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apRoberts-Warren, N..[1],D. Bowring.[1],T. Carr.[1], C. Lanni.[1], M. Kahn.[1], T. Ratliff.[1], and J. Brawley*[2].[1] Wheaton College, Norton, MA 02766-2322; [2] Saquish Scientific, Duxbury, MA 02332.

STATISTICAL ANALYSIS OF COLIFORM LEVELS FOR THE PECONIC BAY REGION

The National Shellfish Sanitation Program (NSSP) provides guidance on how to determine whether coastal waters are suitable for shellfish harvest based on indicators for potential pathogen contamination. One such indicator is fecal coliform. Most states apply NSSP standards for fecal coliform and these are expressed in two statistics: the geometric mean and the 90th percentile. Historical water column monitoring data are used to calculate these statistics for particular shellfish harvest areas and decisions on whether specific areas should be opened or closed for shellfish harvesting are made. This study looked at uncertainty associated with these two statistical standards and how confidence intervals vary over time and space. The potential for developing a relative risk assessment based on uncertainty is evaluated.

Beem*, N.T. and F.T. Short, Jackson Estuarine Laboratory, University of New Hampshire, Durham, NH 03824

EELGRASS IN THE GREAT BAY: HUMAN GROWTH, EELGRASS DECLINE, AND THE NEED FOR EDUCATION

Eelgrass, *Zostera marina* L., declines at both restored and reference areas of the Great Bay Estuary (GBE), New Hampshire, suggest a reduction in the health of the estuary. The NH Estuaries Project reports concomitant increases in both dissolved inorganic nitrogen (DIN) and suspended sediments. The eelgrass beds, transplanted in 1994 as mitigation for habitat loss due to port development, reached comparable functions and values to natural reference sites within 6 years of transplanting. However, data from 2001 to the present shows significant decline in plant parameters, especially eelgrass biomass, density, and leaf area. The overwhelming eelgrass decline at all sites indicates that these trends are the result of an estuary-wide factor. Din concentrations in GBE have increased 59% in the past 25 years, with the single largest contributor of nitrogen being wastewater treatment facilities. Additionally, increased impervious surfaces in the watershed have likely resulted in increased suspended sediments, limiting eelgrass growth. The linkage between human activity and declining eelgrass populations in GBE and the high cost of remediation necessitates immediate outreach efforts to educate the local community and raise awareness of the consequences of losing critical eelgrass habitat.

Berounsky*, V.M., L. T. Green, D. Borkman, S. D. Pratt, and R. J. Bell. University of Rhode Island, Narragansett, RI 02882

THE PETTAQUAMSCUTT ESTUARY OVERTURN OF OCTOBER, 2007: CAUSES & CONSEQUENCES

The Pettaquamscutt River Estuary is a shallow estuary in southern Rhode Island with two deep (12 and 15 m) basins containing almost permanently anoxic bottom waters overlaid with 3-4 m of well-oxygenated waters. In October, 2007 an overturn occurred in the northern basin following an unusually dry summer and early fall which limited the freshwater input to the estuary. A 13oC drop in daily mean air temperature coupled with strong winds presumably prompted the initial event. During these rare overturns the sulfur-rich anoxic bottom waters are displaced with high salinity oxygenated water. The resulting well-mixed water column was essentially without oxygen and the precipitated sulfur imparted a milky color to the overturned water. Such a drastic change has a pronounced effect on the biological, chemical, and physical components of the original ecosystem. Oxygen remained low for the next 6 weeks, when the northern basin became ice-covered. Ammonium levels were high (50-100 μmol/L) immediately after the overturn, about twice as high as those found outside the basin, and values remained about 200 μmol/L over the following weeks. Hundreds of juvenile menhaden were found dead, along with some white perch, striped bass, and a few flounder. Blue crabs were seen burrowing into the sand on shore. Few living benthic invertebrates were found. Phytoplankton samples, taken about a month after the overturn, found *Prorocentrum minimum* dominate and at densities four times greater than outside the basin. Previous documented overturns in 1957, 1971, and 1990 also occurred after an unusually dry period (less than 25 cm of precipitation over 3 months). If there are more frequent dry summers, will there be more overturns?

Brawley, J.W.* Saquish Scientific, Duxbury, MA 02332.

WAQUOIT BAY'S CRITICAL NITROGEN LOADING THRESHOLD(S)

Waquoit Bay is a shallow, semi-enclosed embayment located on the southern coast of Cape Cod (MA). The bay has been studied extensively to determine causal relationships between land-derived nutrient inputs and changes in system metabolism and ecology. This talk describes one approach used to determine ecosystem thresholds associated with system metabolism and SAV habitat. Results from series of models developed for this purpose are compared with other independent studies to illustrate how “critical loads” differ among desired ecological conditions and how nonlinear system responses to nutrient reductions may affect restoration efforts.

Brin*, L.D., and I. Valiela, Boston University Marine Program, Marine Biological Laboratory, Woods Hole, MA 02543

NITROGEN RETENTION AND LOSS IN EXPERIMENTAL SALT MARSH PLOTS EXPOSED TO CHRONIC NUTRIENT ADDITION

Salt marshes are thought to remove and retain land-derived nitrogen (N) that could otherwise cause eutrophication in coastal waters. These processes need to be quantified at within-year and decadal time scales. To investigate the long-term nitrogen retention capacity of salt marshes, we measured dissolved inorganic nitrogen in tidal water entering and leaving experimental plots that have been subject to several levels of fertilizer addition each growing season since 1970. Preliminary results, from sampling over both full tidal cycles and intensively-sampled ebb tides, indicate that tidal DIN export depends primarily on N input rate and tide height. While seasonal losses through tidewater increased substantially with increased N

input, percent retention of added N remains at approximately 99-100% for all treatments, an increase as compared to estimates in 1973. This suggests that ecological changes that have occurred in each plot since establishment have not inhibited long-term N retention capacity, presenting a strong argument for salt marsh conservation.

Buchsbaum, R.[1] and P. Neubert[2]. [1]Massachusetts Audubon Society, 346 Grapevine Road Wenham, MA; [2]ENSR, 89 Water Street, Woods Hole, MA.

MEASURING DIVERSITY AND ABUNDANCES IN SALT MARSH BIRDS: COMPARISONS OF DIFFERENT METRICS AND METHODS

We have sampled salt marsh birds at a number of locations in Massachusetts using standard point count methodology.

Donnelly, Grace M. 147 Sixth Stret, Providence, RI 02906-3733

SEEKONK RIVER ESTUARY:SHORELINE AND SALT MARSH CHANGES RELATED TO A LANDSLIDE EVENT

In June, 1982, there was a massive landslide from part of the 70 ft bluff along the west shore of the Seekonk River in Providence, RI. This event produced a large fan of loose sand in the river. With a sequence of historical aerial photos and ground observations, we documented localized shoreline shapes before and following the landslide. Preliminary observations show: 1)several shoreline changes are related to the 1982 landslide, including extensions to the historical cusps and salt marsh vegetation at Swan Point, Goose Point, and the outer margins of Grotto Brook; 2)fringing salt marshes are also extended; and 3)the initial fan is now a series of concentric bars. A well established salt marsh is on the innermost bar, and recurring crops of *Spartina alterniflora* seedlings develop on the forward margin of the outer bar. We suggest that clean sand from the 1982 landslide, in concert with the improving water quality of upper Narragansett Bay, was a major factor leading to the vigor of the present day salt marshes along this urban river.

Eberhardt*, A. [1], B. Johnson[2], D. Burdick[1], M. Dionne [3] [1]Jackson Estuarine Laboratory, University of New Hampshire, Durham, NH 03824 [2]Bates College, Department of Geology, Lewiston, ME 04240 [3]Wells National Estuarine Research Reserve, Wells, ME 04090

CAN TIDAL RESTRICTIONS IN SALT MARSHES LIMIT PREY ITEMS FOR THE AMERICAN EEL, *ANGUILLA ROSTRATA*?

Saltmarsh primary productivity is widely acknowledged to support coastal food webs, yet support of migratory fish species is not well understood. Research was conducted to elucidate the role of salt marshes in the trophic support of the American eel, *Anguilla rostrata*. Eels were captured from upstream and downstream regions of salt marshes representing tidally restricted and unrestricted hydrologic regimes to examine spatial variation and the effects of hydrologic alteration on trophic dynamics. Results from carbon stable isotope analysis suggest that eels rely on varied organic matter sources between upstream and downstream areas, regardless of the hydrologic regime. Nitrogen isotope data suggest that eels captured in

upstream areas of tidally restricted marshes feed at a lower trophic level than those captured in reference marshes, suggesting a degraded trophic structure in salt marshes containing tidal restrictions. A non-lethal method of sampling eels for stable isotope analysis was evaluated; results suggest that fin tissue is a suitable analog to stable isotope analysis of eel muscle tissue. Future research, including increased stable isotope analysis and a telemetry study, will elucidate the role of salt marsh habitats in the life history of the eel. Results will provide decision makers with information to better manage tidal marshes in general and specifically for the conservation of A. rostrata, a species in decline throughout the extent of its range.

Elmer*, W. H. and Marra, R. E. The CT Agr. Exp. Sta., P. O. Box 1106, New Haven, CT 06504.

TAXONOMY AND PHYLOGENY OF PATHOGENIC AND NONPATHOGENIC *FUSARIUM* SPECIES TO *SPARTINA ALTERNIFLORA*

The rapid disappearance of *Spartina alterniflora* and *S. patens* on high and low marshes in New England has been referred to as Sudden Vegetation Dieback (SVD aka, Sudden Wetland Dieback). Factors such as drought and rising sea levels have been implicated as primary stressors leading to SVD. Other organisms, such as fungi in the genus *Fusarium*, have also been isolated more frequently from *S. alterniflora* in SVD sites than in healthy marshes. These fungal species have been morphologically categorized into morphospecies. Pathogenicity tests showed that three morphospecies were equally pathogenic on *S. alterniflora* and one morphospecies was non pathogenic. Partial sequences in the translation elongation factor 1-alpha, calmodulin, and beta-tubulin genes were aligned and analyzed for 22 pathogenic isolates and 11 non-pathogenic isolates. Phylogenetic analysis of aligned sequences was performed using Neighbor-Joining method with evolutionary distances computed using the Maximum Composite Likelihood method. With each gene sequence, pathogens clustered together with minimal diversity suggesting they may compose one closely related species complex. Non pathogens also clustered together with minimal genetic variation. A blast query to NCBI did not match either of these species. A formal description of these two species is warranted.

Fogarty*, C.E.[1], S.Brown[1], R.W. Fulweiler[2], S.W. Nixon[3], and B.D. Jenkins[1,3] [1]Department of Cell and Molecular Biology,College of the Environment and Life Sciences, University of Rhode Island, Kingston, RI; [2]Department of Oceanography and Coastal Sciences, School of the Coasta nd Environment, Louisiana State University, Baton Rouge, LA; [3]Graduate School of Oceanography, University of Rhode Island, Narragansett, RI

FOLLOWING THE NITROGEN-FIXING AND DENITRIFYING COMMUNITIES WITH MOLECULAR TOOLS IN A CHANGING ESTUARY, NARRAGANSETT BAY

Denitrification is thought to be the major nitrogen (N) cycling process in estuarine sediments, in contrast to N-fixation, which has not been believed to be a significant process. In the summer of 2006, the sediments of Narragansett Bay switched from being a net sink of fixed N (denitrification dominated) to a source of fixed N (N-fixation dominated). It is hypothesized that a general long-term warming trend in the water of the Bay directly resulted in reduced deposition of organic matter to the benthos and a consequent depletion of bioavailable N within the sediment. However, the bulk biogeochemical methods that were used - nutrient flux measurements, N2-N gas flux measurements, and acetylene reduction assays- only reveal that a community of active N fixing micro-organisms exists; these results do not reveal the actual identity, composition, or abundance of these micro-organisms. By characterizing the microbial community

composition in Narragansett Bay sediments, and understanding their activity in relation to N fluxes, we will better understand the complex interactions and long-term consequences of climate shifts and other perturbations of N loading to the Bay.

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

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

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 may 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* was manipulated by subjecting them to different simulated haying regimes during the summer 2005 and 2007 growing seasons. In 2007, plots were also fertilized with N and P. Aboveground biomass, its N and C content, pore water analysis of sulfide, iron, and sulfate/chloride ratios, and rates of sedimentary N fixation were determined. Cutting stimulated initial regrowth of plants in *S. patens* plots, however total cumulative biomass levels were lower in clipped plots at the end of the growing season in the absence of fertilization. Fertilizing led to increased biomass over the season particularly in plots that were clipped and fertilized. Pore water data revealed that the sulfate/chloride ratios were lower in cut plots with increased sulfide and decreased iron concentrations indicative of enhanced sulfate reduction. Plant C:N ratios were much lower in clipped plots. N fixation was highest in clipped plots and lowest in fertilized plots. These data indicated that cutting stimulated sedimentary sulfate reduction, a process known to conduct N fixation. Therefore, haying stimulated the growth of *S. patens*, which lead to enhanced translocation of C belowground that stimulated sulfate reduction and N fixation.

Franz*, D. R. Biology Department, Brooklyn College CUNY, Brooklyn NY 11210

RIBBED MUSSEL POPULATIONS IN JAMAICA BAY – CURRENT CONDITION AND FUTURE PROSPECTS

Jamaica Bay is an urbanized, highly eutrophic estuary. Historically, island and fringing salt marshes have supported very dense populations of Ribbed Mussels, which continue to provide important ecosystem services. However, as marshes rapidly erode, the current condition and future status of mussel populations are of concern. Mussel populations at four fringing marsh sites in 2007 were compared with data from 2004 and, limited information dating to 1991 at one of the four sites. Densities (2-8 $x10^3$ per m^2) and recruitment rates (>20-25% of total population) remain high and unchanged from 2004. However, mussel dry weights and population growth curves indicate substantial declines in comparison with data from the early 1990's. Survivorship curves and observed recruitment rates were used to project future population sizes. Projections suggest that future populations are particularly sensitive to recruitment rates. At current rates, two of the four populations will decline in density. In view of rapid marsh losses, it seems unlikely that recruitment rates will remain as high as currently. Evidence from survivorship curves, growth curves and individual biomass suggest that edge populations in 2007 were living higher in the intertidal shore than edge populations from the past. Possibly, bank erosion rates are exceeding sea level rise. A significant loss of mussels from

Jamaica Bay will severely degrade an already highly eutrophic system.

Freeman*, A. S. [1], F. T. Short[1], I. Isnain[2], F. Razak[2], R. Coles[3], [1] Jackson Estuarine Laboratory, University of New Hampshire, Durham, NH 03824; [2] Sabah Parks, Marine Research Unit, Kota Kinabalu, Sabah, Malaysia; [1] Norther Fisheries Center, Queensland, Australia.

SEAGRASSNET FINDINGS ABROAD: LOCAL LAND-USE PRACTICES THREATEN COASTAL SEAGRASS COMMUNITIES IN SABAH (MALAYSIA).

Seagrass habitats are susceptible to coastal, environmental impacts and serve as early indicators of system-wide degradation. SeagrassNet is a global seagrass monitoring network with 71 sites in 24 countries doing quarterly assessment of fixed transects for plant and environmental parameters (www.SeagrassNet.org). Two SeagrassNet sites were established in a national park in Sabah (Malaysia) in 2001, with one as a reference (pristine) site and one anticipating impacts from nearby waterfront development. Seagrass percent cover at both sites declined significantly between 2003 and 2005, and has remained low in areas of both low and high seagrass diversity (ranging from 1 to 5 species). The extent of species loss, reduction in percent cover, and decreased biomass in both the pristine site and the impact site is indicative of system-wide degradation. We discuss possible causes of the seagrass decline with respect to our simultaneously collected environmental data (i.e., light extinction, temperature, and sediment parameters) and identify a link to a recent change in land-use practices which resulted in extensive deforestation of the watershed proximal to the two Sabah SeagrassNet sites. Satellite imagery confirms the persistent sediment plume covering both SeagrassNet sites and the waters of the national park.

Geoghegan* P.[1], C. Gurshin[1], and A. Legendre[2], [1]Normandeau Associates, Bedford, NH 03110; [2]FPLE Seabrook Station, Seabrook, NH, 03874.

IS THE NEARSHORE DEMERSAL FISH COMMUNITY OF NEW ENGLAND IN AN ALTERNATE STEADY STATE?

Long-term trends in the nearshore demersal fish community of New England are examined through a 30-year database associated with the environmental monitoring program at Seabrook Nuclear Power Station in New Hampshire. Total CPUE peaked in 1982, decreased to a low in 1995 and is now near previous levels. Species composition has changed over time with yellowtail flounder, hakes, and Atlantic cod less abundant and skates, longhorn sculpin, and other non-commercial fish more abundant. Despite these changes, total biomass may be similar to previous years. Pelagic fish such as Atlantic mackerel and Atlantic herring and macroinvertebrate predators such as lobsters and *Cancer* spp. crabs have become more abundant. Increased surface water temperatures may be positively affecting the abundance of macroinvertebrate predators. These observations are consistent with the literature and other long-term databases and may indicate that the demersal fish community has transformed to an alternate steady state with less ecological functional redundancy. Climate change may be affecting the efforts of management agencies to increase the abundance of commercial species to previous levels. The lack of recovery of Canadian cod stocks despite fishing moratoria is illustrative of the potential of recovery for New England commercial species. The literature indicates that the synergistic effects of habitat fragmentation, overexploitation, and climate change may be instrumental in maintaining the current alternate community state. For example, cod in the northwest Atlantic have shown genetic responses to overexploitation including reduced age at length and maturity that may inhibit stock recovery.

Gorokhovich*, Y.[1], and K. Chytalo[2], [1] Department of Environmental, Geographic and Geological Science, Lehman College, City University of New York, Gillet Hall 309, 250 Bedford Park Blvd. West, NY 10468; [2] Department of Environmental Conservation, Division of Marine Resources, 205 N. Belle Mead Rd. E. Setawket, NY 10801.

APPLICATION OF GIS-BASED MULTICRITERIA ANALYSIS TO PRIORITIZATION OF COASTAL PARCELS ON NEW YORK COAST FOR PRESERVATION

Conservation of coastal parcels is important tool for protecting remaining available coastal lands from development. This practice helps: 1. limiting vulnerability of coastal population to natural disasters, including sea-level rise, hurricanes and storm surges; 2. reducing non-point and point pollution sources; 3. limiting urban and sub-urban sprawl; 4. preserving natural features for future generations, education and research. The primary tool for achieving these goals is a purchase of existing available property by the state. These properties include vacant lands, conservation easements and potentially agricultural and recreational lands. Amount of state funding is limited. Therefore potential lands for conservation should be prioritized on the basis of their size, proximity to other natural features and other spatial criteria. The primary tool for this decision-making mechanism is multi-criteria analysis and modeling with Geographic Information Systems (GIS). Presented study shows how spatial modeling and mapping selects and uses spatial criteria for prioritization mechanism; demonstrates a decision-making tool for coastal managers. The results of the study identified more than 200 coastal land parcels available for conservation in New York coastal area within Long Island Sound and prioritized them on the basis of selected spatial criteria. It also show that successful application of presented methodology requires: 1. Free access to the parcel data from coastal communities; 2. Interaction between state and local conservation partners; 3. Identification of conservation goals and translating them into GIS language using spatial variables from multi-criteria GIS model.

Grizzle, R. Jackson Estuarine Laboratory,85 Adams Point Road,Durham, NH 03824.

RECOVERY OF SEAFLOOR HABITATS IN THE WESTERN GULF OF MAINE FISHING CLOSURE AREA

In 1997, the Western Gulf of Maine closure area was established as part of the overall effort to re-build depleted groundfish stocks. Although some commercial gear types (e.g. lobster traps) and recreational fishing are permitted, commercial fishing gear capable of retaining groundfish is prohibited year-round. Our ongoing research program has focused on seafloor conditions in a 400 km2 study area located along the western boundary of the closure, half inside and half outside. Following an initial multibeam sonar mapping effort that produced a 5-m pixel resolution bathymetric map of the study area, approximately 190 sites were sampled from 2002-2005 with some combination of box corer, Shipek grab, and towed videography to characterize sediments, infauna, and epifauna. There were significantly ($p<0.05$) higher (up to 2.5 x) density and taxonomic richness for epifauna on rocky bottoms inside the closure compared to outside. Infaunal density, biomass, and taxonomic richness (family level) were significantly ($P<0.05$) higher (up to 4 x) inside the closure compared to outside, with the most differences in sandy sediments. Preliminary sampling with gillnets in rocky habitats in 2006 and 2007 also indicated greater abundances and biomass of cod and other groundfish inside the closure compared to outside. Overall, these data suggest that removal of gillnets (mainly used in rocky habitats) and otter trawls (mainly used in soft sediment habitats) has allowed substantial recovery of seafloor habitats in some areas within the closure, and these changes may be

affecting groundfish populations.

Hazelton*, E.L.G.[1] and B. Blossey[2], [1]64 Allen Ave, Portland, ME 04103, [2]Ecology and Management of Invasive Plants Program, Department of Natural Resources, Cornell University, Ithaca, NY 14853.

NATIVE *PHRAGMITES AUSTRALIS* DISTRIBUTION IN THE NORTHEASTERN UNITED STATES

Phragmites australis ssp. Americanus is morphologically, genetically and ecologically distinct from the conspecific invasive European Common Reed (Saltonstall et al., 2004). The invasive variety overruns wetlands incurring ecological and fiscal costs, while the native subspecies coexists with native flora. Since the existence of native Common Reed was confirmed by herbarium review and molecular differentiation (Saltonstall, 2002), interest in localized native populations has blossomed. Citizen scientists, land managers and researchers have all forayed into wetlands looking for native *P. australis*, thousands of them sending specimens to the Phragmites Diagnostic Service (PDS) at Cornell University. As yet unreleased, the PDS data contains morphological, environmental, and spatial information for native and introduced *P. australis* populations. We combine locations of morphologically differentiated native and introduced *P. australis* from the PDS with long term field data to determine the distribution of known native *P. australis* populations in the Northeastern United States. Additional population data from the scientific community and a literature review augment our field and PDS data, allowing us to map the distribution of *P. australis ssp. Americanus*. Our study incorporates multiple data sources and methods to give the most comprehensive distribution of native *P. australis* to date.

Hollister*, J. W.[1] and H. A. Walker[1], [1] Atlantic Ecology Division, National Health and Environmental Effects Research Laboratory, Office of Research and Development, U.S. Environmental Protection Agency, Narragansett, RI 02882

LANDSCAPE THRESHOLDS AND THE CONDITION OF NORTHEASTERN ESTUARIES

Anthropogenic impacts to northeastern estuaries have been well documented and many researchers have quantified the associations between broad scale human land uses in contributing landscapes and impacted estuarine condition. However, associations alone are not adequate for identifying thresholds and little work has been done to identify thresholds in the patterns of human use that are indicative of degradation in downstream estuaries. We use conditional probability analysis, non-overlapping confidence intervals, and change point analysis to identify thresholds and explore relationships between patterns of human use in estuarine catchments and the probability of impairment in northeastern estuaries. Preliminary results suggest the following: 1) probability of impairment increases as human use increases, 2) all estuaries with less than approximately 20% human uses are not impaired 3) probability of impairment peaks at intermediate proportions of human use (i.e., approximately between 30-50% of a contributing watershed), and 4) human use alone may not be a tipping point for impairment because non-impaired sites can be found with landscapes dominated by human uses. This last result suggests other factors (e.g. ecoregional variation, estuarine type, habitat differences, etc.) may also play a role in determining how human uses ultimately impact estuarine condition. We expand on these preliminary results with more recent data examined at the individual catchment scale.

Johnson*, C. [1], A. Eberhardt[2] and K. Olivera[3]. [1]Marine and Freshwater Biology Program, University of New Hampshire; [2]Natural Resource and Earth Systems Science Ph.D. Program, University of New Hampshire; [3]Biology Department, University of Massachusetts, Dartmouth.

THE PREVALENCE OF THE NEMATODE PARASITE *ANGUILLICOLA CRASSUS* IN AMERICAN EELS (*ANGUIILA ROSTRATA*) OF GULF OF MAINE ESTUARIES

The nonnative nematode *Anguillicola crassus* parasitizes the swimbladder of the American eel *Anguilla rostrata*. At high infection intensity, the nematode causes deformation of the eel's swimbladder, adversely affecting eel migration and overall life expectancy. Our study will census the mean parasite intensity and prevalence in American eels along the coasts of New Hampshire and northern Massachusetts, comparing data from salt water and fresh water habitats. Samples examined via dissection of the swimbladder will provide a count and weight of the parasites per specimen. Parasite and eel metrics will provide insight into the effects of salt versus freshwater on the presence of these parasites, as well as the effects of eel size class on mean infection intensity. A better understanding of the stresses facing our local eel population may be obtained and compiled with previous research on the eel populations of the surrounding New England area.

Konisky, R. The Nature Conservancy New Hampshire Chapter, Great Bay Field Office, 112 Bay Road, Newmarket NH 03857

NATURE CONSERVANCY PLANNING FOR GREAT BAY ESTUARY, NH: WHAT'S LOST, WHAT'S LEFT, WHAT'S NEXT

The Nature Conservancy (TNC), among many others, recognizes Great Bay Estuary as a nationally-significant conservation landscape. For the past five years, we have been actively working with regional partners to develop spatial planning products that directly support watershed-scale protection of biodiversity. To give these efforts an historical perspective, Odell et al. (2006) researched old maps and surveys (circa 1900-1970) to document the past extent of eelgrass meadows, shellfish beds, salt marshes, and diadromous fish streams in The Great Bay Estuary Restoration Compendium. When compared with current maps, the estuarine habitat degradation was significant, with estimated area losses of 33% for eelgrass (~1000 of 3008 ac), 92% for oyster beds (~1200 of 1302 ac), 42% for salt marsh (~1500 of 3557 ac), and 66% for diadromous fish habitat river miles (1468 of 2203 mi). These baseline estimates show that, although the estuary may appear intact and resilient, a dramatic decline in critical estuarine habitat has occurred over the past century of human habitation in this area. TNC's marine program is now working with partners on a multi-faceted effort to develop a conservation action plan for Great Bay Estuary. Following TNC's Conservation By Design methodology, we have 1) prioritized ecosystem species and habitat targets, 2) identified major ecosystem threats, and 3) developed strategies for action. Nine conservation targets are priorities, including five habitats (coastal matrix forest, salt marshes, eelgrass meadows, oyster reefs, and tidal flats), and four species assemblages (macroinvertebrates, diadromous fish, shorebirds/piscivorous birds, and benthic fish). Fifteen primary threats have been identified, assessed, and ranked across the nine conservation targets. Strategies are now being developed to 1) enhance target viability through restoration activities, 2) abate threats through a variety of policy and programmatic approaches, and 3) increase land/water protection through legislative and economic means. We hope these efforts will lead to a collaborative, ecosystem-based action plan for protection and restoration of estuarine biodiversity in Great Bay Estuary.

Martin*, P.D.1, A Pembroke2, H. Thurston3, R. Kropp3, 1 TRC Companies, 650 Suffolk Street, Lowell MA 01854; 2Normandeau Associates, 25 Nashua Street, Bedford, NH; 3Battelle, 397 Washington Street, MA 02332.

POST-CONSTRUCTION MARINE RESOURCE MONITORING RESULTS FOR THE HUBLINE PIPELINE PROJECT IN MASSACHUSETTS BAY

Increasing demand for natural gas in New England has resulted in the recent expansion of the interstate natural gas transmission system in natural gas pipeline construction in the coastal waters of Massachusetts Bay. The HubLine Pipeline Project consisted of construction of approximately 30 miles of a 30-inch diameter natural gas pipeline within coastal waters between Salem and Weymouth, MA in water depths up to 130 feet. Pipeline construction began in November 2002 and was essentially completed in March 2004, with additional restoration efforts occurring at site-specific locations in early 2005. As part of the permitting process, a Pre- and Post-Construction Habitat Monitoring Plan was developed to characterize baseline conditions and evaluate recovery of habitats and resources of the project area after construction. Baseline information was presented at the Spring 2003 NEERS Meeting. This presentation will provide information on the results of three years of post-construction monitoring, including data on eelgrass, soft sediment infauna, glacial till fauna, hard substrate epifauna, and sediment characteristics. Results revealed soft sediment re-colonization during the first year after construction, and to a lesser extent with glacial till and hard bottom habitats. Challenges in analyzing the comparative criteria included spatial and temporal heterogeneity, unanticipated alteration of the seafloor because of required construction methods, and sample size. Nonetheless, more than three years after construction activities ceased, evidence of the construction disturbance and impact had decreased substantially, and many attributes of the habitats indicate viable, functioning benthic communities.

Mills, K. E., Great Bay National Estuarine Research Reserve, Durham, NH 03824

STRENGTHS AND LIMITATIONS OF STATISTICAL APPROACHES FOR DETECTING MOVEMENT TOWARDS ECOSYSTEM TIPPING POINTS

Exceeding an ecological tipping point can have deleterious effects throughout an ecosystem, and ideally, movement towards a tipping point will be detected with sufficient lead time to avoid reaching it or to mitigate associated consequences. However, the threshold functional responses associated with tipping points makes them statistically difficult to predict in advance of attaining the actual critical point. Looking beyond mean trends in ecological data to variability patterns, correlation structures, and multivariate relationships can provide greater statistical capacity to detect changes in ecosystem conditions that may indicate a shift towards a tipping point. This presentation will establish an ecological rationale for using certain statistical approaches to detect movement towards a tipping point. Water quality and fish community data from Great Bay and the Gulf of Maine will be used to demonstrate the strengths and limitations of certain statistical analyses. In addition, patterns observed through a suite of analyses will be used to evaluate indications of impending ecosystem tipping points in Great Bay.

Mitchell*, E. E. and P.A. Morgan. Department of Environmental Studies, University of New England, Biddeford, ME 04005

COMPARISON OF DISTURBED/UNDISTURBED UPLAND-SALT MARSH BORDERS AND THE

PRESENCE OF INVASIVE/NATIVE HAPLOTYPES OF *PHRAGMITES AUSTRALIS*

Phragmites australis has been observed in marshes in Narragansett Bay,Rhode Island to be more prevalent in salt marshes that border developed shorelines, such as those containing farms, roads, houses and lawns. Other studies have shown that there is an invasive, Eurasian haplotype of *P. australis* that has worked its way into the genetic pool of the North American stock and is different from the native species known to exist in fewer numbers in previous centuries. We wondered if *P. australis* is becoming a dominant force in salt marshes with disturbed uplands in southern Maine, and whether the *P. australis* present on these marshes is the more invasive haplotype. Nine study sites with varying degrees of bordering upland disturbance were chosen for study. Disturbance was defined as human modification of the upland that decreases the natural woody vegetation border between salt marsh and upland to less than 10 meters in width. Morphological characteristics were used to determine the percent of the *P. australis* present along the upland border that was native or invasive. In addition to comparing the degree of upland border development to the presence of *P. australis*, we will also determine whether the presence of the invasive haplotype correlates with the degree of shoreline disturbance.

Moore*, G. E. [1,3], C. R. Peter[3], and D. M. Burdick [2,3]. [1]Department of Plant Biology, [2]Department of Natural Resources, and [3]Jackson Estuarine Laboratory UNH Marine Program,University of New Hampshire, Durham, NH 03824.

STATUS OF THE EASTERN GRASSWORT, *LILAEOPSIS CHINENSIS* (L.) KUNTZE (APIACEAE) IN THE GREAT BAY ESTUARY, NEW HAMPSHIRE, USA

A survey of oligohaline and mesohaline tidal marshes along the upper reaches of eight tidal rivers in the Great Bay Estuary of New Hampshire was conducted to document the occurrence of eastern grasswort, *Lilaeopsis chinensis* (L.) Kuntze. Historical records of *L. chinensis* were documented from the Hodgdon Herbarium of the University of New Hampshire (NHA) and the New Hampshire Natural Heritage Bureau database (Natural Heritage) to assess the presence, absence, or significant population changes of this state-listed rare species. We confirmed the occurrence of seven historically documented populations, noted the plant's likely expansion on four rivers, observed a potential decline of a population on another river, and identified a new population on a river system with no prior documented accounts. The results suggest that L. chinensis has been relatively stable for the last 60 years, although the loss of plants at one of the sites suggests it is threatened by continued development (dams and tidal restrictions) and associated impacts to water quality.

Osher, L. J. Department of Plant, Soil, and Environmental Sciences, University of Maine, Orono, ME.

ESTUARY & COASTAL SCIENCE EXPERTISE NEEDED IN GLOBAL C STUDIES

Scientists from almost every discipline are investigating C cycling within and between ecosystems, and between ecosystems and the atmosphere. Climate modelers use the data produced by these scientists to create models describing the known interactions and predicting future climate scenarios. The data and models illustrate that a significant amount of the CO2 generated by fossil fuel burning in the US is removed annually by photosynthesis in the northeastern US. The modelers conclude that the forest ecosystems of New England are performing this service. To me, this result is an artifact of the data used in the model. The ecosystem maps used identify forests as both covering the greatest land area in the region and having the

highest net primary productivity. The maps used do not include estuary or marsh ecosystems, and as such, the extremely high NPP of these communities isn't taken into account. In addition, the many scientists studying NE forests have yet to find that C in forest biomass or forest soils. My research suggests that a significant amount of the CO2 being fixed in the NE is actually being removed from the atmosphere by estuarine ecosystems. In addition, leading C cycle scientists are suggesting that a better understanding the C dynamics of coastal systems is the next most important step in the study of the C cycle. As one of the few NEERS/ERF scientists working as part of the North American Carbon Program, I invite all of you to join the effort to map coastal ecosystems, describe and quantify the process occurring in these systems, and illustrate the essential role that these high NPP ecosystems are playing in the North American C Cycle.

Pappal*, A. L.[1], and Warren, B. G.[2], [1] Massachusetts Office of Coastal Zone Management, Aquatic Invasive Species Program, Boston, MA 02114; [2] Salem Sound Coastwatch, Salem, MA 01970

SQUIRT SURVIVOR: OBSERVATIONS OF *DIDEMNUM SP. A* AT THE BEVERLY PIER, BEVERLY, MA

In August of 2007, a volunteer monitor with Salem Sound Coastwatch (SSCW) and the Marine Invader Monitoring and Information Collaborative (MIMIC) reported the presence of an unknown organism at the Beverly Pier, a public landing within the Danvers River Estuary, Beverly Massachusetts. The species was positively identified as *Didemnum sp. A*, an invasive colonial tunicate first observed in the Gulf of Maine in 1988. A subsequent survey revealed the presence of the tunicate at several locations along the coast of the Danvers River Estuary and Salem Harbor. Examinations of *Didemnum sp. A* ecology have been conducted in Cape Cod, MA, but it was unclear what traits the tunicate would exhibit in the Danvers River or whether it would even survive through the winter. A pilot study was initiated at the Beverly Pier to examine the invasive tunicate's survival, abundance, and condition through the winter and spring. Monthly observations of abundance (percent cover), colony appearance, temperature, and salinity were collected at four locations within the marina: a subset of wooden pilings, two bundles of electrical cables suspended in the water column, a metal chain suspended in the water column, and an area of storm water inflow. Degradation of the colony began in December, with a marked decrease of colony abundance and biomass observed in February. Although our observations will continue throughout the spring, initial results indicate that *Didemnum sp. A* is able to survive through the winter at the Beverly Pier. More information is needed to evaluate the effect this invasion will have on the ecosystem and economy of the Danvers River Estuary and Salem Sound.

Sarrette*, N.H.[1], K. E. Mills[2], and F. T. Short[1],[1] Jackson Estuarine Laboratory, University of New Hampshire, 85 Adams Point Road, Durham, NH 03824; [2] Great Bay National Estuarine Research Reserve, 225 Main Street, Durham, NH 03824.

COMPARING MONITORING METHODS TO DETECT EELGRASS CHANGE IN GREAT BAY, NEW HAMPSHIRE

The Great Bay Estuary has experienced both declines and recoveries of the native eelgrass, *Zostera marina* (L.), in both biomass and percent cover within the last 24 years. At various times, these losses have been attributed to increased dissolved inorganic nitrogen (DIN), increased suspended solids, and an outbreak of the slime mold *Labryinthula zosterae*, commonly called "wasting disease". In an effort to document the current status of eelgrass in the Great Bay itself, the Great Bay National Estuarine Research Reserve

(GBNERR) has joined with the University of New Hampshire Seagrass Ecology Laboratory to establish a baseline for eelgrass for comparison in future monitoring programs. Mapping and monitoring of eelgrass based on aerial and ground truthed data has been conducted annually by the Seagrass Ecology Laboratory for the past 24 years. The goal of the joint effort is to initiate long-term in situ monitoring of eelgrass communities in Great Bay, using both the GBNERR transect sampling protocols and SeagrassNet protocols. The two protocols are being compared for their ability to detect change in eelgrass biomass and percent cover. The July 2007 sampling using both methods shows comparable biomass and percent cover data between the two methods, but the SeagrassNet protocol yielded data with lower variance.

Short, F.T. Jackson Estuarine Laboratory, University of New Hampshire, Durham, NH 03824

EELGRASS LOSSES INDICATE DECLINING ESTUARINE HEALTH IN GREAT BAY ESTUARY, NH-ME

Eelgrass in the Great Bay Estuary has been monitored for the past 24 years, revealing a pattern of losses (mostly caused by wasting disease) followed by rapid recovery through extensive seedling recruitment. Some direct losses of eelgrass have been documented from Canada goose grazing as a result of their changing migration patterns due to climate change and some permanent losses of both eelgrass and habitat into which eelgrass could recover have occurred as a result of dredge and fill. However, in the past 5 years, losses of eelgrass from the deeper parts of the estuary have accelerated dramatically with eelgrass beds both natural and restored disappearing in the Piscataqua River and Little Bay. In Great Bay itself, which is largely intertidal, eelgrass distribution has declined only slightly but eelgrass biomass losses have declined significantly. The “take home story” of these patterns of losses over the past 5 years is that intertidal eelgrass populations remain widely distributed despite losses of water quality because they receive enough light at low tide to persist, although eelgrass biomass is diminishing in these intertidal areas. In contrast, deeper-growing eelgrass is largely disappearing as water quality impacts have their greatest effect on sub-tidal plants. Monitoring of the sub-tidal eelgrass populations and the deep edge of the bed is critical because small losses in water quality which are difficult to detect through direct monitoring are integrated by eelgrass over time.

Smith, Rosemary C.[1], and Veronica M. Berounsky*[1,2]; [1]Narrow River Preservation Association, Saunderstown, RI 02874, and [2]Graduate School of Oceanography, University of Rhode Island, Narragansett, RI 02882

WHAT’S THAT SMELL?: DOCUMENTING THE OVERTURN OF THE NARROW RIVER (PETTAQUAMSCUTT RIVER ESTUARY) IN THE FALL OF 2007

Neighbors living on the north end of the Narrow River (Pettaquamscutt River Estuary) in southern Rhode Island noticed a peculiar smell and a milky color to the water on October 12, 2007. “What’s that smell?” they were asking. The northern basin of the river had overturned. The water at the bottom of the basin, which is naturally devoid of oxygen, was displaced and rose to the surface where the hydrogen sulfide precipitated out and the lack of oxygen suffocated organisms that could not escape. Dr. Veronica Berounsky, a Narrow River Preservation Association (NRPA) Board member and a researcher at the URI Graduate School of Oceanography, enlisted the help of family, friends and colleagues to study this unique phenomenon over the fall of 2007. How long would this last? There had been three other documented overturns, in 1957, 1971 and 1990, but information was scant. Retired teacher and new NRPA Board

member Rosemary Smith had her first boat ride on Narrow River a few days after the overturn and learned a lot about estuaries and overturns during weekly sampling trips. This presentation helps us to understand the overturn with maps, diagrams, and pictures of scientists and volunteers at work collecting data daily for six weeks, data that will help us understand how the overturn affected the Narrow River and the organisms that live there.

Tilburg*, C.E., P.O. Yund, S. Zeeman, and S.M. Gill Marine Science Center, University of New England, 11 Hills Beach Rd., Biddeford, ME 04005

DYNAMICS OF THE DISCHARGE PLUME FROM THE SACO RIVER

Biological processes in the coastal portion of the Gulf of Maine are closely coupled to the dynamics of freshwater plumes from a series of rivers. These plumes drive a coastal current, supply nutrients to the system, and dictate salinity levels. The Saco River is the fourth largest river in the state of Maine. Discharge rates are highly variable but can exceed 600 m^3 s^{-1} during spring run-off events. During these events, the surface plume may extend over 100 km^2, though the location of the plume is variable. Normally, Saco Bay is highly stratified and the discharge plume remains at the surface without affecting the benthic community. However, large discharge events followed by substantial mixing can result in episodic reductions in bottom salinity. These events can have biological consequences that are dependent on the duration and severity of the salinity reduction. Here we describe two such events as documented by the recently deployed Saco River Coastal Observing System (SaRCOS), as well as the suite of instruments within the Saco River and the adjoining coastal region that composes SARCOS.

Tilburg,C.M. Gulf of Maine Council on the Marine Environment, 156 Woodman Rd Buxton, ME 04093

BRINGING GULF OF MAINE ECOSYSTEM INDICATORS TO THE USERS

Beginning in 2006, the Gulf of Maine Council on the Marine Environment's Ecosystem Indicator Partnership (ESIP) began the complex process of delivering ecosystem indicators for the Gulf of Maine. Indicator selection has been accomplished by the dedication of over one hundred volunteer Canadian and U.S. scientists and managers working in six subcommittees focused on aquatic habitats, climate change, contaminants, coastal development, eutrophication, and fisheries & aquaculture. Initial priority indicators (three to four) have been determined for the six themes. Concurrent with this effort, ESIP engaged in a broad user needs assessment and development of an Indicator Reporting Tool. The initial tool was released in March of 2008 with a revised version expected in early Summer 2008. The creation of the tool relied upon a thorough data discovery process and innovative efforts with respect to the data aggregator and database, along with specific design treatments based on input from technical partners and the project team. The Indicator Reporting Tool is a novel web application that allows users to look at data for the proposed indicators both geospatially and in graphical form. Currently, users can access point-source information, extent of seagrasses and mussel tissue contamination along with other data (www.gulfofmaine.org/esip). In allowing the user to access data for a variety of data providers, ESIP further accomplishes its goal of providing baseline data for the assessment of ecosystem conditions and trends. This collaborative process has been based on sound science and the strength of the extensive transboundary working partnership.

Trowbridge, P.R., New Hampshire Estuaries Project, University of New Hampshire, Durham, NH, 03824.

THE STATE OF NEW HAMPSHIRE'S ESTUARIES

This presentation describes twelve of the 34 indicators of environmental quality of New Hampshire's estuaries that are tracked by the New Hampshire Estuaries Project. The indicators presented describe key trends in the areas of Water Quality, Shellfish, Critical Habitats and Species, and Land Use and Development. Some of the indicators suggest that conditions are improving in the estuaries, such as decreasing bacteria concentrations in the water during dry weather conditions and toxic contaminant levels in the water and sediments at levels of minimal concern. However other troubling trends, such as record low oyster populations, increasing nitrogen concentrations, and rapid upland development, give rise to concerns for the future health of the estuaries.

Volson, B. Department of Fisheries, Animal & Veterinary Science, University of Rhode Island,Kingston, RI 02881.

DOES ZOOPLANKTON SPECIES BIOCHEMICAL COMPOSITION AFFECT REPRODUCTIVE PERFORMANCE OF *MENIDIA* SPECIES FISH IN TWO RHODE ISLAND ESTUARIES?

In the Upper Pettaquamscutt River Estuary (UPR) and the Upper Point Judith Pond (UPJP), Rhode Island, the main forage fish are the silversides *Menidia menidia* and *Menidia beryllina*. The zooplankton communities in the UPR and UPJP are quite different, especially in spring when these two species ripen for spawning. The zooplankton community at UPR is dominated by calanoid copepods, suggesting a rather clean environment, whereas that at UPJP is dominated by polychaete larvae, suggesting a somewhat degraded environment. We study the effect of zooplankton composition, i.e., food quality, on the provisioning of the two species for reproduction and on reproductive success. We measured proximate composition and concentrations of essential fatty acids (EFAs) in the zooplankton food of *Menidia* species, their eviscerated carcasses, gonads, and the eggs they produce to trace the biochemical composition of prey to offspring. We also monitor weights of gonadal and somatic tissues, egg volume, percent hatch and larval length at hatch. For proximate composition, significant differences were only observed in lipids a) for zooplankton between estuaries, b) between *Menidia* spp., and c) between estuaries for each *Menidia* species. For fatty acids, significant differences were only observed in the Σn3, Σn6 and Σn9 fatty acids for zooplankton and for *M. menidia* gonads between estuaries. Despite the observed biochemical differences, no significant differences were found in unfertilized egg volume or % hatch between estuaries for either *Menidia* spp.; however, length at hatch for *M. menidia* at UPJP was significantly greater than that at UPR.

Wigand*, C., McKinney, R., Davey, E. and Holt M. US EPA, NHEERL, Atlantic Ecology Division, 27 Tarzwell Drive, Narragansett, RI, 02882.

DETERIORATING COASTAL SALT MARSHES – LESSONS LEARNED

Noticeable changes in structure and function in some Narragansett Bay, RI and Jamaica Bay, NY coastal salt marshes support the idea that "tipping points" in these ecosystems have been exceeded. Compared to less impacted salt marshes, the deteriorating salt marshes in Narragansett Bay have a higher areal extent of tall *Spartina alterniflora*, lower areal extent of *S.patens*, greater densities of ribbed mussels, greater densities of detritivores, elevated soil respiration rates, lower denitrification rates, and in some cases, net nitrogen

fixation. Migration of *S.alterniflora* into the high marsh zone has been inferred from soil core analyses and reported for some RI coastal wetlands. In addition, our observations over the past nine years at salt marshes that span a gradient of low to high anthropogenic impact support the premise that the *S.patens* is rapidly disappearing at some sites (i.e., four of the ten marshes). In deteriorating marshes in Jamaica Bay, salt marshes have elevated ribbed mussel densities, decreased belowground root and peat stores, and elevated soil respiration rates. The salt marshes in Jamaica Bay are reported to be disappearing at the alarming rate of approximately 35 acres per year. It appears that these switches in structure, and especially the associated changes in biogeochemical processing, describe new ecosystem states that can not sustain healthy coastal wetlands. Although we are unable to pinpoint the exact times of these tipping points or their causes (e.g., sea level rise or nitrogen over-enrichment), it is clear that human-accelerated changes in some coastal wetlands are underway, and that these changes in structure and function are measurable.

Wilson*, Kristin R.[1], Joseph T. Kelley[2], Daniel F. Belknap[2], Evan S. Allen[3], Benjamin R. Tanner[3], [1]Program in Ecology and Environmental Sciences, University of Maine, Orono, ME 04469; [2]Department of Earth Sciences, University of Maine, Orono, ME 04469; [3]Department of Geosciences and Natural Resources Management, Western Carolina University, Cullowhee, NC 28723

IDENTIFYING A UNIQUE, STRATIGRAPHIC SIGNATURE FOR MAINE'S SALT POOL ENVIRONMENTS

Salt pools are shallow, water-filled depressions common to many north-temperate salt marshes. Previous work from Maine suggests that most salt pools are secondary and dynamic features, rather than primary, relict salt marsh landforms. Recent analyses of a time-series of aerial photographs from Ogunquit to Lubec, ME, reveal that many pools alter their shape and size over decadal time periods, contributing to substantial surficial transformations. This study shows that the dynamic exchange between salt pools and tidal creeks may be one mechanism by which considerable surficial change occurs in Maine's salt marshes. Analyses of surficial samples and Dutch cores taken through extant and paleo-pool environments, reveal that salt pools are recognized in the stratigraphic record by dark gray, muddy sediment of high water content, often containing macrofossils of *Ruppia maritima* and *Hydrobia totteni*. Salt pool sediments have greater percent loss-on-ignition (LOI) than tidal flat or creek environments, less than or equivalent to low marsh, and less than high marsh deposits. Similarly, C/N ratios show that salt pool sediments have a lower C/N ratio and a lower percentage of organic carbon than low, high, and higher-high marsh deposits. Salt pool sediments have a C/N ratio similar to tidal flat sediments but a higher percentage of organic carbon. This study indicates that we can identify a consistent, coast-wide, stratigraphic signature for salt pools. These results may warrant a reinterpretation of previous work that attributes within-core transitions between marsh environments to relative sea-level rise and may expand the context within which we manage these critical coastal environments.
