

ABSTRACTS

NEW ENGLAND ESTUARINE RESEARCH SOCIETY

Spring Meeting, May 1-3, 1997

**Wells National Estuarine Research Reserve
Wells, Maine**

Beck, A.D. and S. Morin, Narragansett Bay National Estuarine 'Research Reserve, Prudence Island, R.I. 02872. VISITING SCIENTISTS' RESEARCH PROGRAM AT THE NARRAGANSETT BAY NATIONAL ESTUARINE RESEARCH RESERVE

The NBNERR is comprised of Hope Island, Patience Island and about two thirds of the larger Prudence Island totaling 2300 acres of land and 1800 acres of surrounding waters. The Reserve is situated in the geographical center of Narragansett Bay. Habitats include open water, eelgrass meadows, tidal flats, marshes, cobble beaches, sand beaches, rock cliffs, and upland fields and forests. There were 30 research and monitoring projects conducted at the Reserve from 1992-1996. The NBNERR provides an inviting and supportive atmosphere for visiting scientists. A biological field station with a fully equipped research laboratory was constructed in 1996. Visiting researchers' quarters are available for overnight or extended stays. A meteorological monitoring station and NERRS and citizens water quality monitoring generate long-term data sets for interested investigators. A GIS mapping capability has been developed including base and resource overlay maps. Also logistical support is provided as needed.

Benoit, Lori K. Connecticut College, New London, CT 06320.
IMPACT OF *PHRAGMITES* ON TIDAL MARSH BIRDS IN CONNECTICUT.

Bird and vegetation surveys were conducted at forty salt and brackish marshes in Connecticut to determine whether common reed grass (*Phragmites australis*) has a negative impact on the abundance and diversity of bird species, particularly those listed as endangered, threatened or species of special concern. The average number of species per survey point in *Phragmites*-dominated habitats was significantly less compared to salt and brackish wetlands dominated by salt marsh graminoids such as *Spartina alterniflora*, *S. patens*, and *Pinus gerardi*. Additionally, the birds listed in Connecticut as endangered, threatened or species of special concern were found primarily in salt marshes. These results support the frequent conjecture that tidal marshes overrun by common reed grass have decreased bird species richness.

Bintz, Joanne C., and Scott W. Nixon University of Rhode Island Graduate School of Oceanography, Narragansett, RI 02882 CAN *IDOTEA BALTICA* EXERT TOP-DOWN CONTROL ON THE ENRICHMENT RESPONSE OF A COASTAL MARINE ECOSYSTEM? A MODEL SIMULATION

The common isopod *Idotea baltica* is a prevalent member of the animal community in eelgrass meadows. Detailed autecological studies of *I. Baltica* by Kim Strong and Graham Daborn in Nova Scotia have provided measurements of ingestion, respiration, growth and other parameters that have made it possible for us to develop a bio-energetic model of the species. We have used this model to calculate the potential impact of *I. baltica* grazing on epiphytes and macroalgae associated with eelgrass. In addition, we conducted a study of the effect of *I. baltica* grazing on the nutrient enrichment response of eelgrass, macroalgae and epiphytes using coastal lagoon mesocosms. Preliminary comparison of the model calculations and experimental results suggest that consumption by *I. baltica* does not exert a major top-down control on primary production of this system.

Bonis, Stanley; H. Gaudette. Biogeochemical Systems Center, EOS and Department of Earth Science, University of New Hampshire, Durham NH 03824. TRACE METALS IN THE SEDIMENTS OF GREAT BAY: IS THE ESTUARY HEALTHIER TODAY?

Historically, the Great Bay Estuary has been a center of commerce and industry in the seacoast area of New Hampshire, and continues today as an important economic resource. Effects from the localization of industry on the estuary were reported in the mid-1970's as elevated Cu, Pb, Zn, and Cr concentrations in the surficial sediments. The surficial sediments of the estuary were re-sampled in 1995 in order to determine if significant changes in the Cu, Pb, Zn, and Cr concentrations have occurred over the 23 year period. We report changes in the metal impacts during this period, principally a decrease in the Zn, Cu, Pb and Cr in those tributaries where sewage treatment facilities have been upgraded. In contrast, some parts of the estuary show increased levels of Cu, Pb, and Zn. Chromium concentration levels have decreased in all portions of the system but remain elevated. Our data suggest lessened metal impacts on the sediments of the Great Bay system since the 1970's.

Bruno, John F.* and Tatyana A. Rand. Brown University, Providence, RI, 02912.
NEW ENGLAND COBBLE BEACH PLANT COMMUNITIES: MECHANISMS OF COMMUNITY FACILITATION BY *SPARTINA ALTERNIFLORA*.

New England's cobble beach plant communities are a relatively common, yet virtually undescribed assemblage of annual and perennial forbs which live in an apparently stressful environment characterized by a highly mobile substrate, poor soil conditions, and daily immersion in saltwater. One striking aspect of this community is that it is only found behind beds of the clonal grass *S. alterniflora*, forming parallel bands along the shore. The purpose of this study is to determine the mechanism of community facilitation by testing 4 alternative hypotheses which explain the absence of adult plants in locations without *S. alterniflora*: 1- Insufficient seed supply; 2-Failure of seeds to germinate; 3-Intolerance of seedlings; 4-Intolerance of adults. This is being accomplished through measurements of seed supply and environmental conditions altered by *S. alterniflora* (e.g. flow rate, cobble turnover and soil quality), seed additions, and transplantation of seedlings and adult plants of 4 species. Preliminary results suggests that *S. alterniflora* beds reduce flow rate, wave energy, and substrate movement, increase soil quality, and may enhance seed supply and seedling establishment, thereby facilitating the presence of this plant assemblage.

Brush, Mark J. and Scott W. Nixon. Graduate School of Oceanography, University of Rhode Island, Narragansett, RI 02882. EFFECT OF BIOMASS LAYERING ON PRODUCTION AND RESPIRATION RATES OF *ULVA LACTUCA*.

The effect of biomass layering on production and respiration rates in *Ulva lactuca* was assessed by incubating *Ulva* in 1, 2, 4, and 8 layers under field conditions. Resultant P-I curves showed reduced per gram production rates and lowered photoinhibition as layering increased. Layering also reduced per gram respiration rates. The effects on production were modeled using both Monod and Steele functions. Simulations using the former equation have demonstrated that the reduced rates may be largely attributed to attenuation of light by thalli occurring in the upper layers of the stack, but the empirical data are not sufficiently constrained to select one formulation over the other. The effect on respiration was also modeled to determine whether the decreased respiration rates were the result of limited oxygen diffusion between the layers. Since *Ulva* has a tendency to accumulate in layers under natural conditions, these results improve upon measurements made with single thalli or clumps of algae.

Burdick, David, Roelof Boumans and Frederick Short University of New Hampshire, Jackson Estuarine Laboratory, Center for Marine Biology, Durham, NH 03824; and Michele Dionne, Wells National Estuarine Research Reserve, Wells, ME 04090

IMPACTS TO SALT MARSHES FROM TIDAL RESTRICTIONS AND RESPONSES TO TIDAL RESTORATION

Following restoration of tidal hydrology at two salt marshes in northern New England, several functional indicators were examined: tidal range, surface elevation, soil salinity, plant cover and fish use. Prior to restoration, both systems allowed fresh water drainage through a single culvert, and each had 'a flap gate that prevented salt water from entering the marsh. Impacts included loss of tides, freshening of flood waters and soils, decreased flooding, subsidence of the marsh surface, and a change in vegetation from salt marsh to fresh and brackish marsh species. Following re-establishment of tidal exchange, marsh flooding increased dramatically, leading to greater salinities, greater sedimentation rates, and use of the area by estuarine fish. In addition, fresh water plants were quickly killed by the salt water, but die-back and open water areas were revegetated with *Spartina alterniflora* and other salt marsh plants. Qualitative differences in the responses of marsh indicators to increased tidal flooding, as well as the rates of recovery, reflect contrasting hydrologies.

Cartwright, M. A. DIETS OF FISHES IN THE LITTLE RIVER ESTUARY: TRENDS IN FEEDING SELECTIVITY.

The Little River estuary is a small, undisturbed salt marsh within the Wells National Estuarine Research Reserve in southern Maine. The fish community was sampled along the entire length of the main creek channel throughout the summer of 1995, and stomach contents were analyzed to characterize the overall diets (including overlap among species) and to compare the benthic portions of the diets to the available benthic prey bases in the upper and lower estuary during three summer periods. Statistical models were constructed to determine whether diet composition and selectivity varied spatially, temporally, and/or ontogenetically. In addition, the trophic ecology of fishes in the Little River was evaluated within the context of optimal foraging theory.

The fishes in the Little River generally conformed to the expected pattern of trophic generalism derived from studies in other areas. However, most species exhibited some selectivity in terms of one or two preferred prey types. Selectivity sometimes varied with prey abundance ("switching"), which itself varied seasonally and spatially along the tidal channel. Support for classical OFT was mixed; Atlantic silversides (*Menidia menidia*) and fourspined sticklebacks (*Apeltes quadracus*) broadened their niches when food became abundant, contradicting classical OFT and possibly supporting the "threshold" hypothesis. In contrast, ninespined sticklebacks (*Pungitius pungitius*) and *Morone saxatilis* conformed to OFT by broadening their diets when and where food was less plentiful. Comparison of diet composition and trophic partitioning of these fishes to a study performed in mid-coast Maine revealed the extreme dietary flexibility of these estuarine species. Dominant prey items differed between the two marshes, as did patterns of niche overlap, thus underscoring the variable factors that affect benthic communities, fish communities, and the overall detrital food web.

Chester, Charles M. Department of Zoology, University of New Hampshire, Durham, NH 03824.
DEVELOPMENTAL PLASTICITY IN AN ESTUARINE NUDIBRANCH

Tenellia adspersa is a small (5-7 mm) nudibranch common to New England estuaries. Previous studies have demonstrated that *Tenellia* has a plastic developmental strategy; eggs from the same spawn hatch either as pelagic non-feeding larvae or metamorphose within the egg capsule. This strategy is due to variation in maternal investment; eggs >125mm metamorphose within the capsule. Adult nutritional state affects the size of the eggs and the frequency 'of the two developmental modes. The present study investigated whether offspring from starved adults differed in growth and survival compared to those from fed adults. Juvenile growth varied substantially among both groups. In contrast to fed adults, eggs from starved adults were significantly smaller, hatched as swimming larvae, and developed into smaller juveniles. However, survival to maturity of these smaller juveniles was higher. This suggests that any cost to the offspring associated with starvation is short-term.

Cornelisen, Christopher. Massachusetts Coastal Zone Management, Boston, MA 02202.
DEVELOPMENT OF A REGIONAL DATABASE ON COASTAL HABITAT RESTORATION

Habitat restoration, a relatively young science, is increasingly employed in an effort to reverse degradation of natural resources. With a rise in the number and types of restoration projects there is a need to collect, distribute, and share current information throughout the Gulf of Maine (from Cape Cod to Cape Sable, Nova Scotia). By exchanging information, restoration of coastal habitats and associated species may be pursued in an effective and consistent manner. *A Coastal Habitat Restoration Database* has been developed to serve the region by providing information on restoration projects. The database includes information on projects for the restoration of habitats, such as salt marsh and dunes, and projects for the restoration of one or more species, such as anadromous fish and seabirds. Information is project-specific and includes location, methods for restoration and monitoring, restoration success, and information on permitting, costs, and funding sources. The inclusion of project locations, based on USGS topographic maps and/or coordinates, will allow for integration with Geographic Information Systems. Future efforts include regional advocacy and distribution, and formatting the database for the Internet on the Gulf of Maine Council on the Marine Environment's Environmental Data and Information Management System (EDIMS).

Ryan Davis, and Fred Short. Jackson Estuarine Laboratory, University of New Hampshire,
85 Adams Point Road, Durham, NH 03824.
HELD EXPERIMENTS QUANTIFY THE EFFECT OF BIOTURBATION BY *NEANTHES*
VIRENS (SARS) ON TRANSPLANTED EELGRASS (*ZOSTERA MARINA* L.)

We recently completed a 7-acre eelgrass (*Zostera marina* L.) transplanting project, the largest so far undertaken on the east coast of the United States. The project was successful overall, but one subtidal site failed, with bioturbation by clamworms suspected. The blades of eelgrass transplants were found pulled down into clamworm burrows, causing the remaining part of the blade to lie horizontally on the sediment, where it was quickly buried. Field experiments were conducted in the summer of 1996 to prove that clamworm (*Neanthes virens* Sars) bioturbation can cause transplant loss. Two replicates of three treatments, each providing a varying degree of protection from bioturbation, were used at three sites. The first treatment (the control) provided no protection from bioturbation; the second provided protection from benthic infauna, embedding a screen just below the sediment surface to prevent large benthic worms from reaching the plants; the third provided protection from all benthic bioturbation by growing the eelgrass hydroponically above the bottom on a wire frame. Growth rates, plant survival, and the number of blades pulled into the sediment were recorded for all experimental transplants. *Neanthes virens* were enumerated and measured for biomass for use in the regression analysis.

Eelgrass growth rates were similar for all sites and all treatments, indicating that water quality was sufficient to support eelgrass growth and was not a cause of transplant loss. Transplant survival was significantly different among all treatments ($P=0.0001$): transplants without any protection from bioturbation had the lowest survival and transplants completely protected from benthic bioturbation the highest survival. The number of blades pulled into the substrate was significantly higher for transplants without protection ($P=0.0001$). Field observations showed that the number of blades pulled into the substrate was also significantly higher at the site ($P=0.0047$) which had the highest *N. virens* densities, where previous transplanting efforts had failed. Regression analysis of all experimental data revealed a significant relationship ($r^2 = 0.540$) between the number of blades pulled into the sediment and the total number of *N. virens* present at the site. These results demonstrate that clamworms, *N. virens*, can significantly decrease the survival of transplanted eelgrass and that protecting transplants from bioturbation could significantly increase their survival.

Dettmann, E.H., and MA Abdelrhman, U.S. Environmental Protection Agency, National Health and Ecological Effects Research Laboratory, Atlantic Ecology Division, 27 Tarzwell Drive, Narragansett, RI 02882.
EVALUATION OF SOME METHODS TO MEASURE AND ESTIMATE EMBAYMENT FLUSHING TIME.

Nutrient retention in marine embayments is strongly correlated with mean water retention time (flushing time), which is often used to indicate embayment sensitivity to nutrient loading, and to calculate nitrogen loading limits. Accurate determinations of flushing time are required for calculation of nutrient loading limits for use in community planning. However, these measurements can be costly, and more easily calculated estimators or surrogates (e.g. the tidal prism model and the ratio of embayment area to inlet width) are sometimes used to screen and prioritize embayments for further study. We review results of field and modeling studies that use generally accepted methods to determine flushing time, to illustrate complicating factors that can arise. We also evaluate the tidal prism model and the ratio of embayment area to inlet width as an estimator and surrogate, respectively, for flushing time. Comparison with field measurements shows that while tidal prism model calculations are often a biased and "noisy" estimator of flushing time, they are useful for some embayment types. Similar comparisons for the ratio of embayment area to inlet width show little correlation with flushing time.

D. R. Franz, Biology Dept., Brooklyn College Cuny, Brooklyn, NY 11210
EUTROPHICATION AND MARSH EROSION IN JAMAICA BAY--SPECULATIVE
LINKAGES

The fringing salt marshes of Jamaica Bay are eroding from the seaward edges. I speculate that excessive nitrogen loading indirectly contributes to erosion via a set of linkages, incl.: (1) High summer phytoplankton production contributes to high secondary production of Ribbed Mussels; (2) Nitrogen loading promotes intertidal macroalgal mats (primarily Sea Lettuce) and high growth of *Spartina alterniflora* and possibly *Phragmites*. Hyperdense mussel populations form berms at the marsh edge which retard marsh drainoff, and physically modify the marsh edge, leading to erosional turbulence and enhanced erosion. Mats of drift *Ulva* and grass stems (*Spartina* & *Phragmites*) are rafted onto the marsh flat, producing permanent disturbance patches. Summer *Ulva* production may also contribute to permanent populations of non-migratory Canada Geese which degrade the marsh surface, particularly in winter.

GETCHELL, Stefanie A., BOECKELER, Andrew J., GAUDETTE, Henri E., Dept. of Earth Sciences, University of New Hampshire, Durham, NH 03824. **TRACE METAL CONTAMINANTS IN THE BOOTHBAY REGION: CORE PROFILES OF TRACE METAL CONCENTRATIONS AND Pb ISOTOPIC COMPOSITION**

In an attempt to determine the timing, magnitude, and potential sources of trace metal inputs to the Boothbay, Maine region, sediment cores were collected and analyzed for Cu, Pb, Zn, Cd, ^{210}Pb , and Pb isotopic compositions.

Background Pb concentrations are well-defined. In Boothbay Harbor, Pb contamination becomes evident in 1878, reaching maximum levels of 92 ppm by ~1947. This represents an 820% increase over background levels. In the Gulf Of Maine (GOM), Pb contamination is not detected until 1913. There is a consistent increase in Pb concentrations after 1913, to a maximum in 1983 that equals a 240% increase over background.

$^{206}\text{Pb}/^{207}\text{Pb}$ ratios in both Boothbay and the GOM indicate historically variable sources of Pb contamination in this region of coastal Maine. Although separated by only a short distance, both regions show measurable differences in Pb isotopic trends. These results suggest that non-point source Pb contaminants are temporally variable in source and magnitude over a scale of < 30 km.

Hogan, Jennifer M. and D.L. Graf. Biology Department, Northeastern University, Boston, MA 02115. DISTRIBUTION OF *Melampus bidentatus* IN A NATURAL AND A RESTORED SALT MARSH.

Both restored and undisturbed portions of a salt marsh in Marshfield, Massachusetts were surveyed for elevation, plant cover, plant stem density, and abundance of the eastern melampus (*Melampus bidentatus*). Snail densities in both marshes exceeded most published accounts. *Melampus* density was significantly higher in the natural marsh, even though the two marshes were comparable in elevation and floral assemblage. The difference in density appears to be an artifact of experimental design, attributable to the distance of the sampling stations from the nearest tidal creek. Greatest snail densities were associated with *Distichlis spicata*, which also occurred at the highest elevations. More precise reporting of plant assemblage, location of sampling relative to tidal creeks, and the time of day of sampling is recommended.

Hoven¹, Heidi M., E.T. Short² and K.E. Gaidette², Department of Natural Resources and Jackson Estuarine Laboratory¹; Biogeochemical Systems Center², UNH, Durham, NH 03824. EXPOSURE OF EELGRASS, *Zostera marina* L, TO MARINE SEDIMENT CONTAMINATED WITH Pb: EVALUATING PLANT GROWTH AND Pb UPTAKE.

Eelgrass, *Zostera marina* L, was planted in mesocosms at three different densities in marine sediment of three different lead (Pb) concentrations to determine to what extent eelgrass takes up Pb and to determine whether Pb affects eelgrass growth. Leaf and rhizome tissue Pb concentrations were analyzed using inductively coupled plasma (ICP) spectrometry. Plant uptake rates and accumulation of Pb were determined from eelgrass collected after one and two months' exposure to sediment with medium (90 ppm) and high (600 ppm) [Pb]. Morphology, growth rate, oxygen evolution and chlorophyll fluorescence of eelgrass were monitored after one and two months to determine whether morphological and physiological changes occurred. Eelgrass accumulated Pb in varying amounts, but there was no effect of Pb on eelgrass growth based on measures of growth and physiological activities. Lead uptake by eelgrass was plant density dependent during the first month for shoots grown in sediment with high [Pb]. After the second month of exposure to the high [Pb], uptake rates of Pb were slower for all eelgrass densities. Eelgrass grown in the sediment with medium [Pb] took up less Pb than eelgrass grown in the sediment with high [Pb], but removed proportionately more Pb from the sediment than high sediment [Pb] shoots. Lead uptake was slower after the second month of exposure for shoots grown in the sediment with medium [Pb]. Lead taken up by new eelgrass tissue after the first month of exposure ranged from 17 - 340 $\mu\text{g Pb} \cdot \text{m}^{-2} \cdot \text{day}^{-1}$. Because Pb uptake was not proportional to sediment [Pb] and was influenced by plant density, we speculate that uptake of Pb by eelgrass was limited to the rate of new binding sites produced during plant growth. Since eelgrass growth was not affected by Pb uptake, we propose eelgrass as an appropriate species in remediative actions for Pb-contaminated estuarine sediment.

Kelly, Jack, North Carolina State University; Michele Dionne, Wells National Estuarine Research Reserve; John Sowles, Maine Department of Environmental Protection. **DO TRENDS IN MAINE COASTAL WATERS.**

About two dozen water bodies located along the length of Maine's extensive coastline were sampled during summer-fall of 1995 and 1996. Measurements of dissolved oxygen (DO) were used to assess spatial trends in water quality. Ultimately, the goal is to evaluate the potential vulnerability of Maine's coastal estuaries and embayments to enrichment, particularly from land-derived sources. Results are still being analyzed; in general, high levels of DO were documented. For example, roughly 95% of 1995 DO readings (n= 3611) were $>7 \text{ mg L}^{-1}$ and $> 85\%$ of saturation. Lowest DO values, as a general rule, tended to be found in September at low tide near dawn in bottom water toward the head of an embayment. Regression analysis for 1995 data indicated that lower DO was associated with ecosystems having slightly less tidal range but relatively high freshwater runoff (a proxy for land-derived loading?); additionally, some influence of stratification was suggested. Results were used to establish additional systems for sampling in 1996, when both in situ DO and nutrient concentrations were measured. Pending results will clarify if, in general, ecosystems with relatively high freshwater runoff (often more strongly stratified) tend to have lower annual DO minima.

Liebman, Matthew¹; D. Switzer², P. Nolan², and G. Hellyer². U.S. EPA New England, ¹Boston, and ²Lexington, MA. AN ECOSYSTEM HEALTH ASSESSMENT FOR EPA'S STATE OF THE NEW ENGLAND ENVIRONMENT -- 1997.

Since 1995, the U.S. EPA New England has prepared a "State of the New England Environment" report. The 1997 report includes a section on ecosystem health, focusing specifically on ambient air toxics concentration and deposition, toxic contamination of sediments and biota, eutrophication in lakes and estuaries, aquatic life assessments for rivers and streams, distribution of invasive non-native species, wetland habitat loss, and status of endangered and threatened species. Much of the data for this report derived from large national monitoring networks or databases. For example, the National Ambient Air monitoring network measures air pollutants at selected sites in New England. EPA's National Sediment Inventory (NSI) compiled data from a variety of sources to provide an assessment of sediment quality. Information from state monitoring programs were useful in assessment of aquatic life in rivers and streams, and in determining the trophic status of lakes. Some of the information has been complemented by regional monitoring information, such as EPA's Environmental Monitoring and Assessment Program (EMAP). The most recent data available (1990 to 1996) was assessed. For some aspects of the environment, e.g. some toxics, the environment appears to be improving. In contrast, loss or alteration of habitat and biotic communities continues to be a major environmental problem.

Coren Milbury, Dept. of Zoology, University of New Hampshire, Durham, NH 03824
THE DISTRIBUTION OF JUVENILE SOFT-SHELL CLAM (*Myra arenaria* LINNAEUS)
RECRUITMENT WITHIN THE WEBHANNET RIVER ESTUARY, WELLS, ME

The soft-shell clam *Mya arenaria* Linnaeus is an important economic resource. To assess recruitment, juvenile soft-shell clams were collected through the Webhannet Estuary, Wells, Maine. Samples were collected from 51 sites selected every two hundred meters within six areas of the 13 km estuary. Four core samples were taken at each site, two to assess clam recruitment and two to determine substrate type. Sediment grain size analysis are in progress and will be considered in relation to clam density. It has been observed that a lower percentage of organic matter corresponds inversely with high densities of clam spat. Clam spat were counted, aged, and measured (length and widths). Larval settlement within the estuary was highest by the ocean inlet and decreased as distance from the inlet increased. It appears that two juvenile size classes were observed, suggesting that two spawnings occurred as opposed to the expected

Morgan, Pamela A. and Frederick T. Short, Jackson Estuarine Laboratory, University of New Hampshire, Durham, NH, 03824. **ASSESSING FUNCTIONS OF CREATED SALT MARSHES OF THE GREAT BAY ESTUARY, NEW HAMPSHIRE: PLANT DIVERSITY AND SOIL ORGANIC MATTER CONTENT.**

We assessed two functions of created salt marshes in the Great Bay Estuary and compared them to those of natural salt marshes in the same estuary. In particular, we focused on smaller, fringing salt marshes which are common in Maine and New Hampshire. Twelve natural marshes were selected using principal component analysis for comparison with six created marshes of different ages. The relative abundance of plant species on each marsh was determined from percent cover estimates along band transects, and data were analyzed using detrended correspondence analysis, an ordination method. The resulting site ordination showed all but one created marsh (the oldest marsh) were distinct from the reference marshes. Percent organic matter in marsh soils was determined from loss on ignition of three soil cores per marsh. Created marshes contained significantly less organic matter than reference marshes, but organic matter content did increase in older created marshes.

Olson, Eric and P. Fell. Zoology Department, Connecticut College, New London, CT 06320. **SELECTED MACROINVERTEBRATES ON THREE RESTORING AND THREE REFERENCE MARSHES AT BARN ISLAND, CT.**

Populations of 6 macroinvertebrates that are characteristic of tidal salt marshes (*Melampus bidentatus*, *Geukensia demissa*, *Philoscia vittata*, *Orchestia grillus*, *Uhlorchestia spartinophila* and *Gammarus palustris*) were studied on a marsh (No. 2) that has been in the process of restoration for 18 yrs. and 2 marshes (No. 3 and 4) that have been restoring for 9 yrs., as well as on nearby reference marshes. On marsh No. 2, which has converted from a *Typha* dominated system to ca 78% cover of *Spartina alterniflora*, the density and biomass of *Melampus* are not significantly different from those on the reference marsh; and with respect to the 6 species of invertebrates, the abundance similarity index of the 2 marshes is 0.9. On marsh No. 3, which was largely mud flat and is now ca 45% covered by *S. alterniflora*, the population of *Melampus* is significantly smaller than on the reference marsh and the similarity index is 0.2. Marsh No. 4 is still largely covered by *Phragmites australis*. Although the density of *Melampus* is low, the similarity index between this marsh and its associated reference marsh is 0.5.

O' Neill, D. Christine; and R. Askins. Dept. of Zoology, Connecticut College, New London, CT 06320. **REPRODUCTIVE SUCCESS OF OSPREYS AT TWO SITES IN CONNECTICUT.**

Two populations of Ospreys in Connecticut, one at a freshwater reservoir in Groton and one at Great Island, a salt marsh in Old Lyme, have had substantially different rates of nest success since 1993. Great Island Ospreys have fledged few young while Groton Reservoir Ospreys have had good nest success. The rates at which male Ospreys delivered fish to their nests were not significantly different for the two study areas. Amounts of organochlorines in inviable eggs were similar for the two sites. Evidence for raccoon predation was discovered at Great Island but not at Groton Reservoir. Raccoon claw marks were found on nesting poles and eggs disappeared early in the season on the island. Further monitoring of nest predation is recommended.

Orsted, A. C., R. S. Warren and W. A. Niering. Connecticut College, New London, CT 06320.
RECOVERY OF VEGETATION AND MACROINVERTEBRATE POPULATIONS ON
IMPOUNDED CONNECTICUT SALT MARSHES WITH RESTORATION OF TIDAL FLOODING.

Five formerly *Spartina* dominated salt marshes distributed along ca. 100 km of the Connecticut coast had converted to *Phragmites australis* monocultures after two or more decades of tidal restriction. Tidal flooding has been restored to the various systems for five, six, nine and ten years. Rates of vegetation recovery were followed using '74, '81, '86, '90, and '95 air photos, scale normalized by GIS. Vegetation was also sampled in 1996 along three or four 30 - 50 m transects set normal to the creek at each site. Peat surface salinity, soil water salinity, and soil water depth were measured over the growing season at three points along each transect: Stem density, stem height, and flowering frequency of *P. australis* was taken at each salinity point, as were macroinvertebrate populations. *Spartina* dominated vegetation is returning at rates of 0.6 to 7.7% yr⁻¹; soil water salinity, which is tightly correlated with flooding frequency, appears to be the most important environmental factor accounting for this variability. Invertebrate population densities in restored areas were generally lower than comparable control sites and at least in some areas correlate better with peat surface salinity than with other variables.

Spares, Aaron and Michael Dadswell. Biology Department, Acadia University, Wolfville, Nova Scotia BOP 1X0. GOAT LAKE, A WARM WATER, ESTUARINE REFUGIA FOR MOLLUSCS.

Goat Lake, a tidal, silled, 11.5 m deep lake-like estuary situated in Lunenburg County, Nova Scotia was surveyed as a potential nursery site for shellfish. In a two year study, data on temperature, salinity, pH, and dissolved oxygen was collected to compare to the adjacent waters of Mahone Bay. Results indicate lake-like temperature profiles with a strong thermocline developing during mid-summer and an average surface temperature 2.8°C above adjacent Mahone Bay. The combination of decreased mixing due to the destruction of one of two connecting channels to Mahone Bay and poor flushing leads to anoxic conditions in the lower saline layer. Goat Lake is a warm marine environment serving as a refugia for reproducing populations of molluscs such as ribbed mussels, *Geukensia demissa* and oysters, *Crassostrea virginica* which otherwise do not occur along the east coast of Nova Scotia.

Larry T. Spencer, Natural Science Department, Plymouth State College, Plymouth, NH 03264 H.
H BIGELO, THE U.S. ALBATROSS AND THE GULF OF MAINE

In the spring of 1920, Henry Bryant Bigelow, used the U.S. Fisheries steamer, the *Albatross* to perform a general survey of the waters of southern Nova Scotia and the Gulf of Maine. This presentation will explore the work of Bigelow in the Gulf of Maine and relate those studies to the history of oceanography in general and to the use of the *Albatross* as a research vessel.

Theresa A. Theodose and Justine B. Roths. University of Southern Maine, Portland, ME 04104.
SPATIAL VARIATION IN SOIL NUTRIENT AVAILABILITY, PRODUCTION, AND PLANT
SPECIES DIVERSITY ON TWO HIGH SALT MARSHES IN SOUTHERN MAINE

How soil nutrient availability relates to vegetation patterns under the condition of salt stress was examined in two high salt marshes in Wells, Maine, the pristine Little River Marsh and the recently restored Drake's island Marsh. Primary production, litter production, plant species diversity, and soil N, P, K were determined for two graminoid dominated zones and the saline forb pan zone on both marshes. Primary production and litter production were greater in the restored marsh than in the pristine marsh and higher in graminoid zones than in forb pans. At the pristine marsh, soil N, P, and K were higher in forb pans than in the graminoid zones, but this pattern was only true for N at the restored marsh. Diversity was highest in the forb pan zone of the pristine marsh, but lowest in this zone of the restored marsh. Within the pristine marsh, evenness more so than richness contributed to the diversity trend. Several species co-dominated the forb pan zone of the pristine marsh, and each fell within a distinct plant functional group with respect to probable nutrient requirements. Since the high salinities of forb pans prevent invasion by dominant graminoids from other zones, we hypothesize that a combination of salt stress and high nutrient availability promotes diversity in the pristine Little River Marsh. Such a mechanism may not be operating in the recently restored Drake's Island Marsh.

Walker, Henry¹, D.Q. Kellogg², and A. Gold²; ¹EPA Atlantic Ecology Division, Narragansett, R.I.,
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EVALUATING UNCERTAINTIES IN WATERSHED NITRATE LOADINGS UNDER VARYING
SCENARIOS OF LAND USE: IMPLICATIONS FOR COASTAL RECEIVING WATERS.

There is an increasing need consider multiple objectives in managing nitrogen loadings to watersheds.

Potential changes in nitrogen loading under different land-use scenarios and from alternative management practices are estimated for the Hunt-Potowomut watershed in RI. Nitrogen loadings in the watershed are evaluated to quantify the range and probable distributions of nitrogen inputs to surface and ground water. Simple GIS modeling tools can be used to characterize plausible surface and ground water trajectories. Approaches are being developed for qualitative evaluation of potential nitrogen losses in source areas and via sinks, such as riparian zones, wetlands, and impoundments downstream from source areas. Possible coastal ecological consequences could then be evaluated for differing land use scenarios, alternative watershed management strategies, and uncertainties inherent in these types of calculations.

SALT MARSH ECOLOGY IN THE GULF OF MAINE
ABSTRACTS FROM PLENARY SESSION

Buchsbaum, Robert. Massachusetts Audubon Society, 364 Grapevine Road, Wenham, MA 01984. ECOLOGICAL ASSESSMENTS AND MONITORING OF SALT MARSHES IMPACTED BY TIDAL RESTRICTIONS.

With funding from the Oak Knoll Foundation, we are developing monitoring protocols that can be used to assess the impacts of tidal restrictions on salt marshes and to evaluate the success of restoration efforts. Some of these protocols will ideally be straightforward enough to be carried out by volunteer citizens yet provide sufficient information to aid coastal managers in making decisions about restoration. We have set up a series of transects in the salt marshes of Plum Island Sound, MA through transitional zones between *Spartina* spp. and *Phragmites australis* to document the spread of the invasive *Phragmites* and to estimate a number of vegetation parameters. Wells set up along these transects are being used to measure groundwater depths and salinities in different vegetation zones, and SET tables are used to estimate elevation changes on both sides of a tidal restriction. We are also documenting the use of different vegetation zones by birds and insects and the effect of culverts on the passage of fish. Our preliminary data suggests that the use of *Phragmites* and adjacent habitats by biota is highly variable and may be dependent upon landscape factors.

Burdick, David, Roelof Boumans and Frederick Short, University of New Hampshire, Jackson Estuarine Laboratory, Center for Marine Biology, Durham, NH 03824; and Michele Dionne, Wells National Estuarine Research Reserve, Wells, ME 04090. IMPACTS TO SALT MARSHES FROM TIDAL RESTRICTIONS AND RESPONSES TO TIDAL RESTORATION

Following restoration of tidal hydrology at two salt marshes in northern New England, several functional indicators were examined: tidal range, surface elevation, soil salinity, plant cover, and fish use. Prior to restoration, both systems allowed fresh water drainage through a single culvert, and each had a flap gate that prevented salt water from entering the marsh. Impacts included loss of tides, freshening of flood waters and soils, decreased flooding, subsidence of the marsh surface, and a change in vegetation from salt marsh to fresh and brackish marsh species. Following re-establishment of tidal exchange, marsh flooding increased dramatically, leading to greater salinities, greater sedimentation rates, and the use of the area by estuarine fish. In addition, fresh water plants were quickly killed by the salt water, but die-back and open water areas were revegetated with *Spartina alterniflora* and other salt marsh plants. Qualitative differences in response of marsh indicators to increased tidal flooding, as well as the rates of recovery, reflect contrasting hydrologies.

Deegan, Linda, Ecosystems Center, Marine Biological Laboratory, Woods Hole, MA 02543. AN OVERVIEW OF THE PISCES PROJECT: PLUM ISLAND SOUND AND COMPARATIVE ECOSYSTEMS PROJECT

The goal of the Plum Island Sound and Comparative Ecosystems (Pisces) Land-Margin Ecosystems Research project is to understand the link between processes in terrestrial ecosystems and productivity of estuaries. We have examined how flows of nutrients and organic matter from land affect estuarine food webs and productivity. We have measured the flows of nutrients and organic matter from land uses (urban, suburban, agricultural) and evaluated the usability of the organic matter by bacterial bioassays. We have done whole systems surveys of benthic, pelagic, and fish production, as well as mesocosm experiments to determine the interacting effects of nutrients and organic matter on estuarine food webs. We have found that the flow of nutrients and organic matter from land is strongly controlled by land-use and has important consequences for the productivity of estuaries.

Fegley, Stephen R. Maine Maritime Academy, Castine, Maine 04421; and Brian F. Beal, University of Maine at Machias, Machias, Maine 04654. EFFECTS OF GEOGRAPHY, TIDAL HEIGHT, AND PREDATION ON SETTLEMENT AND RECRUITMENT VARIATION IN AN ESTUARINE BIVALVE MOLLUSK

Soft-shell clams, *Mya arenaria* L., have been harvested commercially from the intertidal along the Maine coast since the mid-1800's. Historically, 45% to 65% of all clams landed in Maine are harvested in the two eastern counties (Hancock and Washington). Between 1982 and 1992, landings in the eastern region of Maine declined by 90% while, concomitantly, landings in southwestern region increased by 15%. The decline may be due to factors affecting 1) the fecundity or spawning success of adults, 2) larval survival and/or transport, or 3) post-settlement success. We investigated the latter using parallel manipulative experiments at six intertidal mudflats in both regions of the coast from April to November 1995. We will discuss biotic and abiotic aspects of the dynamics of newly settled soft-shell clam individuals.

At each of the twelve sites, we initiated a long-term experiment (Experiment I) to examine interactive effects of tidal height (low vs. high) and predator exclusion on clam recruitment using a generalized randomized block design. In April, at each location, 240 four-inch plastic plant pots were filled with a terrestrial "mason sand and buried flush with the sediment. These 2,880 experimental units remained undisturbed for seven months when the contents of each were sieved using a 1.2 mm screen. At two of the six sites in both regions, we initiated a series of short-term studies (Experiment II) to examine spatial and temporal aspects of clam settlement. Again, pots were used as experimental units, however, these were recovered every two weeks and the top 1 cm of sediment from each processed in such a way that allowed us to recover clams as small as 125 microns.

Results from Experiment I indicated that average abundances of *Mya* spat (individuals < 10 mm in length) were early seven times greater in southwestern Maine than those in eastern Maine (mean \pm 1 SE in east = 46.1 (3.5) individuals per square meter vs. 305.6 (19.9). Although there was no consistent effect of tidal height at the eastern Maine sites, nearly twice as many juvenile clams were found near high tide locations. In addition, significantly more recently settled clams were found in pots protected with plastic netting than in those units that were unprotected in eastern Maine. Effects of tidal height on clam recruitment were significant at four of the six southwestern sites, and, in each case, the direction of the difference was opposite that observed in eastern Maine. Protective netting either enhanced settlement of clams or protected spat once they reached the benthos at four of the six sites in southwestern Maine.

Results from Experiment II allowed us to estimate time of year when peak settlement occurred. In southwestern Maine, this occurred during the last two weeks of July and in eastern Maine four to six weeks later. The highest number of individuals \geq 250-microns found in any experimental unit from either of the two eastern Maine sites was 15 (i.e., 1,875/m²). Conversely, as many as 300 individuals (i.e., 37,500/m²) were found in experimental units at one of two southwestern sites. There was no strong evidence that predator exclusion influenced initial settlement or survival of *Mya*. Apparently, differences in abundance between southwestern and eastern Maine *Mya* populations begins prior to larval settlement from the plankton.

Juanes, Francis, University of Massachusetts at Amherst; and Rodney Rountree, National Marine Fisheries Service, Woods Hole Laboratory. A DISCUSSION OF SELECTED CRITICAL RESEARCH NEEDS IN GOM SALT MARSH/ESTUARINE HABITATS: TOWARDS UNDERSTANDING ESTUARINE DEPENDENCE.

From a fisheries perspective there are two major questions of significance regarding Gulf of Maine salt marshes and estuaries, and more generally to all North American estuaries: 1) What is the significance of estuaries as habitat for commercially/recreationally important fishes/invertebrates

(i.e., determining "estuarine dependence"); and, 2) What is the significance of estuaries as an "energy" source to coastal marine communities? Important subsets of each of these questions ask "what are the relative contribution of specific habitat types within the estuary?" These are the "big picture" questions that lie behind much of the estuarine research efforts in the last several decades. Some of the pieces to the puzzle (trees in the forest), include: quantification of the % coverage of specific habitat types in the estuaries, quantification of the occurrence of fish/invertebrates in these habitats by life stage, determination of animal behaviors and how habitats are used, and quantification of trophic linkages among habitats. Others include, quantification of habitat specific immigration-emigration patterns (timing, ontogenetic stage), importance of diel and tidal cycles of environmental conditions on habitat use behavior, and bioenergetics, habitat specific foraging behavior, and carbon-nitrogen isotope sources. To understand estuarine dependence, we must also quantify the relative importance of estuarine and coastal shelf habitats to coastal stocks. This requires a comparison of species occurrence, growth, and survival in both shelf and estuarine habitats along a latitudinal gradient. These are difficult questions to answer and will require multiple discipline studies conducted over regional and coast-wide scales with collaborations among individuals, universities, private research institutions, as well as state and federal governments.

Portnoy, J.W., USGS-Biological Resources Division, Cape Cod National Seashore, 99 Marconi, Wellfleet, MA, 02667. SHORT-TERM EFFECTS OF TIDAL RESTRICTIONS ON SALT MARSH BIOGEOCHEMICAL CYCLING AND *Spartina alterniflora* PRODUCTION

To assess the biogeochemical effects of tidal restrictions on salt marsh sulfur cycling and plant growth, cores of short-form *Spartina alterniflora* peat were desalinated and kept either waterlogged or drained in greenhouse microcosms. Changes in net *Spartina* production and porewater and solid phase chemistry of treated cores were compared to natural conditions in the field collection site over a 21-mo period. Net production among treatments increased significantly in drained and waterlogged peat compared to field conditions during the first growing season. Constantly high sulfide in waterlogged cores accompanied reduced plant growth. Aeration invigorated growth in drained cores, but led to oxidization of sulfide minerals and to lowered pH. During the second growing season, growth declined in the drained treatment, probably because of acidification and decreased dissolved inorganic N. Results are pertinent to the success of current wetland protection and restoration activities in the coastal zone.

Reiner, Edward L., US Environmental Protection Agency, New England Region, Boston, MA. RESTORATION OF TIDALLY RESTRICTED SALT MARSHES IN FLOOD PRONE AREAS

In order to restore tidal flow to salt marshes formerly restricted by tidegates, new automatic electric sluice gates have been installed in two Quincy, Massachusetts salt marshes and one in Winthrop. These automatic electric sluice gates provide daily salt water tidal flow which controls *Phragmites australis* growth and supports the growth of typical salt marsh *Spartina alterniflora*, *S. patens* and *Distichlis spicata* plants. Waterman-Nekton Self-Regulating Tidegates which operate by floats and gravity are proposed to be installed in Revere, Massachusetts on seven separate pipes affecting three salt marsh areas which contain broken flapper type tidegates. These special tidegates are being considered for other Massachusetts marshes to control nuisance monotypic stands of *Phragmites*, restore salt marsh plant and animal communities while providing essential flood control to low lying developments.