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ABSTRACTS

RESPONSES OF EELGRASS SEEDLINGS TO DECREASED LIGHT

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Eelgrass populations both established and restored have been shown to decline at least in part due to reasons partially related to decreases in water clarity associated with increased concentrations of particulates and phytoplankton. In addition, the light climate in shallow estuaries is quite variable on monthly to weekly time scales due to algal blooms and resuspension of bottom sediments. Several studies have shown that aquatic plant species are able to survive in these variable light environments through mechanisms of acclimation and adaptation resulting in changes at both the cellular and whole-plant level. The adaptive advantage of these responses is particularly dependent upon the rate and reversibility of these changes. Responses and acclimation of eelgrass seedlings to changes in light intensity were investigated in flowing seawater aquaria experiments. Replicate populations of *Zostera marina* seedlings were grown under greenhouse shade screens to create three treatment levels (13, 30 and 100% of ambient light). Changes in the relationship between photosynthesis and irradiance (P-I) were monitored during a 3 week, 5 week and 7 week treatment period followed by a recovery period. Other parameters monitored were chlorophyll *a*, root/shoot ratio and morphological features such as leaf length and number. Preliminary results will be discussed.

GETTING SCIENCE TO THE COMMUNITY

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Four activities will be described that demonstrate ways in which individual scientists can become involved in their community and effect decision making. The first activity involves recruiting and educating a group of citizen monitors to assess the effectiveness of a low head fish ladder. The second activity is participation in an advisory group to the state Department of Environmental Protection. The third activity is working within a land trust to provide an educational forum for residents to learn and discuss development issues. The fourth activity is facilitating the organization of a balanced discussion of different energy options in an era when electricity is deregulated. All these examples demonstrate the extent to which an individual scientist can educate his/her neighbors and community with facts about natural resources and potentially controversial issues. This type of informal information sharing is the first step in having an informed community making rational decisions.

HISTORICAL CHANGES IN ATMOSPHERIC NITROGEN DEPOSITION, AND ITS IMPACT ON COASTAL SYSTEMS

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The importance of nitrogen in estuarine systems has been well established. Historical changes in the source of nitrogen to a watershed, and the impact those changes have on receiving waters, can be used to forecast future changes in nitrogen loads. We used our own data on composition and loading rates of NH_4 , NO_3 , and DON in wet and dry deposition, and we reviewed existing literature to calculate rates of atmospheric nitrogen delivery to estuaries of Waquoit Bay from 1938 to the present. The amount of total dissolved nitrogen deposited has remained relatively constant over the past century, but the composition of that deposition has changed. In the early part of the century nitrogen deposition was dominated by ammonium. Since about 1940, deposition has been dominated by nitrate. Ammonium is largely produced from the volatilization of ammonia from agricultural fertilizers and waste. Nitrate is mostly produced by combustion of fossil fuels. The change could have resulted from a shift from agriculture to industrial land uses. We will also assess the relative magnitude of atmospheric imports to nitrogen loads provided by fertilizer use and wastewater disposal from 1938 to the present.

THE SIGNIFICANCE OF HYPSOGRAPHY IN MODELING PRIMARY PRODUCTION IN SHALLOW COASTAL SYSTEMS

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Hypsography (also referred to as hypsometry) is the relationship of depth relative to surface area. Fine-grid estuarine models encompass the effects of hypsography in their calculations of productivity due to the number of spatially represented cells, each with a value for depth. However, some models bypass the chore of containing complex spatial grids and, consequently, attempt to aggregate estuarine depth into one variable, usually mean depth (Z_{bar}). Since depth is integral in determining areal production of primary producers in shallow estuaries it must be necessarily considered in modeling methods. We test the effect of hypsography on phytoplankton production using an empirical net production formulation across three hypothetical hypsographic curves. We apply our comparison to systems with varying depths relative to photic depth. Initial results indicate that adjusting areal production estimates based on hypsography can reduce error and uncertainty in estuarine models.

NITRIFICATION IN WATER AND SEDIMENTS OF THE CASPERKILL, A TRIBUTARY OF THE HUDSON RIVER ESTUARY

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The Casperkill, a stream in the mid-Hudson region of New York, possesses nutrient gradients that implicate the process of nitrification along the stream's 17-km length, with high concentrations of NH_4^+ upstream falling to lower concentrations downstream, and conversely, low concentrations of NO_3^- upstream rising to higher concentrations downstream. To investigate the occurrence of nitrification in the stream, seven sites along its length were sampled on a monthly basis, and measurements of several physical and chemical parameters, including temperature, conductivity, DO, pH, and alkalinity were taken for each site. Nutrient analyses for NH_4^+ , NO_3^- , NO_2^- , and PO_4^{3-} were performed on water samples and sediment cores, as well as analyses for total suspended solids in the water samples. Nitrification rates for water samples were estimated using the difference in the dark incorporation of ^{14}C between nitrification-inhibited versus non-inhibited samples, while rates for sediments were estimated from changes in NH_4^+ , NO_3^- and NO_2^- in inhibited versus non-inhibited sediment slurries at intervals ranging from zero to 24 hours. Analyses of the nutrient data reinforced previously observed nutrient gradients implicating nitrification. Nitrification rates in the sediments were found to be orders of magnitude higher than those in the stream water, although both sets of measurements were found to be highly variable. Water-column nitrification rates ranged from 0 to $4 \mu mol NH_4^+$ oxidized $L^{-1} Day^{-1}$, as opposed to sediment nitrification rates, which ranged from 0 to $500 \mu mol NH_4^+$ oxidized $L^{-1} Day^{-1}$. In spite of the orders-of-magnitude difference between the two sets of measurements, a positive relationship was found to exist between nitrification rates in the water column versus the sediments. NO_2^- and NO_3^- production in the sediment cores were also found to be positively correlated, suggesting the presence of both types of nitrifying microbes.

PATTERNS IN THE SEASONALITY OF PHYTOPLANKTON BIOMASS IN COASTAL ECOSYSTEMS

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We test, through a compilation of published reports, whether specific trends in phytoplankton biomass seasonality can be generalized in northern temperate enclosed coastal ecosystems (ECE) and northern temperate open coastal ecosystems (OCE). Bimodal cycles (i.e., displaying two annual peaks) are the most frequent trends in both ecosystems, and whereas they mostly peaked at late winter and fall in OCE, they peaked mostly in spring and late summer, and also over a wider range of months, in ECE. The interaction between restricted depth or tidal stirring and light seasonality in ECE could be responsible for these differences. Moreover, bimodal cycles reached higher biomass peaks in ECE, which can result from higher water column nutrient concentrations: Unimodal cycles (one annual peak) also occurred significantly in both ecosystems, and whereas they peaked throughout winter and spring in OCE, they peaked mostly in summer in ECE. We suggest that relaxation of phytoplankton limitation by nutrients in ECE subject to high year-round nutrient inputs could match phytoplankton seasonality with seasonality of water-column stratification. These results reveal broad-scale patterns in phytoplankton seasonality in temperate coastal ecosystems, and help identify physical processes generating these patterns.

CONTROLLING *PHRAGMITES* GROWTH IN MESOHALINE TIDAL MARSHES OF THE LOWER HOUSATONIC RIVER: A FIELD TEST

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We hypothesize that the natural flooding regime of mesohaline tidal marshes may be altered to create conditions selecting against *Phragmites* expansion and for growth by *Spartina alterniflora*. In *Phragmites* marshes of the lower Housatonic River, experimental chambers installed with one-way check valves create extended flooding regimes that are monitored using continuously recording piezometers. Relative to control locations where duration of flooding averaged 22-27% during 2 weeks in July (N=27), experimental chambers were flooded for 50-100% of the same time period (N=9). For all locations the maximum depth of flooding was approximately 30 cm. We expect that over the 2 years of the study (begun June '98), increased flooding in experimental chambers will enhance sulfide production in the soils and that evapotranspiration of excess water will concentrate salts to levels that alter *Phragmites* production. Porewater equilibrators in soils of experimental and control locations will be sampled to detect differences in chemical profiles of the rhizosphere. Initial measurements of *Phragmites* vigor (shoot density and height; leaf tissue C:N:P ratios) were completed for all locations in June (N=36). Site disturbance during installation of chambers in the middle of the growing season, however, decreased shoot density in both experimental and control locations. The second year of monitoring will be required to detect experimentally induced changes in *Phragmites* vigor. We expect to show that simple modifications of the hydrologic cycle in mesohaline marshes dominated by *Phragmites* can be used as a strategy for wetland restoration and management.

AN APPROACH TO TEACHING ECOLOGY: LINKING THEORY, RESEARCH, AND MANAGEMENT ISSUES

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We have worked out a way to teach students about coastal ecology while simultaneously enhancing motivation to learn, making evident the need to acquire basic knowledge, and clarifying how research is done and how research results are put to work on real-world issues. Each year, we identify an estuarine issue that has garnered stakeholder concerns. On the first day of the course, we assemble a group of stakeholders who meet with the class and convey their concerns. We then go back to our labs and structure the stakeholder concerns into relevant questions, and follow by designing a research program to answer the questions. The issue to be addressed is chosen so as to provide the opportunity for a broad set of research projects and sufficient aspects to allow the class to divide into groups of 2-3 students on each project. The groups begin their research, and quickly learn teamwork, field and laboratory skills, and that not everything always works as planned. As soon as the projects are started, it becomes self-evident to students why they need to know ecological fundamentals, and we provide the necessary written and discussion materials to cover the field of estuarine ecology. When the students finish their projects, they work up the data and learn basic computer skills, such as spreadsheet use, graphing, and word processing. Results are then written up as if they were submitting their manuscripts for publication, which are reviewed by faculty and returned to them for revising. In this process they learn to collaborate when writing articles, as is common in science. At the end of the course, students present their work in a series of talks to the stakeholders, bringing closer to the process by which stakeholder concerns become research results and are reported to users. The presentation of results allows students to develop speaking skills. The final exam format ties together all of the research projects and text readings by asking students to write an executive summary of the status of the estuary studied in terms of results of the separate projects, and is couched in terms of ecological concepts learned in readings and discussion. What the students take away from this class are ecological concepts and theories, new field, lab, computer and collaboration skills, and most importantly, a sense that ecology can be used as a tool to aid stakeholders, managers, and policy makers in their decisions about environmental issues.

THE EFFECTS OF WIND INDUCED SETUP ON TIDALLY AVERAGED VOLUME FLOW THROUGH THE SAKONNET RIVER NARROWS, NARRAGANSETT BAY

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This study utilizes tide gauges, acoustic Doppler current (ADCP) profiling, CTD profiling, and wind data to investigate the physical mechanisms controlling exchange between Mount Hope Bay and the Sakonnet River passage of Narragansett Bay. The region separating these two areas consists of a series of breakwater-like constrictions referred to as the narrows. A primary question addressed in this work is how these constrictions affect circulation patterns in the region. Although forcing mechanisms for the system include tidal oscillation, density gradients, and wind events, this presentation focuses on wind induced circulation. Results suggest that up to 60 % of the non-tidal sea surface variability may be accounted for by winds blowing to or from 315 degrees, as illustrated by significant setup and draw down respectively. Tide gauge data and four 13-hour ADCP volume flux surveys were used to develop an empirical prediction of volume flux from sea surface gradients for the entire tide gauge deployment period of 41 days. Predicted volume flow anomalies are compared with wind events, and show that wind induced setup dictates the direction of net flow during strong events for up to three days. This study has direct implications concerning the influence of the Sakonnet River passage on the flushing of Mount Hope Bay.

USE OF $\delta^{15}\text{N}$ STABLE ISOTOPE TO UNDERSTAND MIGRATIONS DURING THE LIFE HISTORY OF *MENIDIA MENIDIA* IN WAQUOIT BAY, MASSACHUSETTS

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The Atlantic silverside, *Menidia menidia*, is one of the most abundant fish species found in near-shore coastal waters of the Western Atlantic. During the colder months *M. menidia* are thought to move off shore and overwinter in deeper waters and may represent a significant energy flow from estuaries to open water. The estuaries of Waquoit Bay are subject to different nitrogen loading rates from watersheds. The $\delta^{15}\text{N}$ signals for primary producers are enriched in estuaries with a higher percentage of nitrogen from wastewater, and this relationship is evident in consumers. In this study the $\delta^{15}\text{N}$ isotopic signature and percent nitrogen was examined for *M. menidia*. Because *M. menidia* migrate out of shallow estuaries during the winter, we hypothesize that adults entering the shallow estuaries in the spring will have similar $\delta^{15}\text{N}$ values. As a 'control' we compared the $\delta^{15}\text{N}$ for young-of-year (yoy) and adult *M. menidia* to the values of yoy and adult *Fundulus heteroclitus* a species that spends its entire life history within shallow estuaries. Our results show that adult *M. menidia* caught in the spring and through the summer within different estuaries have a similar percentage of nitrogen in their body tissue and have similar $\delta^{15}\text{N}$ signatures. However, yoy *M. menidia* caught later in the summer exhibited different $\delta^{15}\text{N}$ signatures and percentage of nitrogen in their body tissue; the difference in $\delta^{15}\text{N}$ paralleled that found in the specific estuaries. *F. heteroclitus* adults and yoy exhibited different $\delta^{15}\text{N}$ signatures and percentage of nitrogen in their body tissue. These results confirm that fish growing in specific estuaries bear the isotopic signatures of that estuary; adult *M. menidia* have appeared to migrate from deeper water into the estuaries, and the yoy remain and grow in specific estuaries.

NITROGEN ENRICHMENT OF ESTUARIES: UNDERSTANDING THE SHIFT FROM EELGRASS-TO SEAWEED-DOMINATED COMMUNITIES.

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Loss of eelgrass (*Zostera marina*) habitat often parallels increasing frequency of macroalgal blooms in estuaries worldwide. These seaweed blooms are largely a result of increased delivery of nitrogen from land to estuaries, which increases as urbanization of coastal watersheds increases. We addressed the following questions in a field experiment conducted during summer 1998 in Waquoit Bay, MA: 1) How do seaweed canopies affect eelgrass shoot and growth density, and 2) if seaweed shading is important in contributing to eelgrass decline, what is the "critical" canopy height (and accompanying nitrogen loading rate) at which eelgrass production decreases? We conducted seaweed shading experiments within eelgrass meadows of 2 estuaries, one containing a pristine eelgrass population (and 2 cm seaweed canopy) and the other containing a population (and 9 cm seaweed canopy) which has lost over 90% of its cover in the past decade. The experimental units were 1m x 1m plots of eelgrass fenced within plastic mesh which served to either exclude or include macroalgae. Treatments consisted of total seaweed removal, controls in which extant seaweeds were left alone, and seaweed additions of relatively low, medium, or high canopy heights. In both estuaries, we found slower eelgrass growth rates and lower densities in seaweed addition treatments than in removal treatments. In the pristine estuary, growth and densities in control pens were similar to those of removal treatments. In the declining population, where we observed a significant decrease even in control plots, eelgrass densities increased upon removal of extant seaweeds and growth rates were higher than in controls. Seaweed canopies, thus, directly inhibit eelgrass production by 1) shading existing shoots and causing a decrease in growth rates and 2) shading new seedlings or branching shoots that cannot survive canopies greater than 10 cm in height. Identification of this "critical" canopy height and its associated nitrogen-loading rate will assist in determining urban development strategies.

MUD, MUD EVERYWHERE -- INVERTEBRATE COMMUNITIES, MUD AND ENGINEERED STRUCTURES — HOW DO THEY INTERACT?

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As coastal erosion threatens valuable property in New England and globally, retaining structures are becoming more common in an attempt to stem the rising sea. I am investigating the effects of engineered coastal bluffs on the invertebrates inhabiting intertidal mudflats along the central Maine coast. While tidal mudflats naturally accrete sediment from adjacent bluffs or undergo erosion, the engineered structures dramatically reduce the sediment supply and can lead to severe erosion. Through a comparison of 5 engineered and 6 natural areas, I have investigated species composition (finding 80 species, 36 of which occurred in 96% or more of the samples) and the similarities, as well as differences, between the treatments. Species inventories for each of 220 samples show that species richness and evenness are similar between treatments and both tidal heights sampled. These sites exhibit the common biological trend of one or two dominant species with low abundances of other species. Analyses of sediment samples yielded similar results across the two treatments and two tides. It appears that many ubiquitous organisms, such as the polychaete *Streblospio benedicti*, are able to recolonize severely disturbed sites. Based on preliminary statistical analyses, the effects of engineered structures vary, depending upon the species, but overall, community structures appear to be similar.

RECENT, RAPID DECLINES OF EELGRASS IN SOUTHEASTERN MASSACHUSETTS ESTUARIES, AND EFFECTS ON FISH ABUNDANCE AND DIVERSITY

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Over the past several years, eelgrass (*Zostera marina*) has declined sharply in several estuaries of southeastern Massachusetts. A notable example is Little Buttermilk Bay in Bourne. Eelgrass biomass there has fallen from about 400 g wet weight/m² in 1993 to zero in 1998, with the greatest drop occurring between 1995 and 1996. The loss of eelgrass has been accompanied by profound changes in the fish community, with both abundance and species richness reduced by 75% in 1998 compared to 1996 levels. Possible causes of the eelgrass declines include anthropogenic eutrophication and disease.

TRACE METAL CONCENTRATIONS IN THE ANNULI OF FRESHWATER OTOLITHS

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Trace metal concentrations are possibly unique for man-made reservoirs in comparison to naturally occurring lakes. 20 teleost fish heads were collected from the Quabbin Reservoir and their otoliths were removed. We are currently examining the otoliths using LA-ICPMS (Laser Ablation-Inductively Coupled Plasmid Mass Spectrometry). Trace metal history of the reservoir may be interpreted through trace metal concentration differences in the annuli of the otoliths. Expected results will show the course of trace metal deposition in the otoliths, as well as possible changes of metal concentrations in the reservoir.

ASSESSING CRITICAL NUTRIENT LOADS BY MODELING ESTUARINE RESPONSES IN WAQUOIT BAY, MASSACHUSETTS

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Shallow coastal embayments are increasingly experiencing the effects of eutrophication as a result of anthropogenic nutrient loading. Efforts to anticipate the negative consequences of nutrient loading may rely upon defining a critical loading above which undesirable effects are likely. However, estuarine environments are notably diverse and highly variable in space and time. Therefore, responses of estuarine ecosystems to nutrient loading are also dependent upon factors such as water residence time, stratification, hypsography, and interannual variations in light and temperature. As part of the EPA's Waquoit Bay Ecological Risk Assessment, we have developed an ecological simulation that captures these factors in its formulations and is being used as a tool to assess critical nutrient loads. The model estimates phytoplankton and macroalgal production and stocks, benthic oxygen demand, inorganic nutrient concentrations, and habitat suitability for the ecological endpoint, *Zostera marina*.

THE CURTAIN OF DEATH: PREDATION BY THE MEDUSA *CYANEA CAPILLATA* ON CTENOPHORES *PLEUROBRACHIA PILEUS* AND *MNEMIOPSIS LEIDYI*

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Although medusae are recognized as voracious predators, there is relatively little quantitative information on their feeding rates. There is even less information about the rate at which jellies eat other gelatinous zooplankton, perhaps the dominant part of the nutrition of some species. Preliminary results in experimental tanks (320L) showed that *Cyanea* (bell diameter 45-105 mm) could ingest as many as 40 of the initial 60 ctenophores (*Pleurobrachia pileus*) in half an hour. Clearing rates of 300-700 L h⁻¹ per medusa were calculated from experimental incubation times of 0.5-1 h. Believable laboratory measurements demand natural postures and behavior from both predators and prey. Natural behavior for the lion's mane jelly, *Cyanea capillata*, is to pump its umbrella continuously with its tentacles trailing down, ready to intercept prey. To maintain this behavior in experimental tanks, it was necessary to keep water circulating continuously. Conditions of too low flow resulted in medusae that sunk to the bottom of the tank. *C. capillata* was also observed to feed on the ctenophore *Mnemiopsis leidyi* and digestion times ranged from 1-4 h. for a range of sizes of predators and prey.

THE RELATIVE SIZES OF ATMOSPHERIC DEPOSITION, FERTILIZER USE, AND WASTE WATER FROM SEPTIC SYSTEMS AND A SEWAGE TREATMENT PLANT AS NITROGEN LOADS TO GREEN POND, CAPE COD, MASSACHUSETTS

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We estimated land-derived nitrogen loads to Green Pond, MA by measuring NO₃, NH₄, and DON concentrations in groundwater collected from the periphery of this estuary, and multiplying concentrations by annual freshwater recharge rates. From the geographical pattern of concentrations, calculated loads, and stable isotopic data we try to separate the contribution of atmospheric deposition, use of fertilizer, release of wastewater via septic systems and via a plume from a sewage treatment plant upgradient. From this information we evaluate the status of Green Pond relative to other estuaries, and even relative effectiveness of some nutrient remediation options.

INFLUENCE OF WATERSHED-DERIVED NITROGEN LOAD AND WATER RESIDENCE TIME ON ZOOPLANKTON ABUNDANCE, WAQUOIT BAY, MA

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The influence of watershed-derived nitrogen load and water residence time on zooplankton abundance was examined in three estuaries of Waquoit Bay, MA. Zooplankton abundance, phytoplankton abundance, water residence time, and salinity were measured in each estuary over the summer of 1998. The abundance of calanoid copepods, which contribute >95% of Waquoit Bay zooplankton, did not vary significantly among estuaries exposed to different nitrogen loads. Phytoplankton abundance, however, did increase with increased nitrogen loading rate. The short water residence times of these estuaries (0.3-2.2 days) may uncouple zooplankton abundance from phytoplankton abundance, and hence, from rates of land-derived nitrogen loading.

DEVELOPMENT OF REGIONAL NUTRIENT CRITERIA

Liebman, Matthew

U.S. EPA Region 1, New England

The U.S. EPA is initiating a new national nutrient criteria program to help meet the needs of the "Clean Water Action Plan" announced by Vice President Gore. A major goal of this effort is to develop (by the end of the year 2000) waterbody-type technical guidance manuals for assessing trophic state and developing region-specific nutrient criteria. These manuals will include default, or proposed, regional numerical target ranges for phosphorus, nitrogen and other nutrient endpoints. Ultimately, nutrient criteria will be implemented by state water quality programs through development of state water quality standards, setting limits for discharge permits, and in determining total maximum daily loads (TMDLs). The approach is to collect nutrient-related data to distinguish regional natural background levels of enrichment from over-enrichment caused by pollution. EPA proposes to develop criteria specific to ecoregions and water-body types (lakes and reservoirs; rivers and streams; estuaries). The criteria will be determined based on a synthesis of existing (post-1990) representative data relating nitrogen (N) and phosphorus (P) concentrations or loadings, with important eutrophication endpoints, such as chlorophyll-a concentration or secchi disk depth. As New England regional nutrient criteria coordinator, I have begun to assemble a regional "nutrient assessment team" utilizing experts from New England. The purpose of this team is to develop an approach for establishing criteria, assist with the data gathering effort, and provide peer review. If you are interested in becoming a member of the team, please email me at liebman.matt@epamail.epa.gov or call me at 617/565-3590.

TO SITE OR NOT TO SITE A PRIVATE DOCK: A NEW METHODOLOGY BASED ON NATURAL AND HUMAN RESOURCES FOR PLEASANT BAY, MASSACHUSETTS

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The preparation of a four-town resource management plan for Pleasant Bay, Cape Cod, MA required a comprehensive assessment of the present number of private piers on the bay, the probability of numerous additional piers in the future, and the potential impacts from piers and their use on the resources of the bay. The planning group developed a methodology by which the study area was segmented into twenty-six geographic subsections. Each subsection was evaluated for nine factors representing biological, physical and human use characteristics critical to the impacts of docks and piers. The nine factors, enclosed/open water bodies, water depth, shellfish habitat, eelgrass, fringe marsh, density of existing structures, moorings, navigational channels and recreational activity, were assigned a value of "0", "0.5" or "1". The least significance was assigned 0, and 1 represented the greatest significance. Results that were tabulated and mapped according to resource sensitivity indicated that a significant portion of the Bay's shoreline is extremely resource sensitive. The environmental impacts from construction and use of docks in those areas pose a direct threat to the extensive and fragile resources. New docks have been deemed inappropriate in these highly sensitive areas but less sensitive areas may be more appropriate for construction based on bay-wide criteria to be formulated once the plan is implemented.

USE OF AQUATIC SURFACE RESPIRATION BY *FUNDULUS HETEROCLITUS* AND *FUNDULUS MAJALIS*

McEnroe, Maryann , Janine Armstrong, Mike Mazzella, and Hazel Mutia
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Cyprinodonts such as the mummichog, *Fundulus heteroclitus*, and striped killifish, *Fundulus majalis*, are abundant in bays and harbors of western Long Island Sound. This environment is heavily impacted by anthropogenic inputs and nearshore areas are subject to diel hypoxia characteristic of eutrophic waters. We investigated use of alternate modes of respiration which may enable *Fundulus* spp. to inhabit hypoxic waters. Alternate modes of respiration, such as aquatic surface respiration or air-breathing, confer advantages which may allow fish to exploit marginal habitats (Kramer and McClure, 1982; Kramer, 1983) and may increase tolerance to low dissolved oxygen (DO). Few studies (McEnroe and Allen, 1992; McEnroe et al., in press) have investigated use of ASR by temperature estuarine species. Killifishes possess dorsally oriented mouths and flattened heads that enable them to use the oxygen-rich surface layer of the water without altering swimming posture (Lewis, 1970). We found that both species of *Fundulus* altered their respiratory behavior when exposed to progressive hypoxia in the laboratory and adopted aquatic surface respiration (ASR) increasingly after DO declined below 5.0 mg O₂/l. The threshold for this behavior was between 6.0 and 5.0 mg O₂/l in *F. majalis*. and between 5.0 and 4.0 mg O₂/l in *F. heteroclitus*, and the frequency of ASR was significantly greater in hypoxia (DO<3.0 mg O₂/l) than in normoxia (DO> 6.5 mg O₂/l).

SITE SELECTION OF CREATED SALT MARSHES: TESTING THE INFLUENCE OF SLOPE AND ORIENTATION ON THE GROWTH OF *SPARTINA ALTERNIFLORA*

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Salt marsh transplantation is used with increasing frequency in New England to restore and mitigate impacted marshes. Site selection for salt marsh restoration has many unknown parameters. We designed a field experiment to test whether the parameters of slope and orientation of the marsh surface are significant factors affecting growth of newly planted *Spartina alterniflora*. Thirty pots, each containing one *S. alterniflora* plant in soils typically used in created marsh projects, were buried in a southern Maine salt marsh. Treatments were orientation (north or south facing) and slope (3%, 10% or 25%), with measured elevations used as a blocking factor. Initial and final (86 days) rhizome length, plant biomass, height, leaf size and leaf number were measured. Results indicate that neither orientation nor slope had an effect on plant growth. Therefore it may not be necessary to consider these two environmental parameters in the site selection process for salt marsh creation and restoration projects in the northeast.

EFFECTS OF MARSH RESTORATION ON THE JUVENILE CHINOOK SALMON OF THE SALMON RIVER ESTUARY, OREGON

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Loss of marsh habitat in the Pacific Northwest is a growing problem. The effects of marsh restoration was studied in the Salmon River estuary using stomach contents from juvenile chinook salmon. Fish were collected from May through August, 1997 in each of four marsh regions. The gut contents were analyzed, prey items identified, and statistical analysis performed. Preliminary results show varying trends within and among marshes, and an overall trend in increased food supply and prey diversity within the recovering marshes.

HYDROLOGIC AND CHEMICAL CONTROL OF *PHRAGMITES* GROWTH IN TIDAL MARSHES

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Expansion of the common reed (*Phragmites australis*) into tidal marshes of the Northeast U.S. has resulted in significant changes to the plant community and possibly wetland function. We are conducting a two year study, funded by the CT Sea Grant Program, to determine the linkage between subsurface hydrology, sediment biogeochemistry, and *Phragmites* expansion. The study is being conducted in three tidal marshes along the salinity gradient of the lower Housatonic River Estuary. Continuous water table position, dissolved porewater species (ammonium, phosphate, sulfide), and plant vigor (stem density, height, tissue C:N:P) are measured at *Phragmites*, mixed stand, *Spartina alterniflora* zones on 3 transects at each marsh. We hypothesize that *Phragmites* vigor is positively correlated with porewater turnover rate and turnover rate is correlated with sediment chemistry. We expect that *Phragmites* is limited to areas of high porewater turnover in higher salinity, but not lower salinity marshes. Preliminary results (July 1998) indicate that for all sites water table depth is lowest (9.2 cm) and dissolved porewater sulfide is highest (545 μ M) at the mixed stand zone relative to the *Spartina* and *Phragmites* zones. The highest water table depth was observed in the *Spartina* zone (average = 20.9 cm), although sulfide was lowest (average = 280 μ M) in the *Phragmites* zone. Lower salinity in the *Phragmites* zone (9.4 ppt) compared to the *Spartina* zone (12.9 ppt) might indicate the influence of groundwater input at some sites which could also influence sulfide concentrations. When averaged across vegetation zones, the intermediate salinity marsh had the highest concentration of sulfide (620 μ M) when compared to the other marsh sites. *Phragmites* height at the intermediate salinity site is approximately half that of the other marshes. We anticipate that further calculations will reveal highest rates of porewater turnover at the *Spartina* zone and that an interaction of salinity and sulfide along the estuarine gradient might result in the present position of *Phragmites* stands.

SAMPLING FOR RIVER NUTRIENT FLUXES DURING STORM EVENTS

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Understanding the dynamics of nutrient fluxes in rivers flowing to estuaries requires observing the effects of storm events coupled with non-storm/low flow periods. Nutrient data from two rivers were collected during spring and summer, 1998, with associated river discharge values. This low flow information and the information from several summer storms will be used to decide adequate sampling strategies for the fall period. The use of portable automated liquid samplers were used to retrieve samples at desired time intervals throughout the sampling period without the need for human supervision. For this particular project and use of automated samplers, long term preservation is essential. Sodium azide has proven to be an adequate preservative. However, atmospheric inputs have been observed, even in the small, enclosed environment of automated samplers, particularly for nitrogen species including nitrate, nitrite, and ammonium. Strategies for conditional storm event sampling are being developed.

HISTORIC RECONSTRUCTION OF ECOLOGICAL EFFECTS: A USEFUL TOOL

Pesch, Carol and Richard Voyer
US EPA, NHEERL, AED, Narragansett, RI

An historic study of a community's environmentally impacted area can be a useful tool to engage the public in environmental issues and lead to informed decision-making. Historic studies provide an understanding of how current ecological conditions arose, provide information to identify past pollutant inputs, identify modification or loss of habitat, help identify changes in species composition and abundance, and help in planning remediation projects. New Bedford Harbor was used as a case study for an historic reconstruction. New Bedford Harbor gained attention when it was named a Superfund site because of PCB contamination. But current' conditions in New Bedford Harbor are the result of about 300 years of agriculture, commercial, and industrial activities. Located in southeastern Massachusetts, New Bedford is renowned as a former whaling center and former producer of fine quality textiles. Analysis of historic information about New Bedford revealed four sequential development periods, agriculture, whaling, textiles, and post-textile, each with a distinct effect on estuarine conditions. The historical analysis shows that impacts to New Bedford Harbor occurred throughout the development period, not just in recent years, and provides valuable insight in formulating remediation strategies.

TRACKING MARINE MORBIDITY, MORTALITY AND DISEASE IN COASTAL MARINE ECOSYSTEMS

Sherman, Benjamin H.

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Investigations of marine-born emergent disease (morbidity) and mortality are hampered by an absence of systematic inventory and assessment programs that might detect the patterns and possible climatic influences on the health of marine organisms. A 3-year effort designed to provide a baseline level of historic data to assist researchers in exploring the patterns of change within the marine environment has led to several important new types of hypothesis about disease spread, recurrence and magnitude. However, limitations due to varying data quality, lack of prior systematic inventory and indexing of biological disturbances, and complications involved with tracking climate-related marine disturbance have made it difficult to assess and predict harmful algae blooms and other major marine ecological disturbances (MMEDs). Marine disturbance events are often associated with acute and chronic economic losses which may now be evaluated by enumeration of the costs and duration of particular event types. The approach developed in this paper bridges the differences of 15 separate disciplines by normalizing data using the concept of common anomalies. A database of species groupings, serving as eco-indicators of ecological and economic disturbance, has become a useful tool in the effort to quantify and explore mechanisms of ecosystem change occurring in coastal waters within the last three decades. A description is given of a systems approach and methodology for inventorying, indexing, and extracting information on these significant marine disturbances, diseases, and toxicological events. This presentation will focus upon the integration of temporal, spatial, and topical approaches that led to the development of a unified framework for tracking and assessing damage due to episodic events that otherwise would remain unavailable to academia and resource custodians. An interactive world-wide web site has been developed to incorporate the reporting of new events and to maintain ongoing links to data sources (i.e., remote sensing imagery, climate data, state and federal reports, etc.). In addition an archive of past marine disease events and ecological disturbances are available via an online geographic information system and database. Ultimately, a queryable hypothesis-generating tool for lay and expert use may be made available from selected parts of the project's datasets. (This work was supported by NASA, and NOAA's Office of Global Programs. Grant ID NA56GPO623.)

GLOBAL CLIMATE WARMING AND ITS EFFECTS ON THE WORK OF ESTUARINE SCIENTISTS IN THE NORTHWESTERN ATLANTIC AND ITS EMBAYMENTS: THE BOULDER, COLORADO PERSPECTIVE

Spencer, Larry

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Although far from the ocean, NOAA and CU faculty are telling us that our work in the estuaries of the Northwestern Atlantic might be all wet, literally that is, if the predicted sea level changes take place. This report will be a brief summary of some of the seminars I attend on this topic while on sabbatical leave in the city that Robin Williams and others have made infamous. I will not attempt to solve the global warming problem, but I will describe how Greenland became depopulated in the 11th century and how Icelanders came to love "fish".

INFLUENCES OF LONG-TERM LOCAL AND GLOBAL CHANGES ON WINTERING BIRD ASSEMBLAGES IN A COASTAL AREA

Stieve, Erica and Ivan Valiela

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In the era of concern about anthropogenic influences on global climate, much research effort has been focused on determining if changes in global climate are entirely natural in variation or whether human activities are an exacerbating factor. As the search to quantify our impact on the environment proceeds, efforts also focus on the effects of climate change. The Christmas Bird Count (CBC) is an annual survey that has collected data on bird species and populations for many decades. The Cape Cod Christmas Bird Count, managed by the Massachusetts Audubon Society, has been conducted since 1930. This time span overlaps the same period that has come under focus for anthropogenic influences on climate change. As such, it provides an ideal reference for estimating possible impacts of climate change on wintering bird populations. Initial analysis has shown a large increase in the number of bird species found in the Cape Cod circle since 1930 as well as an increase in the absolute number of birds that winter on the Cape. Species whose wintering range broadly overlaps the Cape Cod area (Intermediate affinity) have declined in number of species and individuals since 1930. Species whose wintering range extends south to Cape Cod (Northern affinity) have shown increases in numbers that correlate with decreases in intermediate affinity species. These trends may indicate an increased incidence of competition between these groups of species, possibly forced by changes in climate. Further examination of the data will also be presented; incorporating preferred habitats of the species, local changes in land use, in addition to other potential influencing factors.

GROWTH OF *FUNDULUS HETEROCLITUS* AND *MENIDIA MENIDIA* IN ESTUARIES OF WAQUOIT BAY, MASSACHUSETTS EXPOSED TO DIFFERENT RATES OF NITROGEN LOADING

Tober, Joanna and Ivan Valiela

Boston University Marine Program, Marine Biological Laboratory, Woods Hole, MA 02543

We estimated the abundance and growth rate of *Fundulus heteroclitus* and *Menidia menidia*, the most common fish species found in estuaries of Waquoit Bay. We sampled fish from June through September in 1996 and 1997 in five estuaries subject to different rates of land-derived nitrogen loading. Abundance of *F. heteroclitus* was greater in estuaries with larger nitrogen loading rates. Growth rates of *F. heteroclitus* obtained from growth rings on scales and otoliths, did not vary among estuaries. Abundance and growth rates of *M. menidia* did not change with increased nitrogen loading rates. These results suggest that populations of *F. heteroclitus* are probably coupled to land-derived nitrogen loading, but *M. menidia* populations are not. Variations in relationships among growth rate, fish abundance, and nitrogen loading suggest that there are important resource limits on the fish assemblage in Waquoit Bay, but not all species are equally affected by such bottom-up trophic processes.

VERIFICATION OF THE WAQUOIT BAY NITROGEN LOADING MODEL

Tomasky, Gabrielle, Ivan Valiela¹, and Margaret Geist²

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World-wide eutrophication of estuaries has made accurate estimation of land-derived nitrogen loads an important priority. We developed the Waquoit Bay Nitrogen Loading Model (NLM) to calculate land derived nitrogen loads from watersheds with diverse land use mosaics to receiving shallow estuarine waters. NLM is appropriate for watersheds with mixes of forested, agricultural, and residential land uses, and underlain by coarse unconsolidated sediments. NLM tracks the fate of nitrogen inputs by atmospheric deposition, fertilizer use, and wastewater disposal, and assigns losses of nitrogen from each source as the nitrogen is transported through the land use mosaic on the watershed surface, and then through the underlying soils, vadose zones, and aquifers. In this presentation we verify NLM predictions of nitrogen loads by comparing NLM predictions to measured loads in different subestuaries in the Waquoit Bay estuarine system. Nitrogen loads predicted by NLM were statistically indistinguishable from field-measured nitrogen loading rates. The fit of model predictions to measurements remained good across the wide range of nitrogen loads, and across a broad range in size (10-10,000 ha) of land parcels. NLM predictions were most precise when specific parcels were larger than 200 ha, and within factors of 2 for smaller parcels. The good agreement obtained in this verification exercise suggests that NLM is a useful tool to address basic and applied questions about how land use patterns alter the fate of nitrogen traversing land ecosystems, and that NLM provides verified estimates of the land-derived nitrogen exports that transform receiving aquatic ecosystems.

TRANSFERRING SCIENCE TO USERS: RISK ASSESMENT AND CRITICAL LOADING OF ESTUARIES

Valiela, Ivan

Boston University Marine Program, Marine Biological Laboratory, Woods Hole, MA 02543

Effective transferring of scientific results to managers and stakeholders requires measures that may not come readily to most of us. We need to use only scientific terms that are essential, and they must be explained clearly. Our concern with uncertainty needs to be converted into thresholds or standards that are demanded in legal proceedings and writing of laws. Results must also be conveyed in timely fashion, often far earlier than we might be comfortable with. Ecological processes have to be introduced in a concrete fashion. Risk assessments and critical loading studies in Waquoit Bay will be discussed as a case history on science transferal.

HISTORY OF NEW BEDFORD: ECOLOGICAL CONSEQUENCES OF URBANIZATION

Richard Voyer and Carol Pesch

US EPA NHEERL, AED, Narragansett, RI

To have an understanding of ecological conditions in an impacted area, it is important to look at how past events affected current conditions. Historic studies provide an understanding of how current ecological conditions arose, provide information to identify past pollutant inputs, identify modification or loss of habitat, help identify changes in species compositions and abundance, and help in planning remediation projects. New Bedford Harbor was used as a case study-for an historic reconstruction. New Bedford Harbor gained attention when it was named a Superfund site because of PCB contamination. But current conditions in New Bedford Harbor are the result of about 300 years of agricultural, commercial, and industrial activities. Analysis of historic information about New Bedford revealed four sequential developmental periods, agriculture, whaling, textile, and post-textile, each with a distinct effect on estuarine conditions. Land was cleared during the agricultural period. A bridge and wharves built during the whaling period changed water circulation patterns and sediment deposition. During the textile period, marshes were filled and mills built on the filled land. The dramatic increase in population as mill workers moved to New Bedford caused a tremendous increase of sewage discharged into the harbor. The post-textile period brought a variety of industries to the area including two electronic firms that contaminated the harbor with PCBs. This historical analysis shows that impacts to New Bedford Harbor occurred throughout the development period, not just in recent years; it provides valuable insight in formulating remediation strategies, and is a useful tool to engage the public in environmental issues.

QUANTITATIVE IMPORTANCE OF *SPARTINA* AND *PHRAGMITES* DETRITUS AND BENTHIC MICROALGAE TO ESTUARINE FOOD WEBS

Wainright, Sam C.¹, Charlotte Fuller¹, Keith Bosley¹, Michael P. Weinstein², Kenneth W. Able³, Carolyn A. Currin⁴,

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Salt marshes support important fisheries by providing juveniles and adults with habitat and food. Yet, there are still large gaps in our knowledge of how salt marshes function as ecosystems. There is a general understanding that plants such as marsh grasses, phytoplankton, and diatoms supply energy to consumers such as invertebrates, fish, birds, and man. However, the relative roles of these plants is still a matter of debate. For example, while marsh grasses are the most obvious plants to the human eye, previous studies have found that phytoplankton and sedimentary diatoms may be more important to consumers. While the invasive plant, *Phragmites*, is widely perceived as undesirable compared to, for example, species of *Spartina*, little is known about the relative roles of *Phragmites* versus *Spartina* from an ecosystem perspective. We have been using stable isotope analysis as a tool to address some of these questions. Recent results from salt marshes along Delaware Bay indicate that resident marsh fishes depend on *Spartina* in *Spartina*-dominated marshes, and on *Phragmites* in *Phragmites*-dominated marshes. Ongoing studies in our lab are concerned with the importance of marshes to "transient" species, such as weakfish and migrating shorebirds, which spend only part of their lives in salt marshes.

COMMUNITY DECISIONS ABOUT MOLLUSCAN SHELLFISH CONTROLS IN MAINE AND MASSACHUSETTS

Wallace, Dana E.

Chance Along Shellfish Farms, Freeport, Maine.

Science has helped communities in Massachusetts and Maine make specific molluscan shellfish control decisions for most of this century. Maine separated from Massachusetts in 1820 and towns retained colonial rights and control over claims as public resources. Research as information gathering, observations, experience, and experiments have enabled community aquaculture practices to evolve based on research findings, yet customs and attitudes have modified wide acceptance and sustainability of commercially exploited species. Examples are cited in applied research in growth studies, predator controls, and transplanting with hatchery and natural stocks, overwintering of juveniles, and other measures.

Substituted for Saturday @ 9:30

"An outsider gets into a saltmarsh", by Elizabeth ('Stu') G. Mehlin

Stu is the author of the new book, **On the Rowley Salt Marsh: An Intimate Visit**

Five years ago, in the tradition of John Burroughs, I went to an island to observe nature in the upland Rowley salt marsh, the estuary west of Plum Island in Massachusetts. Though outside of academia and formal education, I felt it was a valid thing to do. When I first ventured forth, I expected to see birds, raccoons, and deer but instead found much more. I discovered a beautiful world throbbing with life and intricate with relationships. In this presentation I will give you a tour of my saltmarsh lab.