NEERS SPRING 2006 MEETING ABSTRACTS

Adamowicz*, Susan C.[1],and R. Rozsa[2]. [1]Rachel Carson National Wildlife Refuge, 321 Port Rd., Wells, ME 04090; [2]Connecticut Department of Environmental Protection, Office of Long Island Sound Programs, 79 Elm Street, Hartford, CT

SUDDEN WETLAND DIEBACK IN NEW ENGLAND

New England sudden wetland dieback is the rapid loss of above ground vegetation, usually Spartina alterniflora in low marsh habitat but sometimes S. patens and Juncus gerardii on the high marsh. Additional signs include loss of plant litter and elevation; there is also some evidence of root rot. Sudden wetland dieback may be associated with drought as it appeared to be in 1999 (CT and RI), and in 2002 (MA and NY). While New England dieback is similar in many respects to the "brown marsh" phenomenon of Georgia and Louisiana, the exact cause in New England has not been identified. Potentially important biotic differences between New England and southern states will be noted. Scientists from Cape Cod National Seashore, US Fish and Wildlife Service, CT Department of Environmental Protection and others have documented dieback in most New England states (http://wetland.neers.org/) although its full extent is not known. A workshop will be held May 24, 2005 in Wellfleet, MA to obtain updates on dieback occurrences in the region, to discuss concerns with invited speakers from Louisiana and Georgia, and to visit nearby Cape Cod salt marshes with dieback. More information on the workshop is available by contacting either author.

Albright, Jennifer L. School of Marine Science, University of Maine, Orono, ME 04469

DISTRIBUTION AND RELATIVE ABUNDANCE OF THE SAND SHRIMP, *CRANGON SEPTEMSPINOSA* IN THE SHEEPSCOT, KENNEBEC AND DAMARISCOTTA RIVER ESTUARIES, MAINE

Crangon septemspinosa, the sand shrimp, is a widespread inhabitant of estuaries along the northwestern Atlantic from Newfoundland to eastern Florida. Recently, shrimp fishers in Maine proposed the establishment of a limited fishery for sand shrimp. However, the Maine Department of Marine Resources denied the request due to a lack of adequate knowledge regarding the species? role in the estuarine and coastal ecosystems. This project addresses the need for additional information regarding the life history of the sand shrimp in the estuarine habitat. The primary objective is to determine the intertidal distribution and relative abundance of sand shrimp in relation to salinity, water temperature, dissolved oxygen and substrate type. Preliminary data analysis has revealed the presence of a differential distribution of sand shrimp within all three estuaries according to sex and reproductive stage. The next step is to determine which environmental parameters are responsible for the establishment of the inshore population

composition, distribution and abundance in addition to determining if there is a hierarchy amongst the variables.

Anderson, D.M.[1], B.A. Keafer*[1], and D.J. McGillicuddy[2]. [1]Biology Department, Woods Hole Oceanographic Institution, Woods Hole, MA 02543 [2]Applied Ocean Physics and Engineering Dept., Woods Hole Oceanographic Institution, Woods Hole, MA 02543

INITIAL OBSERVATIONS OF THE 2005 *Alexandrium fundyense* BLOOM IN SOUTHERN NEW ENGLAND: GENERAL PATTERNS AND MECHANISMS

From May to July, 2005, an extensive bloom of the toxic dinoflagellate, *Alexandrium fundyense*, occurred along the coast of southern New England. The outbreak eventually closed shellfish beds from central Maine to Massachusetts including offshore federal waters. Initial observations suggest that several factors contributed to this bloom. High runoff substantially increased the amount of fresh water entering the Gulf of Maine. We hypothesize that this provided nutrients, a stratified water column, and a transport mechanism that led to high cell abundances. Most importantly, strong northeast winds advected the population into Massachusetts Bay. Here we evaluate this bloom and the patterns of toxicity in light of the conceptual models for *A. fundyense* dynamics developed during the ECOHAB-Gulf of Maine (GOM) program. Several features of the 2005 bloom conform to the mechanisms proposed in those models, including the alongshore transport of cells in major water masses and advection towards shore due to downwelling-favorable winds. The models need to be refined and expanded, however, based on new data and observations. For example, it is now clear that cells and bloom patches can reach the outer side of Cape Cod and the Islands. Furthermore, a significant decrease in the benthic cyst population following the bloom was detected, while new cyst deposition in southern New England was not observed. This indicates that germination from cyst beds along the Maine coast is likely source and subsequent supply of cells into the southern New England region and is a key factor along with the meteorological and hydrographic conditions necessary for prediction of future blooms in the region.

Barrie*, Stacey, and S. Pratt. URI Graduate School of Oceanography, Narragansett, RI

THE RESCUE OF DATA FROM THE LONG-TERM STUDY OF BENTHOS IN MOUNT HOPE BAY

Located in Somerset, MA, the Brayton Point Power Plant uses water from Mount Hope Bay (which is in both Massachusetts and Rhode Island) to cool its systems. Power plant operators supported mandatory studies of plankton, fish eggs, and other species in the bay from 1972 to 2000. Invertebrate samples were collected from 1974 to 1992, with a brief revival in 1997 and 1998. Sampling was carried out at 3 - 4 week intervals year round. Only a small amount of the data from the studies was available in any electronic form. The goal of this project was to enter

the extensive data into a digital database, making it available for analysis of response to natural and human caused environmental changes and to assess effects of short-term population changes. Several sampling stations, Stations A, C, F, I, I#4, and M, were used over the years; many were near the power plant but Station F was mid-bay near Spar Island and served as a control. The data from Station F is particularly useful to those wishing to look at long-term, natural growth patters as the influence of the power plant was minimal there. Several dominant species in the sample include the amphipod *Ampelisca abdita*; the polychaetes *Mediomastus ambiseta*, *Polydora cornuta*, *Streblospio benedicti*, and *Spiochaetopterus oculatus*; and the bivalve *Nucula annulata*. The data will be used in a study of the effects of long-term change in tidal mixing in Mount Hope Bay, and in an examination in variations in time of reproduction.

Bender*, Geoffrey W., and Anne E. Bernhard. Department of Biology, Connecticut College, New London, CT 06320

HIGH BACTERIAL DIVERSITY ON DIFFERENT SUBSTRATES IN A ROCKY INTERTIDAL HABITAT

The rocky intertidal zone is one of the most well studied environments in the world and a wealth of information has been obtained from the many studies performed in it. However, the vast majority of ecological studies in this habitat have been done on marine macro-organisms, and very little study has been done on the marine microorganisms, including their diversity, distribution, and activity in this region. To investigate these various factors, we collected water samples and surface scrapings from rocks and the shells of mollusks in the rocky intertidal in Groton, CT in the summer of 2005. Bacterial diversity was assessed by TRFLP (terminal restriction fragment length polymorphism) analysis of the 16S rRNA genes of the microbial communities isolated from the different habitats in the intertidal. We are currently identifying dominant community members by sequencing 16S rRNA genes from bacterial clone libraries created from each sample group. Interestingly, microbial diversity was variable among the three samples: the rock and water samples exhibited a total of 30 TRFLP peaks and the mollusk sample exhibited 19 peaks. What was more striking was that each habitat had a different dominant community member, exemplifying the diversity of the microbes in the intertidal. This study suggests that microbial diversity in the intertidal is high, and that further analysis of clones and sequences will better reveal the ecological services of the microbes and the factors that control their distribution.

Benoit, Lori K. Office of Long Island Sound Programs, Connecticut Dept. of Environmental Protection, Hartford, CT

HYDRILLA VERTICILLATA IN NEW ENGLAND: AN INVASIVE THREAT TO ESTUARIES AND COASTAL PONDS

Hydrilla verticillata (L.f.) Royle, a highly invasive plant of predominantly fresh water habitats, has invaded four water bodies in Connecticut, including a coastal pond. Recently, populations have been discovered also in Maine and in Cape Cod, Massachusetts. *Hydrilla verticillata* (hydrilla) possesses numerous life history characteristics and physiological adaptations that make it a successful invader of aquatic habitats. Of particular significance for coastal area water bodies is this species' ability to tolerate salinities up to 11-13 ppt. Hydrilla?s invasive characteristics will be discussed in light of ecological impacts and management considerations.

Brace*, Greg W.[1], R. N. Buchsbaum[2], and M. E. Hines[1]. [1]Department of Biological Sciences, University of Massachusetts Lowell, 01854; [2]Massachusetts Audubon Society, Wenham 01984

EFFECTS OF HAYING ON NITROGEN ACQUISITION AND SEDIMENT BIOGEOCHEMISTRY IN *SPARTINA PATENS* AND *SPARTINA ALTERNIFLORA*

Cutting of saltmarsh grasses, especially *Spartina patens*, is still occurring and is responsible for the removal of large quantities of aboveground biomass in the Plum Island Sound ecosystem. This removal may stimulate aboveground growth, which might lead to a stimulation of belowground plant and microbial processes to enhance nutrient acquisition. To determine the effects of haying, an array of 2 x 2m plots in stands of *S. patens* and *S. alterniflora* was manipulated by subjecting them to different simulated haying regimes during the summer 2005 growing season. Aboveground biomass, its N and C content, and pore water analysis of sulfide, iron, and sulfate/chloride ratios were determined. Cutting of *S. alterniflora* impeded transpiration, causing soils to become highly sulfidic, which then impeded subsequent growth. Conversely, cutting stimulated growth in *S. patens* plots, producing significantly more biomass than uncut controls. Pore water data revealed that the sulfate/chloride ratios were lower in cut plots with increased sulfide and decreased iron concentrations. These data indicated that cutting stimulated sedimentary sulfate reduction, a process known to conduct nitrogen fixation. Nitrogen and C in biomass samples are currently being determined, but it is anticipated that biomass in cut plots will have a higher concentration and higher seasonal accumulation of N compared with controls. Haying stimulates the growth of *S. patens*, which leads to enhanced translocation of C belowground, stimulating sulfate reduction, and presumably N fixation.

Brawley*, John W.[1], N.S. Banas[2], A.D.Mansfield[1], and M. Jiang[3]. [1]Battelle, Duxbury, MA; [2]University of Washington, Seattle, WA; [3]University of Massachusetts, Boston, MA

A TRANSFERABLE METHOD FOR ASSESSING CARRYING CAPACITIES OF SHELLFISH AQUACULTURE IN THE MASSACHUSETTS COASTAL ZONE.

The Duxbury/Kingston/Plymouth (DKP) Bay complex is a macrotidal estuarine system, 30 miles south of Boston within Cape Cod Bay (CCB). The estuary is relatively unimpaired by

land-derived nutrients, pollutants, and pathogens, and exchanges ca. 66% of its volume with CCB on each tidal cycle. The system contains significant wild and farmed shellfish areas, including an oyster aquaculture industry that generates $2-$4M annually. This project examines carrying capacities and the primary factors that determine relative growth rates and spatial distributions of existing and future aquaculture areas in DKP Bay. Factors include upwelling events along the margin between DKP and CCB; water residence times which determine primary production and food availability to benthic grazers; interannual variability of water temperatures and the timing of phytoplankton blooms; wild shellfish densities; and benthic habitat conditions. A combined field and modeling effort will address questions that deal with carrying capacities (i.e., physical, production, ecological, and social). Our approach includes the development of a hydrodynamic/growth model coupled to a strong field component. We will also integrate results of the UMASS Massachusetts Bay/CCB model. Our analyses will support the determination of critical inflection points between industry needs and carrying capacities. Local, state, and regional stakeholders are collaborating on several aspects of this project.

Cadwallader, Matthew L. Department of Geography-Anthropology, University of Southern Maine, ME 04038

PREDICTING THE RECOVERY OF EELGRASS BEDS FOLLOWING DREDGING OF THE ENTRANCE TO MANCHESTER HARBOR, MASSACHUSETTS

Zostera marina (eelgrass) inhabits the shallow protected bays, estuaries and harbors of the Eastern and North Western Coasts of the United States, and the presence of eelgrass populations is usually an indication of a healthy and diverse marine environment. Just as the roots of trees hold a riverbank together, eelgrass roots stabilize the local substrate while the canopy softens the effects of waves and currents to reduce coastal erosion. Forming extensive meadows, eelgrass provides essential habitat to a variety of fish, shellfish and crustaceans of commercial importance. The care and management of these eelgrass beds is paramount to ensure the health of near-shore marine ecosystems. Appropriately employed Geographical Information Science (GISci) can be a significant asset in any effort to monitor the health of eelgrass beds. This poster will describe how GIS cost-surface modeling was used to model the recovery of an eelgrass bed following the dredging of the channel to Manchester Harbor, Massachusetts to allow deep draft vessels access to open water. The results of this work suggest that this approach may offer valuable insights for researchers, policy makers and resource managers of marine environments.

Carmichael*, Ruth H.[1], A. Clapp[1], Z. Sheller[1], A. Tong[1], E. Gaines[2], and I. Valiela[2].
[1]University of Maine at Machias, Machias, ME 04654; [2]Boston University Marine Program, Marine Biological Laboratory, Woods Hole, MA 02543

DIET COMPOSITION OF JUVENILE HORSESHOE CRABS: IMPLICATIONS FOR

GROWTH AND SURVIVAL OF NATURAL AND CULTURED STOCKS

Horseshoe crabs are highly valued for economic, ecological, and educational purposes. These unique values have raised interest in managing natural stocks and culturing crabs for conservation, research, education, and aquaculture enterprises. To inform these efforts, we used N and C stable isotopes to define the natural diet of juvenile horseshoe crabs and then assessed effects of different diets on growth and survival of juveniles in culture. In the natural environment, N and C isotope ratios in juvenile horseshoe crabs changed as crabs grew, with larger crabs consuming larger prey. Linear mixing analyses suggested young crabs were supported by high quantities of suspended and benthic particulate organic matter, shifting among phytoplankton and *Spartina* based foods webs, depending on size. In culture, we tested the relative importance of algae, a major component of suspended and benthic POM, to horseshoe crab diet by feeding juvenile crabs different percentages of algae (*Tetraselmis* and *Enteromorpha* spp.) and protein (*Mya arenaria*, *Mytilus edulis*, *Neanthes* spp.). Juvenile crabs showed a significant increase in size when fed diets >70% protein, but showed a significant decrease in survival compared to crabs fed diets of 60-90% algae. More frequent molting may make crabs more susceptible to natural mortality as well as to infection by concentrations of bacteria typical to culture environments. These results suggest successful conservation and culture of crabs depends on understanding the relative importance of different food sources at different life stages as well as on discerning the balance between factors that increase growth, but reduce survival.

Chadwick*, Cary B.[1], N. Barrett[2], W. H. Moorhead III[3], S. Prisloe[4], E. H. Wilson[4], and R. N. Zajac[1].[1] Dept. Biology & Environmental Science, Univ. New Haven, 300 Boston Post Road, West Haven, Connecticut 06516; [2] USDA Natural Resources Conservation Service, 344 Merrow Road, Suite A (Rte. 195)Tolland, CT 06084; [3] 486 Torrington Road, Torrington, CT 06759; [4] Center for Land Use Education and Research, Univ. of Connecticut Cooperative Extension System, 1066 Saybrook Road, P.O. Box 70, Haddam, CT 06438

INTEGRATION OF REMOTE SENSING AND FIELD DATA TO ASSESS THE SPATIAL DISTRIBUTION AND COMPOSITION OF SALT MARSH VEGETATION IN CONNECTICUT SALT MARSHES

Recent rapid declines in the extent and quality of coastal salt marshes have occurred due to factors such as the modification of coastal landscapes and potentially sea level rise. Because marsh degradation is occurring at accelerated rates, efficient methods for evaluating their condition are needed. The utilization of remote sensing imagery for the study of these habitats can help detect spatially explicit patterns that may not be observed using field sampling alone. This work focuses on developing ways to integrate remote sensing and field based analyses to accurately assess the ecological condition of coastal marshes. High resolution multispectral digital airborne imagery, captured in September 2004 with a Leica ADS40 sensor, was used to

identify and classify vegetation structure of the Ragged Rock Creek Tidal Marsh in the lower Connecticut River using object-orientated image processing software (eCognition) and heads up digitizing in a GIS (ArcMap). Detailed vegetation and GPS data were collected at the study area to assess floristic composition, spatial variation, and species abundance. Preliminary analyses show that certain vegetation patches, particularly those dominated by *Spartina patens*, and *Phragmites australis* , show less field variation relative to patch classification using image data. Patches dominated by *Typha* species tend to be more variable floristically and may be more difficult to accurately classify. This research suggests that high resolution remote sensing imagery may be sufficient for classification of marsh systems, however certain aspects of patch structure may need more detailed field verification.

Cogswell*, Charlotte M.[1], J.H. Ryther, Jr.[1], C.F. Wright[1], F. Mirarchi[2], B. Hecker[3], A.D. Michael[4], D.C. Rhoads[5], D.Stevenson[6], and R. Valente[7].[1]CR Environmental, Inc. Falmouth, MA 02536;[2]Boat Kathleen A. Mirachi, Inc., Scituate, MA 02060; [3]Hecker Environmental, Falmouth, MA 02540; [4]Alan D. Michael and Associates, Magnolia, MA 01930;[5]Falmouth, MA 02540; [6]National Marine Fisheries Services, Gloucester, MA 01930; [7]SAIC, Newport, RI 02840

EFFECTS OF SMOOTH BOTTOM TRAWL GEAR ON SOFT BOTTOM HABITATS IN WESTERN MASSACHUSETTS BAY

In January 2001, Boat Katheen A. Mirarchi, Inc. and CR Environmental, Inc. were awarded a NOAA Cooperative Research Project to study smooth bottom fishing gear-induced habitat impacts in Massachusetts Bay off Scituate, MA. Using local fishermen's knowledge, two 'soft' bottom fishing areas (Little Tow) and (Mud Hole) were selected for the study. Replicate reference and experimental trawl corridors were established in 120 to 140 ft of water. For the July 2001 'immediate impact study' the bottom and water column were characterized before and after repetitive passes with a smooth bottom otter trawl. Areas were surveyed for benthic organisms, sediment surface characteristics epifauna and infauna, fish, and fish prey. An expansion of the project was funded by NOAA in 2002 to investigate 'chronic trawling impacts' by continuing to trawl the experimental trawl corridors twice a week from early August into November. Geophysical, underwater video, benthic sampling and Sediment Profile Camera (SPI) surveys along reference and experimental trawl lanes were conducted in July, September, and November to study the cumulative effects of chronic trawling. Results from these studies indicate that the impact from the sweep of a flat net trawl on these soft bottom habitats in Western Massachusetts Bay was comparable to natural bottom disturbances from storms and tidal currents. Potential future studies would include modeling/simulation studies examining the colonizing species life histories and recolonization rates to explore the optimum frequency of trawling to sustain or enhance benthic prey biomass and a focused field verification program to target the trawl door furrows that were not adequately sampled during the previous studies.

Connors*, Erin and S. Pratt. University of Rhode Island, Graduate School of Oceanography, Narragansett, RI 02882

BENTHIC INFAUNA IN THE WATER COLUMN OF NARRAGANSETT BAY: POLYCHAETES

Active nocturnal emigration of macrobenthic invertebrates into the water column has been reported within western Atlantic temperate estuaries. Information of these events is limited mainly due to the lack of nocturnal sampling. In the summer of 1976 a group at the URI Graduate School of Oceanography, conducted a zooplankton study in Narragansett Bay in which four samples were obtained hourly over a 24-hour period on four days. They enumerated fish eggs and larva and archived the remaining material. We removed all macrobenthic species from one sample in each sample period Polychaetes were identified and counted for this study. A total of nine species were found; *Pherusa affinis*, *Nephtys incisa*, and *Polycirrus medusa* were numerical dominants. Standard size measurements were made of *P. affinis* and *N. incisa*. Factors such as illumination, tides, and weather were examined as bases for emigration. The ascension of all three species occurred immediately after sunset and their descent occurred shortly before sunrise. Other effectors could not be identified. All individuals of the dominant species were immature indicating that reproduction was not motivating migrations. These species are not and would not benefit from retention within the estuary. It appears that the benefit of movement of immature animals may be relocation to a more favorable habitat. Large-scale emigration of these species has not been reported previously.

Dahlen*, Deirdre T.[1], C. Hunt[1], S. Emsbo-Mattingly[2], and K. Keay[3]. [1] Battelle Memorial Institute, Duxbury, MA 02332; [2] NewFields Environmental Forensics Practice LLC, Rockland, MA 02370; [3]Massachusetts Water Resource Authority, Boston, MA 02129

ARE TOXIC CONTAMINANTS ACCUMULATING IN MASSACHUSETTS COASTAL SEDIMENTS FOLLOWING STARTUP OF THE MASSACHUSETTS BAY OUTFALL: A COMPREHENSIVE COMPARISON OF BASELINE AND POST-DIVERSION PERIODS

The Massachusetts Water Resources Authority (MWRA) conducts monitoring to address concerns related to the 2000 diversion of secondarily treated effluent discharge into Massachusetts Bay. Baseline data from 1992 to 2000 showed multiple regions defined by physical and chemical composition. Near the Massachusetts Bay outfall, there is a series of heterogeneous sediments in relatively close proximity to the primary historic source of contaminants (Boston Harbor). Farfield sediments exhibited greater compositional definition from one another, which was attributed to the greater spatial separation of the sampling locations. Factors that influence contaminant variability include local (Boston) and distributed sources, and are primarily related to gradients in depositional environments. Post-diversion

sediment data suggest that four years of treated effluent discharge at the outfall has not increased contaminant concentrations to the bay system. However, abundance of the sewage tracer, *Clostridium perfringens*, has increased variably in sediments located within 2 km of the outfall, providing a distinct effluent signal near the outfall.

Dettmann*, Edward H.[1], L. Cooper[2], L.B. Mason[3], K.M. Henry[4], A. Erhunse[5], J. Jacques[6], and R. Rakauskas[7]. [1] USEPA, ORD-NHEERL, Atlantic Ecology Division, 27 Tarzwell Drive, Narragansett, RI 02882; [2] University of Illinois, Civil and Environmental Engineering Department, Urbana. IL 61801, [3] ARCADIS G?, Inc. 101 Fieldcrest Avenue, Suite 5E, Edison, NJ 08817; [4]University of Rhode Island, Graduate School of Oceanography, Narragansett, RI 02882; [5] Florida A? University, Environmental Sciences Institute, Tallahassee, FL 32307; [6] University of Rhode Island, Political Science Department, Kingston, Rhode Island 02881; [7] Bucknell University, Environmental Studies Department, Lewisburg, PA 17837

RELATIONSHIPS BETWEEN SUMMER CONCENTRATIONS OF TOTAL NITROGEN AND CHLOROPHYLL A IN TEN COASTAL SYSTEMS IN THE EASTERN UNITED STATES

We have examined relationships between summer (June?August) average concentrations of total nitrogen (TN) and chlorophyll a (chl a) concentrations in the near-shore Mid-Atlantic Bight and nine bays and estuaries in the eastern United States: Boston Harbor/Massachusetts Bay, Long Island Sound, Delaware Bay, Tampa Bay, and Chesapeake Bay and four of its tributaries (the James, Rappahannock, Potomac, and Patuxent Rivers). All data are from publicly-available data bases. Both TN and chl a exhibit spatial gradients in each system, with concentrations in estuaries and bays typically highest at stations in the inner system, and low at stations near the seaward boundary. Data for all systems show strong positive correlations between average summer concentrations of TN and chl a at individual stations. Relationships for all systems show year-to-year variation, but when concentrations for individual stations are averaged over summers for multiple years (4?20 years for individual systems, depending on data availability), strong similarities among most systems are apparent. While the two northern-most systems show a somewhat higher chl a concentration for a given TN concentration than the more southerly systems, the slope of the relationship between TN and chl a for these two groups is similar. However, chlorophyll a in Delaware Bay seems largely independent of TN. The similarity among these diverse systems in the response of chl a to TN concentrations suggests that multi-year average concentrations of TN at a given station are a strong predictor of chl a concentrations.

Diaz, Robert J. Virginia Institute of Marine Science, 1208 Greate Road, Gloucester Pt., VA 23062

BENTHIC HABITAT CONDITIONS WITHIN BOSTON HARBOR AND NEARSHORE MASSACHUSETTS BAY

Benthic habitat conditions within Boston Harbor and nearshore Massachusetts Bay were documented with sediment profile cameras in conjunction with the cessation of sewage discharge within the harbor. In December 1991 the outfall in the harbor was moved to the harbor mouth and relocated again in January 2001 to its final offshore location. Overall, general benthic habitat quality within the harbor improved from August 1992 to 2000 with minor variation from year to year. Much of the improvement in habitat quality was commensurate with the expansion of *Ampelisca spp.*, which occurred in high densities mid- to outer-harbor areas till 2005 when their populations crashed. This may signal a new phase for the mid and outer harbor. Inner harbor stations with poorest habitat quality in 1989/90 when initial data were collected, continued to have poor quality habitat in 2005. In nearfield Massachusetts Bay around the offshore outfall, between station habitat quality varied less than in the harbor and overall tended to increase from 1992 to 2005. Over this period there was an increased dominance of biological processes in structuring the bottom at nearfield stations. Benthic community structure at both harbor and nearfield stations was highly correlated with habitat quality indices derived from the sediment profile images

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DiMilla*, Peter A., and S. W. Nixon. Graduate School of Oceanography, University of Rhode Island Narragansett, RI 02882

DETERMINING THE APPLICABILITY OF STABLE NITROGEN ISOTOPES TO DOCUMENT THE SOURCE AND FATE OF NITROGEN IN GREENWICH BAY, RI

Greenwich Bay, RI receives dissolved inorganic nitrogen (DIN) from both local watershed sources and from the larger Narragansett Bay system. While both contribute to system productivity, debate exists as to the importance of individual sources in driving production. Characterizing the ratio of stable nitrogen isotopes $^{15}N/^{14}N$ in the various nitrogen sources and in common system producers and consumers may clarify proportionate reliance upon source contributions. Between July 2004 and July 2005 watershed sources of DIN (e.g. groundwater, sewage effluent, rivers, etc.) were collected and analyzed for their nitrogen isotope signature. Over the same period, common marsh and estuarine producers and consumers were collected from both the upper and lower portions of four coves within Greenwich Bay and at sites around the perimeter of the mainstem. Organism collections, supplemented by a broader sampling of hardshell clam (*Mercenaria*) populations in June 2005, were analyzed for nitrogen isotope ratios by mass spectrometry to characterize spatial and seasonal patterns of isotope signatures across Greenwich Bay. Initial analysis (ANOVA) of organism isotope values shows a weak seasonal signal, no significant difference between upper and lower cove positions, and isolated differences between only two of the four coves. With one site exception, the additional *Mercenaria* localities sampled in June 2005 were isotopically indistinguishable from those

collected in the coves of Greenwich Bay during comparable time periods. Results show a uniformity of isotope signatures within species across the coves and mainstem of Greenwich Bay, and for *Mercenaria*, extending into Narragansett Bay.

Donnelly, Grace M. BIOSPEC, Inc., 147th St., Providence, RI 02906

SPARTINA PATENS: COWLICKS AND STEM CELL ACTIVITY

Cowlicks are often seen within populations of *Spartina patens*, the salt hay grass. In this grass there is continuous leaf size variation during shoot development. As the first five nodes develop, they form progressively longer leaves. The slender shoot becomes unbalanced and bends over. Subsequent shoot growth, with shorter leaves, may extend vertically. The net result is a curved mat of shoots and leaves in a cowlick pattern. Sporadically, the mature vegetative shoot generates a side shoot at the fifth node. The side shoot may appear as a bud with several scales, leaves, and a primary root; or it may develop elongated internodes. The side shoot readily detaches from the fifth node. The detachment can form roots and become a whole new plant, an additional means of clonal growth for a grass that produces flowering shoots at a very low frequency.

Fisher, Ryan. Biology Department, Salem State College, 352 Lafayette Street, Salem, MA 01970

ESTUARINE BIO-MONITORING USING THE MEIOBENTHOS - REVISITING A CASE STUDY FROM MANGROVE SEDIMENTS IN TROPICAL AUSTRALIA WITH A VIEW FOR USE IN SALEM SOUND, MASSACHUSETTS

The use of biological indicators to monitor marine systems has largely been restricted to the macrofauna and macrophytes. Quiescent estuarine waters create vast mudflats whose particle size can enhance retention of pollutants including petroleum hydrocarbons and heavy metals. Detecting the sub-lethal affects of these pollutants before macrofaunal mortality is possible using the meiobenthos. Sub-lethal environmental stresses were detected in estuarine mangrove sediments using a suite of indices including univariate and multivariate analysis of all meiobenthic taxa and a community (genus) profile of the nematode taxon. Indices used in the nematode taxon included an analysis of trophic groups and life history traits. During a six month period, meiobenthic communities scored higher stress values at study sites than reference sites. The establishment of similar monitoring in Salem Sound is being planned.

Foster*, Sarah Q.[1], and A.E. Giblin[2]. [1]Hampshire College, Amherst, MA 01002; [2]Ecosystems Center, Marine Biological Laboratory, Woods Hole, MA 02543

INFLUENCE OF A EUTROPHIC GRADIENT AND *ZOSTERA MARINA* ON NITRIFICATION-DENITRIFICATION IN A SHALLOW ESTUARY

Rates of nitrification and denitrification were measured in sediments along a eutrophic gradient in West Falmouth Harbor, a shallow estuary in Cape Cod, MA. Cores were collected in areas vegetated with *Zostera marina*, and from adjacent bare sediments. Nitrification and denitrification potentials were determined from substrate-amended sediment slurries and direct denitrification rates were determined from intact sediment cores using membrane inlet mass spectrometry (MIMS). The eutrophic gradient affected nitrification and denitrification in opposite ways; more eutrophication hindered nitrification potential while stimulating denitrification. The balance of these two effects is observed in the overall direct denitrification rates which showed no difference in rates along the gradient. This suggests that nitrification was not the primary control on overall denitrification. Other factors such as sediment oxidation/reduction potential and labile organic carbon availability are at least equally as important in influencing denitrification rates. Both nitrification and denitrification were enhanced by the presence of *Zostera marina*: nitrification may be stimulated by oxidation of the plant rhizosphere, and denitrification may be stimulated by increased production of nitrate and by labile carbon release by plants. A tangential finding of this study shows that rates of nitrate consumption were significantly higher than denitrification rates determined using MIMS. This suggests that other processes such as dissimilatory nitrate reduction to ammonium and/or microbial immobilization is also consuming nitrate. Denitrification rates determined by nitrate loss in these sediments may be substantial overestimates.

Fox*, Liza R., and I. Valiela. Boston University Marine Program, Marine Biological Laboratory, Woods Hole, MA 02543.

LONG-TERM CHANGES IN SALT MARSH VEGETATION: EFFECTS OF CHRONIC NUTRIENT ENRICHMENT AND SEA-LEVEL RISE.

Nitrogen enrichment and sea-level rise are intensifying agents of ecological change that are restructuring ecosystems globally, including salt marshes. The long-term effects of these pressures on salt marshes are largely unknown. To examine these effects we have been mapping vegetation within experimental plots in the Great Sippewissett salt marsh, Massachusetts since 1970. This study shows continuing long-term shifts in cover and spatial distribution due to both chronic nutrient enrichment and sea-level rise. With increasing enrichment, there was a shift in species composition primarily due to the loss of *Spartina alterniflora* and the increase in *Distichilis spicata*. During the 35 years of our study, sea-level has risen 12-14 cm. To examine the effects of sea-level rise, we compared the change in percent cover of low and high marsh vegetation. In un-enriched plots, percent cover of low marsh vegetation increased, replacing high marsh species. In fertilized plots, high nitrogen supply increased percent cover of high marsh plants, primarily *Distichilis spicata*, whose thick thatch increases organic accumulation and favors capture of sediment from flooding waters, thus

countering submergence. Increased nitrogen supply and rising sea-level alter the direction of competitive success among different species of marsh plants, and force long-term interactions that reshuffle the spatial distribution and the composition of swards of salt marsh communities. Results from this study offer a unique opportunity to understand how the interaction of chronic nutrient enrichment and sea-level rise that is occurring in estuaries world-wide will restructure salt marsh ecosystems.

Fox*, Sophia E.[1], M. Teichberg[1], L. R. Heffner[2], and I. Valiela[1]. [1]Boston University Marine Program, Marine Biological Laboratory, Woods Hole, MA 02543; [2]Present address: University of California Los Angeles, Department of Environmental Health Sciences, Los Angeles, CA 90095

MACROALGAL BLOOMS: THE RELATIVE INFLUENCE OF NUTRIENT SUPPLY, GRAZING, AND PREDATION IN WAQUOIT BAY, MASSACHUSETTS

Anthropogenic nutrient inputs to coastal zones have led to eutrophication of estuarine systems and macroalgal blooms. Although the increase in blooms worldwide is recognized, there is disagreement as to the relative role of different control mechanisms. Some studies have shown that nutrient supply alone controls blooms from the bottom up the food web, while others have suggested control from the top down by consumers, either directly by grazers or indirectly by trophic cascades. In this study, surveys and experiments in Waquoit Bay, MA, have shown that increased nitrogen loads from watersheds lead to increased growth rates and biomass of bloom-forming species of macroalgae, as well as decreased abundance and diversity of consumers. To examine the relative role of controls on macroalgal growth, we carried out an experimental enrichment, in which macroalgal growth increased with increasing nitrogen and phosphorus supplies. In an additional experiment, we showed that top-down effects interact with nutrient effects. Grazing and cascading effects by consumers were paramount where nitrogen supply was low, but as nitrogen load increased, bottom-up controls overwhelmed top-down mechanisms. Since macroalgae and consumers are major bioassays integrating the time course of the eutrophication status of estuaries, and are the best record of changes forced on ecosystems by land use changes in watersheds, these data elucidate biological controls responsible for increasing macroalgal blooms in coastal waters.

Geoghegan, Paul. Normandeau Associates Inc., 25 Nashua Road, Bedford, NH 03110.

THE BOSTON HARBOR ARTIFICIAL REEF: A CASE STUDY OF DESIGN EVOLUTION, REGULATORY INTERACTION, AND PERFORMANCE EVALUATION.

An artificial reef was deployed in Boston Harbor as part of the mitigation effort to offset the loss of 0.6 acres of subtidal habitat used for disposal of excavated and dredged materials generated

by the Central Artery/Tunnel project. The evolution of the design and subsequent performance monitoring of the reef provides lessons for the development of mitigation efforts in Boston Harbor and other northern temperate waters. The original design was a rock rubble reef interspersed with concrete structures. The final permit for deployment required prefabricated structures that provided the required surface area and compensated for the footprint of the reef itself. These requirements resulted in the design of 20 terrace type reefs that provided surface area in the water column. In substitution for three of the terrace reefs, six rock rubble reefs were deployed to allow comparisons between the reef types. After five years of monitoring, the lower cost rock rubble reefs are outperforming the terrace reefs in numbers and taxa richness of fish, crabs, and macroinvertebrates. Anemones and other soft-bodied invertebrates are common on the terrace reefs while blue mussels are common on the rock rubble reefs. The increased habitat diversity and edge habitat provided by the rock rubble reefs probably account for the better performance. Habitat forming kelps that are present on nearby natural ledges have recently only been found on the terrace reefs. Selection of design types for artificial reefs should include an understanding of the life history requirements of the target species. Construction of artificial habitat will increase production of target species only if it provides a habitat that limits production.

Goodrich *, Tara M.[1] , L. J. Osher[1], and S. Barker [2]. Department of Plant, Soil and Environmental Science, University of Maine, Orono, ME 04469; [2] Maine State Department of Marine Resources, Boothbay Harbor, ME

TOOLS FOR MEASURING CHANGES IN EELGRASS (*ZOSTERA MARINA*) DISTRIBUTION OVER TIME

Seagrasses are important to estuarine communities in that they support biological growth, provide critical habitat and physically stabilize benthic substrates. Loss of seagrass cover is a significant problem in that it has declined 70-90% over the last 50 years along the Atlantic coastline (Short and Duarte 2001). The most common cause of seagrass loss is light limitation caused by N loading to the system and subsequent eutrophication. In most New England estuaries, decades of nutrient additions have greatly reduced seagrass communities. The resource managers in these areas have little baseline data available from which to develop eelgrass revegetation strategies. This presentation describes the methods we are using to quantifying the natural changes in eelgrass cover over time. The site of our study estuary is Taunton Bay, in Hancock County, Maine. Taunton Bay?s watershed is mostly forested with minimal agricultural, industrial, or residential land use. As a result the estuary has had very low inputs of anthropogenic N inputs. Using aerial photographs and a GIS system, we are digitizing the area of eelgrass cover in the Bay from eight sets of aerial photos collected over the 50-year period between 1955 and 2005. Differences in chromatic tone are being used as a measure of percent eelgrass cover (stocking density) in each observed patch. Aerial photo analysis and mapping of percent eelgrass cover estimates for some years were supported by ground truthing using underwater cameras. Differences in area and percent cover between photos are being

calculated using spatial analysis software readily available with most GIS systems. Differences in photo scale and quality will be addressed.

Griffin, Pamela J. University of Southern Maine, Portland, ME.

THE LANDSCAPE ECOLOGY OF NEW ENGLAND SALT MARSH FORB PANNES

Perennial forb pannes are unique islands of biodiversity in northern New England salt marshes that have recently been the subject of extensive community ecology work. High salinity and waterlogging relative to surrounding graminoid dominated areas have been found to contribute to their presence; however they are not as successful in less stressful environments where interspecific competition favors graminoid domination. No studies have addressed the role of landscape level factors on forb panne occurrence or species composition. I seek to relate location, diversity, and species composition of forb pannes to landscape level parameters at the Little River Marsh in Wells, Maine. During the summer of 2005 I collected GIS based data to map the area these forb assemblages occupy and to georeference quadrats of plant counts. With these data, I calculated evenness, a component of diversity that is a more sensitive indicator of environmental change than species richness. By analyzing forb pannes at this broader scale, I hope to reveal information about underlying processes that control salt marsh forb distribution and their possible role as early indicators of global change.

Hall*, Maurice P and S. Zendeh. Take A Second Look (TASL) , 661 East Fifth St., So.Boston, MA 02127

TRENDS IN WINTERING WATERFOWL POPULATIONS IN BOSTON HARBOR - 1980 TO 2005.

Volunteers have conducted waterfowl population counts several times a winter for 25 years at 135 fixed sites from Nahant to Hull. November events census birds as they migrate south to wintering grounds, whereas January and February counts census birds presumably on their wintering grounds. Most shorebirds, Common Eider and Bufflehead have shown no long-term patterns. Species showing decreases include Dunlin, Red-breasted Merganser, Common Goldeneye, Brant Goose, Black Duck, Bonaparte's Gull, Great Cormorant, Double-crested Cormorant, and Greater Scaup. Species showing increases are Mallard Duck, Canada Goose, Mute Swan, Red-throated Loon, Horned Grebe, Red-necked Grebe, Long-tailed Duck, White-winged Scoter, and Surf Scoter. Possible factors implicated in the changes will be discussed.

Horn*, Lotte[1], M. van Keulen[1], and E. Paling[2]. [1] School of Biological Sciences and Biotechnology, Murdoch University, Western Australia 6150; [2] Marine and Estuarine Research

Laboratory, Environmental Science, Murdoch University, Western Australia 6150

TRANSPLANTING SEAGRASS IN A HIGH ENERGY ENVIRONMENT, WESTERN AUSTRALIA

Posidonia sinuosa sprigs were transplanted in a high energy environment at Cockburn Sound, Western Australia as part of the *Seagrass Research and Rehabilitation Plan*, Murdoch University. The study aimed to transplant 1.5 ha of seagrass into an area where seagrass was previously lost due to industrial and nutrient inputs. The main challenges faced during transplantation included strong currents and wave action which resulted in loss of previous transplanting efforts. Sprig material, consisting of rhizomes with roots and leaves, was collected from a donor meadow currently being dredged for shell sand. The sprigs were tied to wire staples to anchor the transplants at the recipient site. Survival of sprigs was significantly reduced due to strong currents and heavy epiphytic fouling. In addition, changes in photosynthetic activity were monitored using an underwater pulse amplitude modulated fluorometer (Diving-PAM) to determine seagrass stress during transplantation, and post-transplantation recovery. Removal of the sprigs from the water during transport resulted in a decrease in maximum electron transport rate (ETR_{max}), mainly due to desiccation. By the time the sprigs were planted at the recipient site, their ETR_{max} was significantly lower than plants at a control meadow. ETR_{max} of the sprigs took up to three months to increase to the same level recorded at the control meadow, primarily due to the desiccation stress suffered during transport. Since the leading human-controlled cause of transplant failure was desiccation stress, future transplanting efforts should endeavour to keep seagrasses submerged at all times during the transplanting process.

Hunt*, Carlton D. [1], D. Dahlen[1], L. Lefkovitz[1], S. Pala[1], and K. Keay[2]. [1]Battelle, Duxbury, MA; [2]Massachusetts Water Resources Authority, Boston, MA

CONTAMINANTS IN BOSTON HARBOR SEDIMENTS: 1990 TO 2005

Loading of contaminants to Boston Harbor has been reduced through harbor cleanup initiatives implemented over the past fifteen years. These reductions have demonstrably improved the quality of surface sediments in the harbor. The improved sediment quality of Boston Harbor is evident in the recovery of the health of major living resources (e.g. winter flounder) and general reduction in contaminant levels in fish and shellfish resources in the system. The harbor improvements are documented in chemical loading estimates, trends in contaminants and sewage tracers in surface sediments, and through then and now comparisons of harbor sediment chemistry data to marine sediment quality guidelines. Information that documents the improvements will be presented.

Jiang*, Mingshun and M. Zhou Department of Environmental, Earth and Ocean Sciences, University of Massachusetts Boston, 100 Morrissey Blvd., Boston, MA 02072

MESOSCALE EDDIES IN MASSACHUSETTS BAY AND THE IMPLICATIONS TO BIOGEOCHEMICAL CYCLES

Massachusetts Bay (MB) is an important coastal embayment serving a productive fishing ground, a high-use endangered right whale feeding habitat and a busy commercial harbor. Located in the western Gulf of Maine (GOM), MB circulation is driven by the GOM inputs through the northern open boundary, local atmospheric forcing and freshwater inputs. Interactions of these forcing, complex topography and local fluid dynamics produce rich meso-scale eddies that are important to biogeochemical cycles in MB. In this presentation, we will examine these meso-scale processes using numerical simulations of a coupled physical-biogeochemical model for MB ecosystem with a special focus on late spring 2005 when two strong Nor?easters occurred along with massive Alexandrium bloom in the New England waters especially in MB. The implications of these meso-eddies to biogeochemical cycles in MB will also be discussed.

Keay*, Kenneth E.[1], M. Hall[1], and M. Delaney[2]. [1]Environmental Quality Department, MWRA;[2]Department of Laboratory Services, MWRA, 100 First Avenue, Charlestown Navy Yard, Boston MA 02129

POLLUTION REDUCTIONS RESULTING FROM MWRA'S BOSTON HARBOR PROJECT

MWRA?s court-ordered Boston Harbor Project was designed to bring wastewater treatment for the Metropolitan Boston area into compliance with the Clean Water Act. Components included a stringent toxics reduction and control program, construction of a state of the art wastewater treatment plant, and shifting the wastewater outfalls 9.5 miles offshore. These and other improvements have combined to decrease MWRA's loading of solids and trace metals to the Harbor/Bay system, for example, by more than 80% each. Ongoing sewer system projects are further reducing pollutant loads resulting from remaining wet-weather discharges into the Harbor.

Kinney*, Erin L., and I. Valiela. Boston University Marine Program, Woods Hole, MA 02543

DEVELOPMENT OF A SENSITIVE AND WIDESPREAD INDICATOR OF ESTUARINE NITROGEN LOADS: STABLE ISOTOPIC SIGNATURES IN SALT MARSH CORDGRASS

Eutrophication is a widespread and pervasive agent of ecological change in coastal

environments. Land-derived sources of nitrogen from wastewater, fertilizer, and atmospheric deposition drive the widespread eutrophication that is thoroughly altering structure and food web of coastal environments. To assess environmental changes forced by increasing enrichment, it would be useful to have sensitive and widely applicable indicators of nitrogen enrichment. The $\delta^{15}N$ of salt marsh cordgrass (*Spartina alterniflora*) might be such an indicator. *Spartina alterniflora* is a broadly distributed species throughout temperate latitudes, and so it can be widely distributed bioassay for eutrophication. I first link $\delta^{15}N$ of *S. alterniflora* to land-derived N load entering subwatersheds of the Waquoit Bay estuarine system (or percent wastewater contribution), and then develop a routine sampling protocol that accounts for possible differences in seasonality of $\delta^{15}N$, salinity, sediment properties, and what details of sample pooling will be needed to include in the routine protocol. Preliminary results indicate that $\delta^{15}N$ of *S. alterniflora* is related to land-derived N load and percent waste water contribution, as previous studies in Massachussetts (Cole et al. 2005) and Rhode Island (Wigand et al. 2001) have suggested. There is some question as to the effect of seasonality on these relationships, however the preliminary data suggest that early to mid-summer collection provides the most robust relationship between $\delta^{15}N$ of *S. alterniflora* and N loading to the estuary.

Lefkovitz*, Lisa F.[1], M. Hall[2], and M. Moore[3]. [1]Battelle Memorial Institute, Duxbury, MA 02332; [2] Massachusetts Water Resources Authority, Boston, MA 02129; [3] Woods Hole Oceanographic Institute, Woods Hole, MA 02543

FISH AND SHELLFISH MONITORING IN BOSTON HARBOR AND MASSACHUSETTS BAY FROM 1992 THROUGH 2005

The Massachusetts Water Resources Authority (MWRA) monitors fish and shellfish to address public health concerns and provide indications of chemical contaminant effects on overall marine health. Concerns were expressed that the relocation of sewage effluent into the relatively clean waters of Massachusetts Bay could result in chemical contamination of the fisheries. The monitoring program implemented to address these concerns includes over 13 years of flounder, lobster and caged mussel samples from Boston Inner Harbor, Deer Island and the Outfall Site and reference locations within Boston Harbor and Massachusetts Bay. Fish and shellfish tissue (meat and liver) is analyzed for PCBs, Pesticides, PAHs and metals. Flounder health is assessed through external examination and histological analyses of livers for the presence of abnormalities. Tissue organic and metals concentrations show a relative decline in flounder and lobster since 1992. Only PCBs in flounder liver showed an increase in post discharge years at the Outfall Site. Caged mussels also indicated a general decline in organic concentrations in Boston Inner Harbor and Deer Island. However, a statistically significant increase in PAHs, pesticides and Hg and Pb was detected in mussels at the Outfall Site in post discharge years. Flounder health has improved throughout the harbor as indicated by a decrease in the number of tumors. In 2003, external ulcers were noted on the blind side of many fish caught throughout

the Harbor. Investigation into the cause of the ulcers has been inconclusive however, they appear to be seasonal and as of spring of 2005, the frequency and severity of the lesions appear to be declining.

Leschen*, Alison S., R.K Kessler, and B. Estrella. Massachusetts Division of Marine Fisheries, 50A Portside Dr., Pocasset, MA 02559

EELGRASS RESTORATION IN THE NEW AND IMPROVED BOSTON HARBOR: PROGRESS SO FAR

The Massachusetts Division of Marine Fisheries is restoring eelgrass (EG) to Boston Harbor. Improved water quality from sewage treatment projects has made this attempt feasible in areas where eelgrass had previously died off. This is one of 4 restoration projects funded as partial mitigation for presumed impacts to fisheries resources by the Algonquin Gas Co. pipeline (?Hubline?) built across the Harbor in 2002-3. Twelve preliminary test-planting sites were selected and planted with 200 EG shoots, based on a modified PTSI model (Short 2002) and groundtruthing, with data synthesized and displayed using ArcMap. Sediment, which remains unsuitable after years of deposition, was limiting in many areas. Four of the 12 sites were selected for secondary test transplants (1000 shoots) based on shoot survival at the original 12 sites. Three of these sites were planted at a large scale in fall 2005 with a total of 14,500 shoots using both hand-planting and a PVC/jute mesh planting frame we developed. Both techniques worked well; one relies more on divers, the other on shore help. We used volunteers extensively in both cases. Survival in late fall was high, with new growth and rooting of transplanted shoots evident. Flowering shoots were collected from donor beds and stored in seawater tanks until seeds matured and dropped out. Seeds were then collected and planted in different densities to test for effect. A new, less labor-intensive technique will be used in 2006. Shoot planting will continue this spring and summer, along with an expanded biological monitoring program. This project offers an example of eelgrass restoration in a previously degraded environment, where conditions that caused the original die-off have been improved.

Libby*, P. Scott[1] and M. J. Mickelson[2]. [1] Battelle, Brunswick, ME 04011; [2] Massachusetts Water Resources Authority, Boston, MA 02129

FOURTEEN YEARS OF MWRA WATER QUALITY MONITORING - HARBOR VS. BAY OUTFALL EXPECTATIONS AND OBSERVATIONS

On September 6, 2000, the Massachusetts Water Resource Authority (MWRA) transferred their effluent discharge from Boston Harbor to an outfall in Massachusetts Bay. Limited ecological impact was predicted for the transfer and has been validated by the long-term MWRA monitoring program (1992-2005). After five years of post-diversion monitoring, changes in the nutrient regimes in the harbor and bay are unambiguous ? dissolved inorganic nitrogen (DIN)

levels have decreased in the harbor and coastal waters while increasing locally near the bay outfall. In Boston Harbor, the dramatic decrease in DIN has been associated with significant decreases in chlorophyll and particulate organic carbon, lower primary production, and changes in seasonal primary productivity patterns. In the bay outfall area, there is no indication that the higher nutrient loads have translated into significant changes in phytoplankton biomass, whether measured as chlorophyll, particulate organic carbon, or abundance. Overall, post-diversion monitoring has documented small increases in the winter/spring phytoplankton biomass and subtle changes in the plankton community including apparent changes in the frequency, magnitude, and duration of *Phaeocystis* blooms in the Bay. The 2005 red tide renewed interest in the potential effect the outfall may have in exacerbating such blooms, however, associations between the bay outfall and regional phytoplankton blooms have not been observed. This presentation summarizes the overall water quality findings of the MWRA monitoring program and reviews various modeling approaches to assess the relative impact of the MWRA outfall during the 2005 *Alexandrium* bloom.

Liebman, Matthew. US EPA, New England, Boston, MA 02114

IS MONITORING MASSACHUSETTS BAY NECESSARY? (YES)

Massachusetts Bay is one of the nation's most important cultural, natural and historic resources. Even before the Pilgrims landed on Cape Cod, the resources of the bays have been important to marine mammals, Native Americans and European fisherman. Now, of course, we recognize the importance of the bay to sustain a rich biological community and for swimming, sailing and other recreational opportunities. In 1988, EPA approved the relocation of the Metropolitan Boston sewage outfall (operated by the Massachusetts Water Resources Authority) from Boston Harbor to Massachusetts Bay to ensure that Boston Harbor is meeting water quality standards, while not causing any impairments to Massachusetts Bay. This decision was partly based on computer models of water quality. The modeling also helped determine the best outfall location, which was screened for many factors, including dilution, proximity to sensitive shoreline resources, and the potential to cause nutrient enrichment. Both EPA and the Commonwealth of Massachusetts insisted on effluent and ambient monitoring, however, to determine whether the predictions of the models are valid, to determine whether changes in the Massachusetts Bay ecosystem can be attributed to the MWRA outfall discharge, and to improve the plant's operations in response to ecological or health based thresholds. These requirements were informed partly by the public's and certain government agency's concerns that endangered species, such as the Right Whale, and other resources, such as fish and shellfish, not be harmed by the outfall discharge. Baseline monitoring of parameters such as water and sediment quality, benthic diversity, toxics in fish and shellfish began in 1992, and compliance monitoring (in the "NPDES" discharge permit) began in 2000. One of EPA's goals in writing the MWRA's discharge permit was to give the public unprecedented access to monitoring data. Since 2000, we have learned the value of this monitoring - accountability, credibility and transparency. This presentation will provide specific examples of how the steady stream of monitoring data, and access to detailed information about unexpected problems and agency responses have proved

valuable in ensuring the environment is protected.

Maciolek, N.J[1]., James A. Blake*[1], K. Keay[2], and R.K. Kropp[3]. [1]ENSR Marine and Coastal Center, 89 Water St., Woods Hole, MA 02536 [2]Massachusetts Water Resources Authority, 100 First Ave., Charlestown Navy Yard, Boston, MA 02129 [3]Battelle Marine Sciences Laboratory, 1259 West Sequim Bay Road, Sequim, WA 98382

CHANGES IN BENTHIC INFAUNAL COMMUNITIES ASSOCIATED WITH SEWAGE ABATEMENT PROGRAMS IN BOSTON HARBOR

A long-term monitoring program to understand changes in benthic habitat quality associated with the clean-up of Boston Harbor was established by the MWRA in 1991. Discharge of sludge into the harbor ended in 1991. In 1998 all effluent discharge from Nut Island was discontinued and full secondary treatment was implemented. In 2000, all wastewater discharges were diverted to the new outfall in Massachusetts Bay. Since the abatement of pollutant loads to the harbor, distinct improvements have been noted at several of the eight stations monitored annually, especially at those nearest Deer Island. For example, the faunal assemblages at T01, formerly an extremely degraded benthic habitat, changed markedly after 2000, with the fauna shifting to an assemblage of species more indicative of other locations throughout the harbor and the numbers of opportunistic species declined. A harbor-wide increase in species richness was also evident after 2000, and species diversity as measured by Fisher's alpha and Hurlbert's rarefaction also increased. However, detailed analyses of individual stations, as well as other lines of evidence, such as the decrease in levels of the sewage marker *Clostridium perfringens*, strongly support the conclusion that the benthic environment in the harbor is indeed recovering from years of pollutant input. When viewed collectively, there is a long-term trend of increasing species diversity throughout the Harbor. When each station is evaluated individually, it is clear that species richness and diversity (as measured by log-series *alpha*) have increased at each of the eight traditional harbor stations through 2004.

Miller*, Jeremy W.[1], and P. Morgan[2]. [1]Wells National Estuarine Research Reserve, 342 Laudholm Farm Road, Wells, ME 04090; [2]University of New England, 11 Hills Beach Road, Biddeford, ME 04005

BENTHIC INVERTEBRATE COMMUNITY RESPONSE TO HYDROCARBON CONTAMINATION IN CASCO BAY, PORTLAND, MAINE

Casco Bay has experienced two significant oil spills in recent history - the Tamano Tanker spill in 1972 and the Julie N spill in 1996. In addition, the Fore River and its tributaries have experienced numerous small spills over the years, including the August 2002 fuel oil spill (2,900 gallons) and the April 2003 jet fuel spill (6,000 gallons). Although the impacts of oil

spills on salt marsh plants has been studied extensively, very little research has focused on the response of benthic invertebrate communities to impacts from oiling events. The research that has been conducted shows that elevated levels of hydrocarbons in salt marsh sediments negatively impact a number of salt marsh invertebrate species while making space available to opportunistic early colonizing species. We sampled benthic invertebrates from three sites within the Fore River and three reference sites in Casco Bay. We compared invertebrate assemblages between the oiled and reference marshes in an attempt to identify potential indicator species of marsh function for New England salt marshes. The Fore River sites had lower densities of invertebrates than the Casco Bay reference marshes and also contained species identified by previous studies as "highly tolerant" of hydrocarbon contamination. Species known to be intolerant of hydrocarbon contamination were found exclusively at the reference marshes. We believe that the results we have gathered from this study, coupled with results from our 2002-2003 Casco Bay fringing salt marsh study, provide a solid foundation for future long-term monitoring of fringing salt marshes in the Fore River and in all of Casco Bay.

Mills*, Angela J., and R. H. Carmichael. University of Maine at Machias, Machias, ME 04654

USING MOLTS TO DISCERN JUVENILE HORSESHOE CRAB POPULATION STRUCTURE AT TAUNTON BAY, MAINE

Juvenile Horseshoe crab (*Limulus polyphemus*) molts were collected from an intertidal marsh adjacent to a known spawning site on Taunton Bay in Franklin, Maine. Molts were collected, measured, and sexed every 2 weeks corresponding to full and new moon low-tides during the post-spawning period, when juveniles are hatching and molting (Aug-Oct). We found 153 juvenile molts, ranging in size from 20-165mm. Previous studies indicate crabs in this size range are largely "subadults" and most molt once per year. The male to female sex ratio of molts was 1.27, not significantly different from 1:1. There was no significant difference in size frequency distribution between male and female molts. The number of molts collected per visit decreased significantly during the sampling period, suggesting more crabs molt earlier in the season. The average size of molts increased through time, independent of sex, suggesting smaller crabs molt earlier in the season, while larger crabs molt later. Sex ratio also was independent of sampling date, indicating molt timing is similar for males and females. These data can be further applied to define cohorts and estimate rates of growth and molting. By serving as a proxy for size and number of living individuals in a population just prior to molting, molts provide important information on population dynamics that can be difficult to directly measure. This approach may be applied to 1) populations such as in Downeast Maine that are difficult to study because of water depth, turbidity, and temperature or 2) assess subadult crabs that are generally difficult to capture because they are smaller than adults and more highly mobile than younger crabs.

Moore*, Gregg E.[1], D.R. Keirstead[2], P. Sokoloff[1], and F. T. Short[1].[1] Jackson Estuarine Laboratory, University of New Hampshire, 85 Adams Point Road, Durham, NH 03824; [2]

USDA-NRCS, 2 Madbury Road, Durham, NH 03824

INTEGRATING SUBAQUEOUS SOIL DATA IN SITE SELECTION MODELING OF EELGRASS (*ZOSTERA MARINA*) RESTORATION IN GREAT BAY ESTUARY, NEW HAMPSHIRE

Eelgrass (*Zostera marina*) is the dominant seagrass of the northeastern United States yet acute and chronic environmental stresses such as development, decreased water quality, plant disease and herbivory have impacted distribution throughout the region. Within Great Bay Estuary, efforts are underway to restore historic eelgrass meadows using our site selection model, the *Transplant Suitability Index* (TSI), to identify optimal planting locations across the Estuary?s widely variable substrate and bathymetric features. The TSI has not previously included subaqueous soil classification and subtidal landforms as descriptive inputs. Using the National Cooperative Soil Survey classification system to define landscape units, we collected soil cores throughout the restoration site to evaluate the inclusion of these parameters into the TSI. We identified 6 landscape units within the 144 hectare subtidal area along the Bellamy River. Of these landscape units, 4 occurred within a 15 hectares subarea indicated as suitable for restoration by the TSI. The Tidal Flat landscape unit, characterized by typic fluvaquents, may provide more suitable habitat due to typically lower dissolved O_2 associated with silty layers and buried organic horizons; while typic hydraquents on Fluvial Marine Terraces are of lower suitability due to their low bulk density and soil strength. Moreover, landscape units can be reliably inferred using standardized methods and field indicators. Thus, preliminary analysis suggests that integrating soil classes and subtidal landform into the TSI may provide greater predictive value for eelgrass restoration in systems where these parameters are highly variable across the subtidal landscape.

Moore*, Slade B.[1,3], and S. Perrin[2]. [1]Department of Marine Resources, P.O. Box 8, West Boothbay Harbor, ME 04575; [2] Friends of Taunton Bay, P.O. Box 585, Bar Harbor, ME 04609;[3]Current address: Woodlot Alternatives Inc., 30 Park Drive, Topsham, ME 04086

SEASONAL MOVEMENTS AND RESOURCE-USE PATTERNS OF THE AMERICAN HOSESHOE CRAB (*LIMULUS POLYPHEMUS*) IN A GULF OF MAINE EMBAYMENT

Dramatic declines in populations of the American horseshoe crab (*Limulus polyphemus*) have underscored the need for effective management of the species. Currently, the majority of in-situ observations describing horseshoe crab ecology are the result of spawning period investigations, during which time horseshoe crabs frequent intertidal areas. Consequently, a basic understanding of their subtidal habits during the remainder of the year is largely lacking, yet nevertheless necessary for the development of well-informed management strategies. We attempted to address this need by tracking crabs using sonic telemetry, a technology in frequent use by ecologists for obtaining high-resolution spatial/temporal movement data. Our efforts focused on crabs located in Taunton Bay, Maine, which contains the northernmost documented

breeding ground for the species. Results obtained from this work were based on data describing movements of two groups of crabs tracked from 16 June 2003 to 23 June 2005. Despite the brevity of this study, our work identified *Limulus* movement and resource-use patterns that have direct application to the development of a comprehensive, ecosystem-based management strategy for Taunton Bay.

Moore, Slade B.[1], Maine Department of Marine Resources, P.O. Box 8, West Boothbay Harbor, ME 04575; [1] Current address: Woodlot Alternatives Inc., 30 Park Drive, Topsham, ME 04086

THE TAUNTON BAY ASSESSMENT: A CONTEXT-BASED ECOLOGICAL CHARACTERIZATION

In 2000 the Maine Legislature responded to mounting public concern over the effects of fishery-related seabed damage by enacting a five-year moratorium prohibiting the use of drags in the Taunton Bay Estuary. An unfunded mandate attached to the dragging prohibition required the Maine Department of Marine Resources (DMR) to assess the effectiveness of the moratorium by February 2004. Without a clear directive, financial support, or staff, a small group of collaborators from the fishing industry, local environmental groups, academia, interested neighbors, and DMR worked to fund, develop and execute (often at the same time) a project that would address immediate concerns and have lasting management value. The resulting Taunton Bay Assessment provides an example of a rapid and effective science-based response to an emerging natural resource issue and also underscores the feasibility of and need for comprehensive, ecosystem-based management of discrete coastal areas.

Morgan*, Pamela A., and W. Nolton. Department of Environmental Studies, University of New England, Biddeford, ME 04005

IDENTIFYING INDICATORS OF ECOSYSTEM FUNCTION IN NEW ENGLAND?S FRINGING SALT MARSHES

Multiple efforts are currently underway to develop methods for assessing the biological integrity of a variety of estuarine systems. Finding the best indicators of ecosystem function for a particular habitat type can be a challenging task. This study focuses on fringing salt marsh habitat; on identifying indicators that can be used for long term monitoring purposes as well as for understanding the functional status of a particular fringing salt marsh at a single point in time. After developing a methodological approach for identifying indicators of fringing salt marsh functions, we tested our approach by analyzing vegetation data collected from 18 fringing salt marshes in southern Maine over the past four years. Our analysis revealed useful indicators of two important fringing salt marsh functions: primary production and the maintenance of plant communities. We plan to develop additional indicators that will be

ecologically meaningful as well as useful to resource managers.

Nelson*, Katelyn A. and A. E. Bernhard. Department of Biology, Connecticut College, New London, CT 06320

PATTERNS OF ARCHAEAL COMMUNITIES CORRELATE WITH SALT MARSH VEGETATION PATTERNS

New England salt marshes are characterized by distinct vegetation patterns and are dominated by species of *Spartina*. While these vegetation patterns have been well characterized, few studies have investigated the microorganisms associated with them. Therefore, the objective of our study was to compare Archaeal communities within different vegetation patches to see if community patterns corresponded to vegetation patterns. Sediment samples were taken from areas of S. patens, S. alterniflora (tall form), and *S. alterniflora* (short form) growth at Barn Island in Stonington, CT. DNA was extracted and the 16S rRNA genes were amplified and cloned for sequence analysis. Preliminary results show that, while Archaeal diversity was relatively low at all three sites, communities varied. Sequences related to the recently isolated ammonia-oxidizing crenarchaeote dominated samples from *S. patens* and *S. alterniflora* (tall form) sites, but were not detected at the *S. alterniflora* (short form) site. The *S. alterniflora* (short form) site was, however,dominated by other uncultured crenarchaeotes. Of 43 sequences, only 5 euryarchaeotes were identified, all of which were found in areas of *S. alterniflora* (tall and short form). Sequencing results showed clear differences in Archaeal communities between the three sites, however, we are uncertain as to whether these differences are due to differences in vegetation or in environmental conditions. Additionally, since many sequences were closely related to a known ammonia oxidizer, the presence or absence of these microorganisms among the different vegetation sites may be related to differences in nitrogen availability.

Noel*, Paula E., G. K. Macdonald, S. E. Byers and G. L. Chmura. Department of Geography and Global Environmental and Climate Change Centre, McGill University, Montreal, QC H3A 2K6 Canada

RECOVERY, RESILIENCE AND RESISTANCE OF BAY OF FUNDY SALT MARSHES

By examining the hydrology of recovering and reference marshes we are finding that Fundy marshes have a high degree of ecological resistance and resilience. The Bay of Fundy?s recovering marshes have been undergoing unmanaged restoration through breaching of dykes. We are studying these sites to examine the long term recovery of marsh habitat, geomorphology, surface and subsurface hydrology as indicators for setting practical restoration goals. We present results for Saints Rest Marsh on the lower Bay which has been recovering for more than 50 yr. Using a combination of field mapping and analysis of historic air photos we

are determining the extent change of the channel network; asking to what degree the grid system of ditches associated with reclamation has been incorporated into the network and how much of the original creeks have been reactivated. Our mapping shows that Saints Rest has 3 times greater pool area as a proportion of total marsh area than the reference site. As a component of the salt marsh habitat the pools show resilience both in form, by their re-emergence with no human intervention, and in function, as the invertebrate fauna of pools in the recovering marsh is indistinguishable from that of the reference marsh. Thus recovering marshes may be more attractive to fish and birds. We also found that unlike microtidal marshes, the water table of our macrotidal marshes is relatively unresponsive to tidal flooding, probably due to high bulk density and low infiltration rates. This characteristic imparts resistance to Fundy marshes since increased tidal heights associated with sea level rise will have limited impact on soil saturation, and consequently vegetation of Fundy marshes.

Oczkowski*, Autumn J., and S.W. Nixon. Graduate School of Oceanography, The University of Rhode Island, Narragansett, RI 02882

HUNTING FOR 'CADDY'S PEAK': AN EXAMPLE FROM THE NILE DELTA LAGOONS, EGYPT

In 1993, John Caddy provided us with a simple and intuitive conceptual model relating the observed and potential relationships between fishery landings and nutrient inputs in semi-enclosed seas, such as the Mediterranean. He described a positive correlation between landings and nutrient concentrations up to some mesotrophic threshold, beyond which increased nutrient loading would lead to decreases in fish landings. While never proven, Caddy's Peak has been cited countless times as a warning of the potentially deleterious effect that nutrients can have on coastal water bodies. Here we present the first evidence of Caddy's Peak from the coastal lagoons of Egypt's Nile Delta. These lagoons are among some of the most heavily impacted in the world and demonstrate the shift from eutrophic (enriched) to dystrophic (overly-enriched). In particular, Maryut Lagoon lies just inland of the coastal city of Alexandria and has alone progressed through Caddy's Peak, where fertilizer enrichment after the closure of the Aswan High Dam in 1965 coincided with an increase in fish landings, which then declined when sewage was discharged into the lake in 1981. This dataset provides a powerful first example of ecosystem level responses of coastal fisheries to increasing nutrient inputs that reach and then exceed the point at which yields increase with fertilization.

Olsen*, Ylva S. and I. Valiela. Boston University Marine Program, Marine Biological Laboratory, Woods Hole, MA 02543

A COMPARATIVE STUDY OF THE EFFECT OF SEDIMENT FERTILIZATION ON SEAGRASS IN A TEMPERATE AND A TROPICAL ESTUARY

Worldwide seagrass decline over past decades has primarily been related to anthropogenic nutrient inputs, however controls on seagrass cover, biomass and production are not fully understood. Here we examine the importance of bottom-up controls by nutrients in a temperate and a tropical estuary. In Waquoit Bay, MA seagrasses have dramatically declined because of shading owing to algal proliferation created by eutrophication. In contrast, in Jobos Bay, PR, nutrient inputs are low and seagrass area has not changed significantly in the past few decades. There have been differing results of experiments involving N and P enrichments of seagrasses with some reports indicating that growth of seagrasses are impaired, not changed or increased by nutrient supply. We fertilized *Zostera marina* in Waquoit Bay and *Thalassia testudinum* in Jobos Bay and followed the response by mean growth as well as $\delta^{15}N$ of seagrass tissues. In both systems the fertilizer N was readily taken up by the seagrass. In Jobos Bay there was no detectable growth response to the nutrient enrichment although $\delta^{15}N$ and %N responded. In Waquoit Bay there was a response to fertilization only if macroalgae were removed in conjunction with seagrass fertilization. This shows that the nutrient limitation by bottom-up control mechanisms in Waquoit Bay is secondary to the control excerted by macroalgal shading, due to seagrass growth being primarily light limited. This study shows differential responses to enrichment in two seagrass systems and two seagrass species.

Osher*, Laurie J., and J. Jespersen. Department of Plant, Soil and Environmental Science, University of Maine, Orono, ME 04469

CARBON STORAGE IN ESTUARINE SEDIMENTS: THE MISSING SINK?

Scientists working to balance the global carbon budget agree that there is a large sink for atmospheric CO_2 in the Northern Hemisphere. Stable C isotope ratios and oxygen concentrations of that CO_2 indicate that the sink is terrestrial. However, forest and non-forest terrestrial ecosystems are not the sink. We hypothesized that estuarine sediments in the Northern Hemisphere store significant amounts of C, and may represent the C sink missing from the global C budgets. To address this hypothesis, we studied the organic carbon (OC) present in sediments of Taunton Bay estuary in Hancock County, Maine. We quantified this C from the sediment surface to 100 cm depth, and generated data for similar depth and in the same units as are used in the global models. Our found that the sediment of this shallow estuary stores as much OC/ha as soils in New England's moderately well-drained upland forests. Using stable C and N isotope data, we determined that the majority of the OC in these sediments was fixed by estuarine biota, not upland plants. This result challenges the widely held belief that the OC stored in estuarine sediments has been transported from the surrounding watershed via surface water and subsequently settled out on the sediment surface. The data generated supports the hypothesis that OC stored in estuaries of the Northern Hemisphere *do* store significant amounts of C. In our future research, we will map the distribution of estuaries along the central Maine coast and quantify the C stored there. We will use these data to illustrate that by including estuarine and coastal systems in global C models, C cycle scientists can come much closer to balancing the global C budget.

Overton Bussell, S. [1] and R. Hurst[2]. [1]Department of Conservation and Recreation; [2]Proposal Graphics

Coming to Life: The Back to the Beaches Story

to be filled in later

Peacock*, Emily E.[1], C. M. Reddy[2], and G. R. Hampson[3]. [1] Boston University Marine Program, Woods Hole, MA 02543; [2]Woods Hole Oceanographic Institution, Woods Hole, MA 02543; [3]Woods Hole Group, Falmouth, MA 02536

THE PERSISTENCE OF PETROLEUM HYDROCARBONS IN TWO BUZZARDS BAY SALT MARSHES

Existing evidence indicates that temperate salt marshes are often the most susceptible environment for long-term preservation of petroleum hydrocarbons. Ile Grande salt marsh in France contained oil for at least 13 years after it was spilled in 1978. Numerous studies have examined petroleum hydrocarbons spilled by the barge *Florida* in 1969 in the Wild Harbor salt marsh in Buzzards Bay, Massachusetts. Recent work at Wild Harbor shows that petroleum hydrocarbons can persist in marsh sediments for decades, with a similar distribution and total petroleum hydrocarbon content found in the first few years after the spill. A second Buzzards Bay oil spill occurred in 1974 and contaminated Winsor Cove, only four km from Wild Harbor. To enhance the limited existing evidence of decadal-scale persistence of petroleum hydrocarbons in salt marshes, and look for possible differences in weathering and distribution patterns, we returned to Winsor Cove, which had not been analyzed for petroleum hydrocarbons since shortly after the spill. The samples collected in Winsor Cove reveal that oil does persist for 30 years, and the horizontal distribution of the oil is similar to that of Wild Harbor, having higher oil content closer to the water. Vertically in the sediments, the remaining oil in Winsor Cove is at the surface, differing from Wild Harbor, where the oil is found 4 to 20 cm below the marsh surface. This difference is accompanied by a stronger recovery of grasses in Wild Harbor, and a higher rate of erosion in Winsor Cove. Studies from both salt marshes show the susceptibility of temperate salt marshes to long-term preservation of petroleum hydrocarbons and present different scenarios for the fate of the persisting oil.

Rivers*, David O., and F. T. Short. Jackson Estuarine Laboratory, University of New Hampshire, 85 Adams Point Rd., Durham NH 03824

SEASONAL CHANGE IN HABITAT AREA AT THE DEEP END OF EELGRASS

(*ZOSTERA MARINA* L.) MEADOWS

Accurate assessment of eelgrass (*Zostera marina* L.) meadows is important for mapping, habitat estimates and restoration efforts. The deepest parts of the meadow are the most difficult to assess, yet the depth to which eelgrass grows greatly affects the total area of habitat. The light-limited growth conditions of eelgrass at the deep end of the meadow can cause dynamic seasonal changes in meadow area. Delineating the edge of a meadow can be problematic if plant growth is sparse. For this study, the edge of a meadow was defined as shoots occurring no more than one meter apart. Fluctuations in maximum eelgrass depth were monitored quarterly at the deep end of five meadows along a water clarity gradient extending up the Great Bay Estuary, NH. Permanent transects were established parallel to the deep edge of each meadow. Positive and negative changes in maximum depth of eelgrass were measured in reference to the transects, in order to calculate change in eelgrass habitat area. Habitat area at the deep end of these meadows varied between sites and seasonally within a site. Seasonal fluctuations in meadow depth suggest light driven dynamics in the position of the deep edge. In addition to seasonal changes, the amount of eelgrass habitat at the deep ends of these meadows also varied from year to year, indicating that accurate assessment of habitat area cannot be based on one year?s data.

Rutecki*, Deborah, and M. Scherer. Marine Research/Normandeau Associates Inc, 141 Falmouth Heights Rd., Falmouth, MA 02556

ASSESSMENT OF HATCHERY REARED WINTER FLOUNDER, *PSEUDOPLEURONECTES AMERICANUS*, AS A MITIGATION TOOL IN CAPE COD BAY, MA.

Winter flounder is an important commercial, recreational, and estuarine indicator species. Pilgrim Nuclear Power Station monitors the Cape Cod Bay winter flounder population to assess potential impacts of plant operations on the local ecosystem. To assess the feasibility of contributing to the local winter founder stock and mitigating potential operation impacts tagged young-of-the-year winter flounder were released into Plymouth Harbor annually from 2001 to 2005. Released hatchery-reared and wild young-of-the-year flounders were collected using a beach seine in Plymouth Harbor near the release site to determine their survival, growth, and diet composition. The findings from the hatchery-reared fish were then compared to those from the wild young-of-the-year flounder. Post-release collections indicate that hatchery reared fish survived, grew, and successfully adapted to wild food resources. Hatchery enhancement can be a reliable mitigation tool for winter flounder in Cape Cod Bay.

Shields*, Erin C., and C. Weidman. Waquoit Bay National Estuarine Research Reserve, East Falmouth, MA

EXPLORING QUANTITATIVE APPROACHES TO CHARACTERIZING HYPOXIC EVENTS

An important problem for coastal resource managers is determining the trend or relative severity of hypoxia in a given coastal system over time. This problem boils down to answering the commonly asked but difficult to answer question, "Is local water quality getting better or worse?" For estuarine hypoxia, some of the difficulties lie in the transient nature of hypoxic events and determining the critical thresholds of DO concentration and duration that delineate them. Long term average concentration of DO is fairly meaningless in that severe hypoxia is often balanced by extreme hyperoxia, often in the same day, and significant degradation or improvement in DO conditions can be lost in the signal noise. Cumulative time below certain thresholds is a better measure, but does not capture the event aspect of hypoxia that can most affect lethality to infauna. This project takes advantage of Waquoit Bay NERR's long-term, high frequency System Wide Monitoring Program (SWMP) dissolved oxygen data at a single site to explore quantitative approaches to characterizing hypoxic events for purposes of comparison. Quantifying the severity and frequency of hypoxic events can be similar to approaches used to describe climate events such as storms or droughts, and such statistics could be used to compare how "bad" particular events, months or years were at one location, and more meaningfully measure the relative health of coastal systems.

Short, Frederick T. University of New Hampshire, Jackson Estuarine Lab, Durham, NH

INDIAN OCEAN TSUNAMI IMPACTS ON MANGROVE, SEAGRASS AND CORAL REEF HABITATS

The major earthquake off Sumatra and the subsequent series of earthquakes in the Andaman and Nicobar Islands on 26 December 2004 produced the devastating Boxing Day tsunami. In actuality, on that day a series of tsunamis propagated in all directions across the Indian Ocean, reaching land as huge surges of water impacting the coastal seascape, smashing the coast, killing thousands of people, and devastating coastal communities. Damage to the coastal seascape (mangrove, seagrass and coral reef habitats) was patchy, site specific depending on exposure and bathymetry, and remains unknown in many locations. The habitat damage was greatest in areas closest to the source of the tsunami including Indonesia, Thailand, the Andaman and Nicobar Islands and Sri Lanka. Some coral reefs were destroyed in the few areas of uplift, were severely damaged in some areas from sediment and debris washed into the sea from the land and by coral rubble thrown by waves, but in most of this vast area, corals escaped serious damage. Mangrove damage was highly variable with a few areas, particularly Aceh, Indonesia, having entire forests destroyed, but most areas receiving minor damage. Intact mangrove forests, and to a lesser extent coral reefs, acted as buffers to the tsunami waves and protected inshore lands and villages in many areas. Seagrasses, in some heavily hit areas, were smothered by sediments and eroded by enormous wave energy, but for most of the region the extent of the seagrass impact is unknown, due to a lack of any pre-tsunami seagrass information. Thus, a major recommendation is to increase awareness of seascape habitats and

initiate widespread monitoring throughout the Indian Ocean.

Sokoloff*, Paul D., G. E. Moore, and F. T. Short. Jackson Estuarine Laboratory, University of New Hampshire, 85 Adams Point Road, Durham, NH 03824

A MESOCOSM STUDY TO DETERMINE THE EFFECT OF LOWERED SALINITY ON EELGRASS (*ZOSTERA MARINA*)

Water management structures such as dams and weirs can significantly alter freshwater flow to coastal areas, affecting the salinity gradient in receiving estuaries and near-coastal marine environments. Eelgrass (*Zostera marina*) is the dominant seagrass in the North Atlantic, where it thrives in a salinity range of 5 psu to 36 psu. Yet in estuarine and coastal waters adjacent to large-scale water management operations, water management decisions may cause salinity to drop to 0 psu. To assess the potential effect of acute and chronic decreases in salinity on eelgrass, a mesocosm study was conducted to simulate eelgrass response across an experimental salinity gradient. Twelve 0.8m^3 fiberglass, open-topped tanks were filled with 10 cm of a one: one mixture of organic mud and sand and then planted with 107 eelgrass shoots/m^2 in July 2005. Four salinity treatments, 0, 5, 10, and 20 psu, were randomly assigned to the tanks and maintained by the control of both fresh and salt water inputs. Eelgrass biomass, health and survival were then monitored over the next three months. The 0 and 5 psu treatments had detrimental effects on both growth and survival of *Z. marina*, manifested as reduced biomass production, chlorotic leaves, epiphytic algae growth and premature death. The plants subjected to the 0 psu treatment were all dead by the end of the experiment, and plants remaining in the other treatments showed a significant relationship between overall health and salinity. A significant positive relationship was found between salinity and biomass production.

Taylor, David I. Environmental Quality Department, Massachusetts Water Resources Authority, Boston, MA 02129

WASTEWATER DIVERSION, AND CHANGES TO THE HARBOR WATER-COLUMN?

External loadings of materials are one of the factors that regulate the structure and function of estuarine ecosystems. Boston Harbor has recently experienced a large reduction in material loadings, as a result of diversion of wastewater discharges offshore. Much less is known of the effects of decreases, than increases in loadings, on estuaries. Five years have passed since the diversion, and the purpose of this paper is to compare eutrophication-related, water-column conditions in the Harbor before and after diversion. The paper addresses differences for the water-column data averaged Harbor-wide. Significant differences have included 30% to 55% reductions in concentrations of N and P, 5% to 30% reductions in molar ratios of N:P, 25% to 30% reductions in chlorophyll-a, a 30% reduction in particulate organic carbon, and 5%

increases in mid-summer, bottom-water dissolved oxygen concentrations and percent saturation. For water-clarity (measured as k or secchi depth), concentrations of total suspended solids, and salinity, Harbor-wide averages for the 5 years have not been significantly different from baseline. Significant increases in clarity, and decreases in TSS, have, however, been observed in specific areas of the Harbor.

Tucker*, Jane[1], A.E.Giblin [1], S.W. Kelsey [1], C.S. Hopkinson [1], and B.L. Howes [2]. [1] The Ecosystems Center, Marine Biological Laboratory, Woods Hole, MA; [2] University of Massachusetts, Dartmouth, MA

BENTHIC METABOLISM AND NUTRIENT FLUXES IN MASSACHUSETTS BAY RELATED TO THE RELOCATION OF THE BOSTON SEWAGE OUTFALL

We have compiled a long-term dataset on benthic metabolism and nutrient fluxes for the Boston Harbor/Massachusetts Bay ecosystem as part of a monitoring program designed to assess the impacts of the relocation of the Boston sewage effluent outfall from Boston Harbor into the bay. We have reported before on the changes we have observed in the harbor, which have clearly been driven by changes in sewage inputs. To date, however, we have not observed any changes in Massachusetts Bay related to the operation of the new outfall. What drives the variability we have seen in Massachusetts Bay? We are fortunate among coastal researchers to have access to a comprehensive dataset from the monitoring program that includes over seven years of baseline, pre-relocation data and five years of post-relocation data. We continue to try to interpret our benthic flux dataset in terms of trends that have been reported in other parts of the monitoring program. For instance, we have previously noted apparent links between water temperature, water column chlorophyll, and benthic fluxes, and between storms, infaunal populations and sediment redox. As more data have been added to the dataset, have these observations held?

Vincent, R. Jackson Estuarine Laboratory, Universitiy of New Hampshire, Durham, NH 03824.

ECOLOGICAL RESPONSES TO DITCHING AND DITCH-PLUGGING IN NEW ENGLAND SALT MARSHES

The practice of ditch-plugging is used as a method for salt marsh habitat restoration and enhancement, but the long-term effects from this methodology are unclear. Additionally, human made ditches have existed on salt marshes for decades, but the effects of ditching on ecological functions are only poorly understood. Clearly, a greater understanding of ecological changes due to hydrologic alterations is needed. The purpose of this study is to investigate the ecological responses to anthropogenic impacts in salt marsh habitat and how these responses compare to the functions and ecological interactions observed in naturally occurring salt marsh systems.

The study will provide some understanding of the long term effects of ditching and ditch plugging on hydrology and the resulting impacts to surrounding habitat and wildlife use in four New England salt marshes. Variables to be analyzed will include: ground and surface water levels; soil chemistry, structure, strength, and surface elevations; vegetation communities; nekton populations; and bird use. Results of the study will aid in designing habitat restoration and enhancement methodologies that avoid unintended long term effects to salt marsh structure and function.

Watts*,Alison W., and T.P. Ballestero. University of New Hampshire, Durham, NH 03824

PAH CONCENTRATIONS IN WETLAND PLANTS ? DOES THE SEDIMENT MATTER?

Polycyclic aromatic hydrocarbons (PAHs) were measured in several wetland plant species grown in sediment contaminated with up to 900 ppm total PAHs. After approximately 3 months, the plants were harvested, cleaned, and analyzed for an expanded suite of PAHs which included both the 16 priority PAHs and alkyl PAH homologs. Sediment and air samples were also collected and analyzed. PAH compounds were detected in all of the samples, and the highest concentrations were, as expected, in the contaminated sediment. The root samples were generally about an order of magnitude lower, and were strongly correlated with the concentration of the soil they grew in. The concentrations in foliage were low (less than 2ppm total PAHs), and did not correlate with soil concentration. There was no significant difference in low molecular weight PAH compounds detected in the foliage of plants grown in contaminated sediment, plants grown in control sediment located adjacent to contaminated sediment, and plants grown in control sediment at a different location. A slight increase in high molecular weight PAHs was detected in plants grown in contaminated sediment. This data suggests that most of the PAHs detected in the foliage of the plants is a product of atmospheric deposition, and is not effected by root contact with high PAH concentrations.

Wolf*, Steve[1], M. Greenblatt[1], S. Kelly[1], P. Neubert[2], I. Williams[2], R.J. Diaz[3], J.H. Ryther[4], C.Wright[4], T.J. Fredette[5], D.A. Carey[6]. [1]ENSR, 2 Technology Park Dr.,Westford, MA 01886; [2]ENSR, 89 Water St., Woods Hole, MA; [3]Diaz and Daughters, 6198 Driftwood Ln., PO Box, 114, Ware Neck, VA 23178; [4]CR Environmental, 639 Boxberry Hill Rd., E. Falmouth, MA 02536;[5]NED, US Army Corps of Engineers, 696 Virginia Rd., Concord, MA 01742; [6]CoastalVision, 215 Eustis Ave., Newport, RI 02840

STABILITY AND RECOVERY OF CAPPED IN-CHANNEL CAD CELLS: BOSTON HARBOR, MASSACHUSETTS

The Boston Harbor Navigation Improvement Project involved dredging within the Inner

Harbor and construction of nine confined aquatic disposal (CAD) cells beneath the navigable channel from 1997 to 2000. The cells received dredged sediments that were unsuitable for unconfined open water disposal, and were capped with sand to further isolate the dredged material. Given that the use of CAD cells directly beneath the channel was a relatively new technique, investigations were required to assess the effectiveness of disposal into the cells, cap placement, and longer term stability and benthic recovery of the cells. The longer term follow-up investigation was performed in August 2004, four to seven years after completion of individual CAD cells and included bathymetry, side-scan sonar, underwater video, and sediment-profile imaging. The bathymetry and side-scan sonar data revealed that all nine CAD cells remained as stable structures with no evidence of significant cap disturbance. As expected, limited further consolidation of the material within the cells had taken place. While many of the cells had sand exposed at the surface at the completion of the project, silt-clay was identified as the predominant surficial sediment in 2004. This shift was expected as natural deposition takes place over the cells. Sediment-profile images taken in 2004 revealed that the benthic habitat conditions within the cells and reference areas were similar, but both were indicative of a stressed environment, not unexpected given periodic episodes of poor water quality and disturbance associated with a working harbor. The towed video footage revealed an environment teeming with small fish and crustaceans, both over the CAD cells and reference areas

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Zwingelstein, Brian* and P. Morgan. Dept. of Biological Sciences and Dept. of Environmental Studies, University of New England, Biddeford, ME 04005

GREEN CRABS, FISH AND ADJACENT LAND USE: AN INVESTIGATION OF FRINGING SALT MARSHES ALONG THE YORK RIVER, MAINE

We studied the ecology of six fringing salt marshes on the York River in Maine, during the summer of 2005. Our fish sampling revealed a great abundance of the invasive green crab, *Carcinus maenas*, compared to the local fish populations. This is similar to what had been observed in previous fringing salt marsh studies in southern Maine. The objective of this study was to determine if the great number of crabs was correlated with fish use of the marshes. We sampled the fringing marshes with fyke nets during day and night spring tides in June and August. Although we found no correlations between the biomass density or the density of individuals of fish and green crabs, we saw a trend of increased numbers and biomass of green crabs in fringing salt marshes adjacent to more highly developed uplands.
