lower in Oct. than in Feb. Chl a concentrations in the Fall were low at 0.95μg/l. Winter concentrations averaged (n= 8) 5.59μg/l and peaked at 7.38μg/l. Long *Skeletonema spp*. chains were dominant at most sites and in all nutrient compositions in Oct. and Feb, peaking at 232 cells/ml in the winter. In the higher nutrient concentration samples, larger diatom forms (*Rhizesolenia* and *Asterionella*) dominated with cell densities of 22 cells/ml and 11 cells/ml, respectively. The fall sample was more diverse and dominated by more diatom forms but at lower cell densities. Averages of total cells/ml in the fall averaged 142 cells/ml, while winter averages were much higher at 561 cells/ml.

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DESIGNING A RAPID RESPONSE PROTOCOL FOR MARINE INVADERS IN THE STATE OF MASSACHUSETTS

The negative impacts of marine invaders are becoming increasingly evident to coastal resource managers, and while we recognize that prevention is the most effective means of minimizing these impacts, new species may still invade. Therefore, an early detection and rapid response (EDRR) plan will be necessary to manage these incipient invaders. A recent regional workshop sponsored by the Northeast Aquatic Nuisance Species Panel (the Panel) provided a framework for a rapid response protocol. The Massachusetts Office of Coastal Zone Management and the Panel are working to develop and fully implement this protocol by: (1) Organizing a regional response network. This network will include an organization to take leadership in the event of a newly discovered invasive species, coordinating efforts by and communicating with the various entities involved. A directory of taxonomists, scientists, and managers will be developed so that the presence of a new invader can be quickly confirmed. (2) Developing a system for identifying rapid response trigger species. This system will aid mangers in identifying invaders that have the greatest risk of negative impact and developing response plans with the greatest probability of success. A risk assessment methodology is being developed to rank organisms as “trigger species,” those that are not yet invasive in the region but are likely to become established if introduced and/or are likely to cause significant damage. These projects are a part of many ongoing programs to detect and manage new marine invaders to Massachusetts and the Northeast Region.

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PROPOSED USE OF LENGTH ALONG SHORELINE OF EELGRASS BEDS AS A MEASURE OF SUBMERGED AQUATIC VEGETATION (SAV) IN EMBAYMENTS

The U.S. EPA's Atlantic Ecology Division (AED) has a multi-year research program to develop empirical nitrogen load-response models for embayments in southern New England. This research program is part of EPA's Aquatic Stressors Program, which is designed to provide managers with tools to manage aquatic environments. As part of this program, AED is developing a nitrogen load-response model with submerged aquatic vegetation (SAV) as one endpoint, using SAV measurements from aerial images of 44 embayments along the Connecticut, Rhode Island, and southern Massachusetts shores. Because of the large number of study systems and the need to develop a rapid, inexpensive method of measuring SAV, a linear measurement of eelgrass beds rather than the traditional area measurement was proposed. In order to test this proposed method, an existing map of eelgrass beds in Massachusetts (1999, MassGIS) was used to examine the relationship of the linear measurement (length of eelgrass bed along the shoreline) to area. When the length along the shoreline of eelgrass beds (summed by embayment) was plotted against area of eelgrass beds(summed by embayment) for 23 Massachusetts embayments there was a strong curvilinear relationship. When length along shoreline of individual beds in the 23 Massachusetts embayments was plotted against area of individual beds, the relationship was not as good. When the total area of eelgrass beds per embayment is large (> 1,000,000 sq m) and the embayment has a complex shoreline with islands there is more variability. However, for embayments of moderate size and complexity, and eelgrass bed area < 1,000,000 sq m, length along the shoreline seems to provide a good approximation of SAV.

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IMPACT OF GRAZING BY CANADA GEESE (*BRANTA CANADENSIS*) ON AN EELGRASS (*ZOSTERA MARINA* L.) MEADOW IN GREAT BAY ESTUARY, NEW HAMPSHIRE

Fishing Island, in Great Bay Estuary on the Maine-New Hampshire border, is the site of an intertidal eelgrass bed that is part of SeagrassNet, a long-term seagrass monitoring program. Eelgrass bed parameters of canopy height, percent cover, and above-ground biomass are monitored quarterly at the site. Eelgrass parameters were compared between a year when no grazing by Canada geese occurred (October 2001 to July 2002) and a year when Canada geese over-wintered at the site (October 2002 to July 2003). Eelgrass bed parameters during the first year of the study demonstrated seasonal fluctuations typical for the region. During the second year of the study, when up to 100 Canada geese were observed actively grazing at the site throughout the winter, eelgrass parameters did not show a typical seasonal response. Instead, parameter averages declined in both winter and spring, and eelgrass recovery was not significant during the summer growing season. Additional field work examined eelgrass shoot density, seed density, and seedling density from February 2003 to July 2003 in an effort to quantify vegetative or sexual recovery of eelgrass at the meadow. The results of this field work confirm that no significant recovery of eelgrass occurred in the summer following the grazing event. An estimated giving-up threshold for Canada geese at Fishing Island – the biomass level at which it becomes unprofitable for geese to continue grazing – is comparable to

estimated thresholds for Brant geese at European seagrass meadows. The results of this research provide insight on the connectivity between waterfowl and seagrass management concerns.

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PROTOTYPE TESTING OF A SUBMERSIBLE INSTRUMENT TO DETECT INDICATOR BACTERIA AND MONITORING RHODE ISLAND COASTAL WATERS

Health risks posed by fecal contamination at beaches are determined a day too late. With support from EPA Region I and others, we have begun testing prototypes of a new detector, the SubBio Analyzer. This instrument will be remotely deployed and directed to autonomously sample, perform analyses rapidly, and report results via the internet to managers. For the methodology, we are adapting commercially available enzyme-based media that is approved by the USEPA and used to quantify bacteria easily by visual inspection. A bench-top detection system with novel electro-fluidics and miniaturized, sensitive electro-optics has significantly decreased the time to detection for bacterial indicators. LabVIEWTM software has been designed to control the instrument remotely and has automated and customized settings. A disinfection procedure between samples and on-board calibrations are being assessed. A submersible instrument capable of rapidly analyzing multiple bacterial indicators could serve as a warning system to water quality managers, so that beaches would be appropriately closed when a health risk is present and open when the water is safe. Over the summer of 2004, we have also taken part in water quality monitoring efforts. Results from Greenwich Bay, Newport Navy Base, and the Providence River in Rhode Island show overall moderate to minimal levels of indicator bacteria during the sampling periods. Elevated numbers were observed in the northern section of the Providence River estuary and in Warwick and Apponaug Coves. Consistent with the 2001 EMPACT report, we noted some discrepancies among the indicators and tests used for determining alert/action rates.

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THE AUSTRALIA REEF CUTTLEFISH (*SEPIA* SP.); A TAPHONOMIC STUDY

Much is known about the natural history, behavior, and physiology of the Australian Reef Cuttlefish. This presentation will briefly introduce some of those aspects, but the real purpose of the talk is to describe a small taphonomic study undertaken while visiting Heron Island (an island at the southern end of the Great Barrier Reef). Taphonomy is the study of the fossilization process. Early during my stay on Heron Island I noticed that a large number of cuttlebone had been washed up on the southern beach shore. I photographed a random sample of those shells. Using image analysis software, I have now analyzed the size distribution of the shells and the degree of shell wear and tear. This information could be used to analyze the same features of fossilized cuttlefish, but that task will be left to someone else.

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PERSPECTIVES ON HYPOXIA IN LONG ISLAND SOUND

Western Long Island Sound (wLIS) has experienced a long-term decline in the July/August summer minima bottom dissolved oxygen (DO) concentrations. This statistically significant five-decade decline continues despite New York City having eliminated routine raw discharges of sewage, upgraded sewage treatment to nearly complete secondary, and introduced nitrogen control. It is our conclusion that long-term changes in physical oceanographic processes are having an impact on the hypoxia problem in wLIS. Specifically, we show that there has been a 50-year increase in summertime thermal stratification and that the divergence between surface and bottom water temperature begins earlier in the year. Surprisingly, the increase between the surface and bottom water temperatures is largely caused by a decline in summertime bottom water temperature of the western Sound. The earlier and more intense establishment of thermal stratification may be a consequence of reduced wind stirring. Surface and bottom salinities appear to have declined over a much shorter period of record. However, the difference between bottom and surface salinities may have increased, further intensifying summertime density stratification. Haline fluctuations may be largely a function of Hudson River and Connecticut River discharges.

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INFLUENCES OF AN ANTHROPOGENIC GRADIENT IN FERTILITY ON NUTRIENT CONSERVATION IN *IVA FRUTESCENS*, A WOODY SALT MARSH PERENNIAL

Nitrogen (N) and phosphorus (P) resorption proficiency and efficiency were measured in a salt marsh woody perennial, Iva frutescens, along a gradient of N fertility. Nitrogen and P resorption data and regression analyses of watershed characteristics were used to determine the degree to which N fertility is related to N and P nutrient resorption in Iva. Mean resorption of N and P from senescing leaves was both less proficient and less efficient than most plants studied to date. Nitrogen and P resorption proficiencies differed significantly among sites of differing N fertility. Conversely, N and P resorption efficiencies did not differ among the three fertility classes. In 2001, P resorption proficiency was significantly related to both Iva tissue ^{15}N and the percent of each salt marsh watershed classified as residential. Headwater phosphate levels were significantly related to P resorption proficiencies combined for both study years. Nitrogen resorption proficiency and efficiency during 2001 were also significantly related to headwater phosphate levels. Nitrogen resorption proficiency combined for both study years was significantly related to total headwater N concentrations, but the relationship clearly indicated the presence of two, not three, N fertility classes, while plants growing under higher fertility were less proficient at resorbing N than those at sites of lower total N fertility. Additionally, total headwater N accounted for 71% of the variability in N resorption proficiency. This evidence supports the hypothesis that plants growing at sites of higher N fertility are less proficient at resorbing N than those growing at sites of lower N fertility.

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WASTEWATER LOADING REDUCTIONS, AND THE 'OLIGOTROPHICATION' OF BOSTON HARBOR

Over the past decade, Boston Harbor has experienced reductions in external loadings of total nitrogen (TN), total phosphorus (TP), total suspended solids (TSS) and particulate organic carbon (POC). For loadings from all non-ocean sources combined, the reductions have been in the order of 80% to 90%. Reductions in

wastewater loadings have largely been responsible for the reductions. Over the same decade, the water column of Boston Harbor has exhibited a series of significant changes. These have included, among others, reductions in concentrations of N and P, lowered phytoplankton biomass and primary productivity. They have also included increases in concentrations of TSS, bottom-water DO concentrations and bottom-water DO percent saturation values. This paper identifies relationships between the changes observed in the Harbor and the changes in non-ocean loadings to the Harbor. For certain variables, including N, P and POC, clear relationships existed between changes in the Harbor and changes in loadings. For others, including chlorophyll-a, the relationship was more complex. For still others, including TSS and water clarity, the patterns of Harbor changes in the Harbor were unrelated to external loadings.

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MASSACHUSETTS BAY: BEGINNING TO SEE THE FOREST

We have been involved in monitoring benthic metabolism and nutrient fluxes in Massachusetts Bay for over ten years (beginning in 1993). This work has been part of a large monitoring program designed to assess the impacts of the relocation of the Boston sewage effluent outfall from Boston Harbor into the bay. The monitoring program has produced a long-term, comprehensive dataset that includes seven years of baseline, pre-relocation data and nearly four years (so far) of post relocation data on physical, chemical, geological, and biological properties of the Bay. To date, we have not observed any changes in benthic metabolism related to the operation of the new outfall. Instead, we have begun to get a picture of Massachusetts Bay as part of the larger Gulf of Maine system, and to assess the natural variability in the ecosystem, which in many cases is larger than our a priori assumptions led us to expect. What drives this variability? We have begun to see indications of climate forcing (through temperature changes and storms) on the system. We have also begun to see linkages among various components of the ecosystem. For example, there appears to be a relationship between water temperature and water column chlorophyll, with a subsequent link to benthic respiration. Similarly, large storms seem to affect benthic infaunal populations, which in turn alter sediment redox characteristics. Synthesizing this long-term dataset will create a better and more comprehensive understanding of how climate drives the Massachusetts Bay ecosystem.

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FOUR YEARS OF PRE- AND POST-RESTORATION MONITORING OF A SOUTHEASTERN MASSACHUSETTS SALT MARSH

Padanaram Marsh, an 8-acre back-barrier wetland bordering Apponagansett Bay in Southeastern Massachusetts, has been tidally altered by human activity for decades. In May 2003, a replacement culvert was installed to increase tidal exchange between the Bay and marsh. Ecological data were collected at the marsh both prior to and following restoration. A total of 43 1-m2 plots were monitored along eight transects to document marsh vegetation changes. Marsh plant species richness significantly decreased following restoration, indicating the loss of the salt-intolerant plant community that had dominated the marsh

periphery. P. australis height and vigor significantly decreased, while S.alterniflora height and vigor significantly increased in the second post-restoration growing season as compared to the results of the two pre-restoration years. Soils were sampled from 41 locations, including companion vegetation plot samples, in the marsh using a McCauley peat corer to monitor any physical and/or chemical changes or factors affecting plant survival and growth. pH at the surface of the fringe marsh significantly increased as a result of the installation of the new culvert. In addition, incubation pH values at both the surface and at a 50 cm depth in fringe marsh and open water significantly decreased and are approaching reference marsh conditions. Five of the erosion-accretion open-water stations experienced net losses (2-12 cm) and five experienced net gains (1-14 cm) following restoration. Fish sampling of the marsh using a 1-m2 throw trap revealed a total of 4 fish species using the flooded marsh plain that prior to restoration, was not providing habitat for fish.

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EELGRASS, *ZOSTERA MARINA*, RECOVERY IN NARRAGANSETT BAY: RESTORATION LESSONS AND SUCCESSES IN A EUTROPHIC ESTUARY

Eelgrass, *Zostera marina*, is widely recognized as an important habitat for shallow water ecosystems. Narragansett Bay has shown a dramatic decline in eelgrass populations since the 1930's. Save The Bay, in partnership with the University of Rhode Island Graduate School of Oceanography (URI GSO), has been transplanting eelgrass on a large scale since 2002. In 2002, 2003, and 2004, we transplanted 3, 4.5, and 10 acres, respectively. Planting techniques used include the TERF^{TM} (Short et al. 2002) method and hand transplanting. Based on success rates, we have adapted our methodologies with respect to both patch spacing and shoot densities within the transplanted sites. Throughout our habitat recovery process, we have continually analyzed and adjusted our protocols by testing a variety of restoration techniques. Each process has benefits and costs, which we have tried to balance with the most efficient methodology both in terms of time and public education.

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USE OF BENTHIC INFAUNA TO CHARACTERIZE *ZOSTERA MARINA* TRANSPLANT BED MATURITY

Eelgrass, *Zostera marina*, is widely recognized as an important habitat for shallow water ecosystems. Narragansett Bay has shown a dramatic decline in eelgrass populations since the 1930's. Progressive habitat restoration methods have sought to replenish eelgrass beds through transplanting. During the 2002 field season, Save the Bay, Inc. conducted three large-scale transplants using the TERF^{TM} (Transplant Eelgrass Remotely with Frames) method (Short et al. 2002). The three transplant sites were barren, unvegetated sand flats which sustained natural healthy beds at one time. Benthic infaunal communities of transplant beds and natural beds were analyzed to compare richness and diversity. A comparison of 2002 and 2003 benthic samples suggest the transplant sites are approaching a state of maturity similar to natural beds after one year of submersion.

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TEMPORAL AND SPATIAL ABUNDANCE OF THE CTENOPHORE, *MNEMIOPSIS LEIDYI*, IN A VERTICALLY STRATIFIED ESTUARY ON LONG ISLAND SOUND

The purpose of this study was (1) to determine whether blooms of the ctenophore, *Mnemiopsis leidyi*, in the Thames River Estuary, Connecticut, were temporally concordant with ctenophore blooms elsewhere in the northern part of their range; and (2) to characterize the distribution of *M. leidyi* relative to hydrographic structure in this highly stratified estuary. During 23 April-5 September 2004, I observed two main peaks in the abundance of large (>1.0 cm) *M. leidyi*. One peak occurred on 9 July (9.2 indiv/m^3), and one occurred on 5 September (8.3 indiv/m^3). This pattern is inconsistent with those previously reported for nearby Narragansett Bay, Rhode Island, where blooms reached higher densities and usually consisted of a single seasonal maximum. Abundance of large *M. leidyi* in the Thames River Estuary differed between water masses, with large individuals less abundant above the pycnocline, where salinity was 21-27 ppt, than below the pycnocline, where salinity was 28-31 ppt. This result, coupled with the earlier appearance of *M. leidyi* at downstream stations, suggests that ctenophores entered the estuary from Long Island Sound rather than from warmer, upstream locations. Incidentally, parasitic larvae of the sea anemone, *Edwardsia leidyi*, were first observed in ctenophores on 17 August. Since that time, larvae have occurred in 24% (N = 98) of the large ctenophores and 2% (N = 268) of the small (0.1-1.0 cm) ctenophores caught in this study. Future research will involve stable isotope analysis to investigate the trophic status of *M. leidyi* relative to larvae of commercially important fishes.

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ELECTRONIC PUBLICATION OF DATA AND METHODS FOR COASTAL MONITORING AND ASSESSMENT

We are designing an electronic report on coastal conditions in the Northeast (from Delaware to Maine) for release in 2005. The report will be similar in appearance to a chapter on Northeast Coastal Conditions (EPA, National Coastal Condition Report 2), but based on twice as many data, and include computational tools. In designing the report, we plan to utilize “reproducible research” concepts. In addition to text and graphics, “reproducible research” publications include data, metadata, software tools and scripts which help the reader reproduce the statistical and graphical analyses, and interactively explore underlying analysis methods and data structures in more detail. Summary statistics and graphics on National Coastal Assessment (NCA) data will be displayed in an ArcGIS-9 Project along with the underlying data in attribute tables, Excel spread sheets including macros, and other formats. A series of report highlights will provide additional detail illustrating NCA probabilistic sampling designs, simple Excel spread sheet calculations of area-weighted statistics, calculation of confidence intervals, and the use of GIS techniques. Several highlights will illustrate how the NCA data can be combined with other data from targeted monitoring and model output for assessing local conditions. For this talk, we illustrate the approach using: 1) ArcGIS-9, 2) data collected in 2000-2001 by the NCA program for quantifying baseline conditions, 3) additional data from both fixed stations and targeted sampling in Narragansett Bay, and 4) the use of output from the USGS-EPA New England SPARROW Model as input into 5) a nitrogen mass balance model for estuaries.

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SEASONAL DIATOM ASSEMBLAGES OF THE CHINCOTEAGUE BAY

Species composition, dominance and succession of the diatom community were measured seasonally at 3 sites in the Southern Chincoteague Bay. Identification of diatoms were made using light and scanning electron microscopy. Phytoplankton densities were determined using a Palmer Maloney counting chamber of 0.1 ml volume. A total of 24 genera were identified consisting of 14 pennate and 10 centric taxa. In the fall sample, only 7 genera of centric diatoms were found, which increased to 9 in the winter sample. Pennate diatoms accounted for 13 genera in the fall sample and only 11 in the winter. *Pseudo-nitzschia, Rhaphoneis, Cyclotella, Bacillaria,* and *Diploneis* were only present in the fall, where as *Rhizosolenia, Eucampia, Chaetoceros, Thalassionema,* and *Fragilaria* were only present in the winter samples. *Skeletonema* was the most abundant and dominant form of the phytoplankton community ranging from 26 cells/ml in the fall to 215 cells/ml in the winter at two of the test sites. *Navicula* (15 cells/ml) and *Coscinodiscus* (17 cells/ml) were also dominant forms of the fall diatom community. Also important in the fall were *Rhizosolenia* (22 cells/ml) and *Chaetoceros* (12 cells/ml). Dinoflagellates (102 cells/ml) dominated the winter showing a definite seasonal component. Plankton counts mimicked chlorophyll a values with both 3.5 times higher in the winter compared to the fall.

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USING CARBON ISOTOPIC RATIOS TO MONITOR ORGANIC MATTER FLOW PATTERNS IN TIDE-RESTORED SALT MARSHES

Current efforts to evaluate the progress of salt marsh restoration include monitoring of hydrology, vegetation, sediment and water chemistry, and nekton and waterbird use, but none of these directly measures organic matter flow to consumers. delta^{13}C stable isotope analyses were performed on *Fundulus heteroclitus* and marsh primary producers (angiosperms, macroalgae, submerged aquatic vegetation, and phytoplankton) to evaluate organic matter flow from primary producers to *Fundulus*. Study sites ranged from *Spartina*-dominated reference marshes, marshes under various regimes and histories of tide-restoration, and a severely tide-restricted *Phragmites* marsh. *Fundulus* delta^{13}C values from reference *Spartina* marshes and immediately adjacent tide-restored/restricted marshes were compared revealing greatest differences at the tide-restricted *Phragmites* marsh. Differences decreased with the degree of pre-restoration tide restriction. As expected, organic matter flow became more similar to a *Spartina*-dominated marsh as tide restriction was lessened. This study demonstrates that monitoring *Fundulus* delta^{13}C values may be a useful way to evaluate the trajectory of ecological change for marshes undergoing tidal restoration.

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DIFFERENTIAL RESPONSE OF LOW AND HIGH MARSH SOIL RESPIRATION TO NUTRIENT ADDITIONS

Although it is widely recognized that plant productivity in marshes is nitrogen-limited, there is some evidence to suggest that microbial activity may be constrained by phosphorous availability. In order to determine the relative importance of nitrogen versus phosphorus limitation to microbial metabolism, I examined patterns of soil respiration in response to nutrient amendments in a salt marsh ecosystem in southern Maine, USA. Throughout the 2004 growing season, I measured carbon dioxide flux from plant-free soil in a high marsh, and an adjacent creek-side low marsh, following periodic, experimental additions of nitrogen or phosphorous. Within both the high and low marsh, nitrogen additions had no effect on carbon dioxide production relative to controls. Consistent with the results from several other studies, phosphorus amendments significantly increased carbon flux within the low marsh. However, phosphorous additions led to a significant decline in carbon dioxide flux within the high marsh. These preliminary results suggest a potentially important, differential response to nutrient loading in high and low salt marshes, which could have important implications for predicting the response of coastal wetlands to the combined effects of cultural eutrophication and sea-level rise.