NEERS SPRING 2003 ABSTRACTS

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HOW TO MODEL HYDRODYNAMICS AND RESIDENCE TIMES OF 27 EMBAYMENTS IN 4 MONTHS

The hydrodynamics and residence times of 27 embayments were modeled during the first year of a project whose goal is to define the relation between nitrogen loadings and ecological responses of 44 systems that range from small to the size of Narragansett Bay and Buzzards Bay. The challenge was to use a simple method that could be implemented quickly for a large number of systems with limited field data. To do this, we had to assume two-dimensional characteristics of the systems, calm winds, and no freshwater inflow. We also had to sacrifice some accuracy: rough estimates of turbulent diffusion and dispersion coefficients were provided by minimal calibration, bottom friction was estimated from bottom type and water depth on published maps, and tidal forcing was obtained from tables and web sites. GIS provided digitized boundaries and bathymetries for each system, which were then used to generate two-dimensional grids for the finite-element models used in predicting circulation and transport. Tidal flushing of embayment water was calculated by tagging the water in the model systems with a simulated tracer and calculating the e-folding times. All systems were modeled using the same procedures. Comparing our results with published results for some of the systems suggested that our procedure reasonably reproduced the flushing behavior in the 27 systems.

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THE MOUNT HOPE BAY TIDAL RESTRICTION ATLAS: IDENTIFYING MAN-MADE STRUCTURES WHICH ALTER TIDAL HYDROLOGY AND DEGRADE ESTUARINE HABITATS IN MOUNT HOPE BAY

For nearly a decade, Massachusetts has been systematically inventorying, assessing, and restoring coastal wetlands degraded by infrastructure crossings such as bridges, culverts, roads and railroads. Where these structures cross coastal wetlands they can restrict tidal flow to upstream wetlands unless properly designed and constructed. *The Mount Hope Bay Tidal Restriction Atlas* is the most recent addition to the inventory efforts. Where previous atlas projects have focused on salt marsh, this Atlas expands the range of evaluated habitats to

include a variety of potential shellfish and finfish habitats. This project view was originally precipitated by the relatively small area of salt marsh in Mount Hope Bay. However it both highlights the importance of other tidal habitats impacted by tidal restrictions and conforms with regional interest in water quality and finfish impacts. The project methodology included review of orthophotography and available digital data, investigate a subset of sites, and compile an assessment report for each field-visited site. Field investigated sites were assessed and prioritized for future consideration by state and federal agencies. The sponsors recognize that the prioritizations are based on limited information and welcome additional information and research on all tidal restrictions in the region. The Mount Hope Bay Atlas is a useful tool for a variety of groups that are interested in ecosystem restoration. The primary goal is to help municipalities, state and federal agencies and other organizations identify, prioritize, and initiate restoration projects that will improve the health of the Bay's aquatic environment.

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AMPHIPODS AS PREY FOR THE INVASIVE CRAB*, HEMIGRAPSUS SANGUINEUS*

Since 1988, the non-indigenous Asian shore crab, *Hemigrapsus sanguineus* has increased its range and density along the rocky coast of the eastern United States. Ecological impacts of this invader have not been determined. Amphipods, mesograzers present in rocky intertidal habitats, may be a prey item for this crab. The objectives of this study were to determine 1) if *H. sanguineus* consumes amphipods and 2) if *H. sanguineus* alters amphipod densities in the field. These objectives were examined with laboratory feeding trials and manipulative field experiments used to control predator densities. *H. sanguineus* consumed amphipods in the laboratory with more amphipods being eaten in experiments with no sediment compared with those with sediment, suggesting a small impact in the field. Crabs of all sizes consumed amphipods, although smaller crabs (7-11 mm carapace width) consumed more than larger crabs (22-26 mm CW). Field experiments showed little interaction between amphipods and *H. sanguineus*. Cage treatments with higher densities of H. sanguineus had more amphipods present when compared to those treatments which had fewer crabs; in those treatments, fewer amphipods were present. Although *H. sanguineus* consumed amphipods in the laboratory, the impact on amphipod density in the field was minimal. This weak effect may be attributed to the presence of additional prey items for *H. sanguineus*, cage effects, or other factors. This study demonstrates that although laboratory studies might indicate a strong, direct interaction between two species, it is difficult to transpose those results to the field, due to complex interactions that occur under natural conditions.

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ANADROMOUS FISHERY RESOURCE RESTORATION IN THE ACUSHNET RIVER WATERSHED THROUGH THE NEW BEDFORD HARBOR PCB SETTLEMENT.

In 1983, the U.S EPA listed New Bedford Harbor (NBH) as a Superfund site due to high levels of polychlorinated biphenyl contamination. The Acushnet River, the main freshwater input to NBH, and its watershed, is a primary focus of restoration efforts through the NBH Trustee Council (NBHTC), a multi-agency entity responsible for developing and implementing a restoration plan to restore natural resources injured by the NBH contamination. Project partners initiated an anadromous fish restoration plan, targeted on re-establishing passage for river herring (*Alosaspp.)* and other species that have been blocked by three dams from their watershed spawning migrations. The NBHTC funded a feasibility study that assessed fish passage alternatives for the lower two dams. Here, we present the proposed dam removal designs, and discuss the various issues associated with these projects and the installation of a 265-foot long Denil fishway at the uppermost dam forming New Bedford Reservoir, a 200-acre lake providing significant river herring spawning habitat. Completion of these projects will allow access by river herring to ~4.4 miles of river in addition to the reservoir and upstream habitats. NBHTC supported and funded other projects, including land acquisitions and/or conservation restrictions on hundreds of acres bordering the Acushnet River to help sustain river base flows and protect other riverine natural resources. When these projects are completed, riverine habitat will be restored and riparian corridor will be protected, ecologically linking the Acushnet River watershed restoration and preservation activities to the NBH estuary and helping achieve restoration of injured fishery resources.

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IMPACTS OF SEAWALLS ON SALT MARSH PLANT COMMUNITIES

Seawalls are often built along naturally dynamic coastlines, such as at the upland edge of salt marshes. Hardened structures may have process level effects on the marsh which could impact marsh characteristics. Process level effects were studied at five pairs of walled and natural salt marsh sites in the Great Bay Estuary of New Hampshire. Parameters were measured along randomly located transects at set distances from the wall. Impacts to sedimentary processes, wrack accumulation, groundwater, and vegetation characteristics were assessed. Preliminary results indicate that the presence of seawalls tends to eliminate a relatively diverse vascular plant community that normally grows between the high marsh and the upland. Seawalls may affect wrack accumulation and sedimentary processes by acting as a barrier to water flow and energy dissipation. Changes in these processes may have effects on the marsh plant community. The results of this study will be applicable to many salt marshes in New England, and will help managers increase their awareness of seawall effects.

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SOFTSHELL CLAM RESTORATION AND ENHANCEMENT EFFORTS ON MASSACHUSETTES' NORTH SHORE

Millions of wild-caught and hatchery-reared softshell clams (*Mya arenaria*) have been released onto approved tidal flats in Rowley, MA. In 1999, six capture nets were set onto flats in the Rowley River. Only two nets successfully collected wild clam seed. In 2000, 20 capture nets were set and all nets retained seed; some nets collected thousands of clams per square foot. Most clams caught in 2000 were distributed among local flats; ~200,000 were transferred to the Northeastern Massachusetts Aquaculture Center's (NEMAC) Cat Cove Marine Laboratory and over-wintered. Concurrently, 200,000 clams were held using spat bags in the Rowley River. These clams were seeded in the spring of 2001 and covered with predator exclusion netting. In 2001, 30 capture nets were deployed and all collected soft-shell clam seed; maximum density reached a few hundred per square foot. Clam densities were reduced by replacing the capture nets with larger predator exclusion nets. Seed naturally redistributed beneath the protected area. Between 1999-2001 natural recruitment yielded large numbers of clam seed. However, in 2002 almost no seed was collected under capture nets in Rowley (and nearby towns such as Gloucester and Ipswich). Poor recruitment was partially compensated by hatchery production. The Town of Rowley received over 800,000 hatchery-reared clams from NEMAC. Clams were cultured in Floating Upwelling System (FLUPSY) until they were planted in the fall and covered by predator exclusion nets. To restore and maintain healthy clam flats requires broad community support that includes monitoring and recording keeping, facilitating wild recruitment, possibly a hatchery, creative networking, and a lot of work.

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A NEW COASTAL AND ESTUARINE MANAGEMENT MODEL SYSTEM: APPLICATIONS TO ESTUARIES IN THE SOUTHEASTERN US COAST AND MOUNT HOPE BAY

A new coastal and estuarine management model system has been developed based on a finite-volume coastal ocean model (FVCOM). This system includes 4 components: 1) meso-scale meteorological model (MM5), 2) hydrodynamics model (FVCOM), 3) water quality model (modified WASP5), and 4) computer interface GUI system. MM5 model is driven through nested approaches by the National Weather Service ETA model. This model provides a forecasting field of wind stress, heat flux, precipitation/evaporation over a time domain of every 5 days, with hindcasting calibration using the real-time wind measurement data. FVCOM is driven by tidal forcing at the open boundary over the shelf, meteorological forcing output from

MM5, freshwater discharges from upstream ends of rivers, and groundwater sources. FVCOM also include a wet/dry point treatment that is capable to simulate the flooding/drying process over estuarine-tidal creek-salt marsh intertidal complex A nudging data assimilation method is incorporated into FVCOM, which is used to calibrate the model prediction using the real-time observational data for purpose of a long-term environmental prediction. The modified WASP5 includes the bottom re-suspension process to build a linkage between water column and benthic ecosystem dynamics. The interface GUI system allows managers to visualize the distributions and animations of selected physical, biological and chemical state variables. A 3-D Lagrangian program is also built on the interface GUI system, which allows managers to trace the trajectories of tracers for the evaluation of impacts of point or non-point pollutants on environments. The management model system successes in applying to the Satilla River, Georgia, and the Mount Hope Bay.

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MAPPING AND MONITORING RESOURCES OF MT. HOPE BAY

The MA Department of Environmental Protection has developed a comprehensive GIS database of the wetlands and coastal submerged aquatic vegetation of the region which includes a large scale change detection methodology.

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IMPACT OF *PHRAGMITES* CONTROL TREATMENT ON MACROINVERTEBRATE ASSEMBLAGES ON A BRACKISH MARSH IN CONNECTICUT

Herbicide (September 2001) followed by mowing (January 2002) was used in an attempt to control expansion of *Phragmites australis* within *Typha angustifolia* dominated tidelands of the Lieutenant River, Old Lyme, CT. This study focuses on the impacts of this treatment on high marsh macroinvertebrate populations. Animals were collected over the summer of 2002 in *Phragmites, Typha*, and Treated areas using pit traps, litter bags and Breder traps. Three pit-traps and six litter-bags were set along 30m transects; four transects per vegetation type. Traps were sampled from mid-June to mid-August during spring tides; bags were deployed for the month of July and Breder traps (ten/vegetation type) were used in July and August. Gut contents of *Fundulus heteroclitus* captured in Breder traps when leaving the high marsh also measured high marsh invertebrates. The most frequently captured organisms were Amphipods and hydrobiid snails. The total number of organisms captured was not different between Treated and *Phragmites* in pit-traps and litter-bags. With both pit traps and litter bags, Amphipods were significantly more abundant in Treated than in *Phragmites*, but frequency of occurrence in *Fundulus* guts was similar, suggesting that the fish target amphipods. The total

number of organisms in *Typha* tended to be higher than in *Phragmites*. Hydrobiid abundances were not different among Treated, *Phragmites* and *Typha*. Amphipod abundances were higher in *Typha* sites than *Phragmites* sites. Herbicide treatment and mowing does not appear to negatively impact macroinvertebrate assemblages.

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HYPOXIC WATERS IN NARRAGANSETT BAY , RHODE ISLAND

Narragansett Bay is considered to be a relatively well-mixed estuary which is not subjected to the seasonal stratification and hypoxia found in areas like Long Island Sound. However, recent (1999-02) surveys of dissolved oxygen (DO) concentrations have documented intermittent hypoxia (<3 mg/l) during neap tides. Lowest oxygen levels consistently reoccur in the Providence River and the western side of Greenwich Bay, but near-hypoxic to hypoxic levels also intermittently occur in the Upper Bay, upper West Passage, and parts of Mount Hope Bay. Graphical mapping of oxygen minima fields in Narragansett Bay will be presented, and physical and biological causal mechanisms will be discussed.

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TRENDS IN FISH ABUNDANCE IN MOUNT HOPE BAY

Trends in abundance for five fish species in upper and lower Mount Hope Bay (UMHB, LMHB) were evaluated relative to Narragansett Bay (NB) to assess the effect of anthropogenic stressors on fish populations in Mount Hope Bay (MHB) from 1972 to 2002. Sources of data included the RIDFW trawl survey for NB and LMHB, the URI GSO trawl survey for NB, the MRI trawl survey for UMHB, and the impingement screen index for the Brayton Point Station for UMHB. The potentially impacted MHB fish abundance indices were standardized against the control NB indices by making a ratio of the annual values. The slopes of the natural log of the standardized indices vs. time were estimated using linear regression analysis. A slope not significantly different from zero was interpreted to indicate that the data did not support the hypothesis of either a positive or negative trend in the index. Power analyses and likelihood profiles were used to confirm the results of the regression analyses.
The results of these analyses indicate that winter flounder, windowpane flounder, hogchoker, tautog and scup all fared as well in LMHB as in NB over the entire observation period. In UMHB the results for windowpane flounder, hogchoker and tautog indicate that these species fared as well or better than in NB. However for scup and winter flounder the results of the analyses in UMHB are equivocal. Some analyses indicate no difference in fish abundance

trends between UMHB and NB, while other analyses indicate both positive and negative fish abundance trends in UMHB as compared to NB.

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EXAMINING THE DECLINE OF NARRAGANSETT BAY WINTER FLOUNDER, WITH A PARTICULAR EMPHASIS ON MOUNT HOPE BAY

The Narragansett Bay winter flounder population has experienced a severe decline in abundance over the last two decades as evidenced by catches in the three standardized trawl surveys conducted in the Bay: the RI Division of fish and wildlife fall and spring surveys, the Marine Research Incorporated Mount Hope Bay survey, and the University of RI weekly trawl survey. These data indicate that winter flounder abundance in Mount Hope Bay, located in the northeast corner of Narragansett Bay, has declined more severely than the Bay as a whole. The objective of this study was to use field data to describe and compare the declines of winter flounder in Narragansett and Mount Hope Bays. For each region, we compared estimates of abundance and mortality rates between 7 life stages: egg, larval, young-of-the-year (YOY) spring, YOY fall, age-1 spring, age-1 fall, and age-2 spring. We used these data to determine the key factors, or those juvenile life-stages that best represent total juvenile mortality. Finally, we examined environmental variables that may have affected winter flounder abundance and mortality rates within Narragansett and Mount Hope Bay. The variables considered included age-class abundance, year, water temperature, precipitation, fishing mortality, seal abundance, double-crested cormorant abundance, chlorine discharge from wastewater treatment facilities, dissolved oxygen, salinity and power plant flow and heat load. Stepwise regression and regression tree analyses were performed to determine those environmental variables that best explain changes in stage-specific mortality rates.

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NEKTON USE OF FRINGING SALT MARSHES SUSCEPTIBLE TO OIL SPILLS IN CASCO BAY, MAINE

Casco Bay is the largest oil port in northern New England, handling over 20-million tons of crude oil and oil products annually. Because the Casco Bay tidal marshes are predominantly fringing marshes, their value as habitat for juvenile nekton and shellfish should be established. To measure values and functions of these marshes, a project is underway to map marsh habitat, survey fish and invertebrate populations, assess plant communities, and investigate sediment accretion rates. Stratified Random Sampling was used to include a range of habitat quality in the survey, from minimal to heavy human impact. This presentation will address the larger project’s component of surveying juvenile nekton in fringing marshes by Wells NERR

researchers. A rigorous sampling protocol using fyke nets occurred in June through September of 2002 and will resume in 2003. This information will help guide oil spill management, and improve baseline knowledge for assessing natural resource damage for remediation planning when a spill occurs.

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FISH VERSUS HUMAN CORRIDORS ? THE IMPACT OF ROAD CULVERTS ON FISH MOVEMENT

Decades of coastal development and use of salt marshes as transportation corridors have made tidally restricted marshes common in the United States. In recent years, salt marsh restoration projects have focused upon restoring hydrology to return the functional values lost as a result of reduced tidal flow. Many of the benefits of tidal restoration projects are fairly well known (e.g., increased hydrology, recolonization by native vegetation), but the impact of tidal restoration on fish movement is not well understood. To examine the effects of tidal restoration and culvert size on fish passage, a mark-recapture study was conducted on the common marsh resident *Fundulus heteroclitus* in restricted, restored, and reference salt marsh habitats. A total of 5155 fish were marked in the first year of a two-year study, with an average recapture rate of 17.7%. Recapture data demonstrate that *F. heteroclitus* exhibited unrestricted movement in both reference and tidally restored creeks, but impaired movement in tidally restricted creeks. Fish passage through tidal restrictions appears to be influenced by elevated flow and reduced light levels. Our results will help guide management efforts to restore salt marshes for enhanced fish passage and support of secondary production.

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EFFECTS OF THE BRAYTON POINT STATION THERMAL DISCHARGE ON REPRESENTATIVE IMPORTANT SPECIES IN MOUNT HOPE BAY

A biothermal assessment was performed as part of the evaluation of the effect of Brayton Point Station (BPS) on representative important species (RIS) in Mount Hope Bay. Nine RIS vertebrate species, including winter flounder, and one RIS invertebrate were studied. Predictions of the temporal and spatial location of the thermal plume from BPS were provided by Applied Science Associates, Inc. using their hydrothermal model of the bay. The biothermal assessment was performed for a range of biological functions that occur seasonally or throughout the entire year among the RIS. These include critical growth, reproduction, avoidance, migratory blockage, and thermal mortality. The analysis evaluated the thermal effects of a variety of BPS operating conditions including no plant, historical plant operation, and operational scenarios with various technological alternatives. In order to summarize the

data on key metrics in a usable format, a series of figures was developed. These took the form of polygons that depict how the key thermal tolerances varied with acclimation temperatures of the affected organisms. These figures in conjunction with the results of the plume model permitted quantitative evaluation of the effects of the plant's thermal discharge on the RIS. In comparison to prior analyses, the approach includes: (1) refined spatial resolution making it possible to pinpoint the location of any predicted biothermal effects, (2) delineation of species-specific habitats by life stages, and (3) the inclusion of a unique assessment of chronic thermal mortality. The analysis concluded that the BPS thermal discharge is not causing appreciable harm to the RIS.

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A RAMAS POPULATION MODEL OF WINTER FLOUNDER IN MOUNT HOPE BAY

A region-wide decline in winter flounder abundance during the mid-1980s is documented in several independent surveys conducted in Narragansett Bay and the adjoining water bodies. To explore possible causes for the decline a model of the winter flounder population in Mount Hope Bay which is part of the Narragansett Bay complex was developed using RAMAS GIS/metapop software. The objective was to model the influence of population stresses including fishing, cormorant predation, habitat degradation and losses at a power plant. Model results show reasonable agreement with the data from the surveys conducted in Mount Hope Bay and indicate that the mid-1980s decline was largely the result of over fishing. Coincident with tightening of fishing regulations in the early 1990s cormorant populations and predation have increased. Model results show this has been a factor inhibiting any recovery that might have resulted from the reduction in fishing pressure. While direct power plant losses and habitat effects have had some effect on the population, model results indicate they are not of sufficient magnitude to have caused the observed decline in the abundance indices nor to materially inhibit a recovery in the indices to pre-1980 levels.

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MONITORING AND ANALYSIS OF BENTHIC NUTRIENT FLUX USING REAL-TIME IN-SITU INSTRUMENTATION

Benthic chambers have been used for many years to obtain sediment oxygen demand (SOD) and nutrient flux rates, through the monitoring of oxygen and/or nutrient change in these closed systems. Technology for real-time dissolved oxygen monitoring has been available for many years, while monitoring of dissolved nutrients has been undertaken by removing aliquots of the benthic chamber headspace for later laboratory analysis. ENSR International using a DPA analyzer from Systea of Italy has obtained real-time measurement of nitrate/nitrite, orthophosphate and ammonia from the headspace of a benthic chamber. The automated DPA

system removes an aliquot of sample from the benthic chamber headspace and analyzes the sample immediately. The system accuracy is comparable to that found in low-level nutrient laboratories and allows the real-time monitoring of benthic nutrient flux. Field tests of this system were accomplished in both a pond in Connecticut and a lake in Texas. In addition to benthic flux rates, the instrument can be deployed in a mooring configuration for autonomous time series measurement of nutrient parameters in both freshwater and marine systems. Potential future uses of this system include TMDL development and long term coastal monitoring.

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AN ESTIMATED HEAT BUDGET FOR MOUNT HOPE BAY

A simple heat budget has been constructed for Mt. Hope Bay (MHB) for two one month periods: the summer 1997 (August - September) and winter 1999 (February - March). The box model considered includes the heat flux contributions from the Brayton Point Power Plant (BPPS), those due to exchange across the air-sea interface, those from the Taunton River and those due to the tidal exchange between MHB and Narragansett Bay and Sakonnet River (NB/SR). Comprehensive measurements of the temperature of Mt. Hope Bay temperature fields (made by ASA Inc.) and meteorological data from Green Airport (Warwick, RI) and the Buzzards Bay National Data Buoy Center (NDBC) buoy were used to estimate the different heat flux component contributions. The box model results for summer show that, within the uncertainty of the estimates, the heating of MHB due to BPPS discharge is approximately balanced by the sum of heat losses across the air-sea interface and through NB/SK/MHB tidal exchange. The summer balance is achieved by assuming that about 2%-3% of the colder NB/SK tidal input water is exchanged with the warmer MHB during each tidal cycle. The winter box model results show that the BPPS heating is virtually balanced by solely wintertime air-sea cooling; i.e the tidal exchange did not play any significant role in the winter heat budget. Taunton River contributions in both seasons was negligible.

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FACTORS DRIVING DISTRIBUTION OF MIGRATORY STRIPED BASS ACROSS MASSACHUSETTS ESTUARIES.

Since the recovery of the Atlantic migratory stock, record numbers of striped bass (*Morone saxatilis*) have been feeding in Massachusetts estuaries. Because coastal Massachusetts provides important foraging habitat for striped bass during their annual migration, the growth

and health of the migratory stock may depend on the amount of suitable habitat and quality of forage present. To better understand spatial and temporal variation in striped bass distribution and what factors may drive that variation, both within and across seasons I (a) compared striped bass relative abundance among 13 Massachusetts estuaries, (b) examined how factors affecting feeding success and growth are related to fish distribution, and (c) evaluated the relationship between striped bass and their prey. For spring, summer, and fall of 1999, I related estuary temperature, food eaten, prey availability, and potential rate of consumption to numbers of striped bass. Across seasons, striped bass were consistently abundant in northern Massachusetts estuaries and were most abundant during spring. *Crangon septemspinosa* provided a diet staple for striped bass in all seasons, but in fall, *Brevoortia tyrannus* was the primary diet item. Variation in spring distribution was best explained by the relative proportion of invertebrates and numbers of fish eaten. In summer and fall, multivariate models including potential consumption and diet composition or temperature explained 76-97%. of the variation in striped bass distribution; though in fall, the proportion weight of fish prey alone explained 70% of the variation.

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CONSTRUCTING A HIGH RESOLUTION SEA SURFACE CLIMATOLOGY OF SOUTHERN NEW ENGLAND USING SATELLITE THERMAL IMAGERY

Mapping near-shore sea surface temperature cycles (climatologies) is important for understanding ecological change and coastal circulation processes. Spatial patterns of seasonal temperature change are generally more complex than can be modeled or inferred from in situ measurements. In this research, we constructed high spatial resolution sea surface climatologies for southern New England and Narragansett Bay using an extensive series of thermal measurements from Landsat Thematic Mapper sensors. Seasonal temperature patterns were mapped at 60 meter resolution using a curve fitting analysis. This method reveals that isolated water bodies warmed faster and to a higher temperature than deeper, well-mixed waters. High amplitude seasonal temperature changes tend to be well correlated with faster response times (earlier maximum and minimum temperatures), except in a few circumstances, notably Mount Hope Bay. This bay reaches a maximum temperature at a date coincident with similar shallow embayments, but is persistently one degree warmer, implying possible anthropogenic forcing. Lakes and shallow estuaries tend to respond in accordance to their depth, while bays and the coastal ocean are differentiated based on circulation patterns. Ocean temperatures have extremes from 7 to 15ÁC (winter to summer, respectively), while lakes range from -2 to 24ÁC. This technique reveals a surface climatology which is not apparent without a temporal component, and spatial detail that cannot be resolved with in situ records.

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ESTIMATED IMPACTS OF CORMORANTS ON FISH POPULATIONS IN THE NARRAGANSETT BAY ESTUARY

The potential impact of cormorant fish consumption on fish populations in the Narragansett Bay estuary (i.e., including Narragansett Bay, Mount Hope Bay, Sakonnet River, and Providence River) was evaluated and compared for Mount Hope Bay and the Sakonnet River versus Narragansett Bay. The local exponential increase in cormorant populations during the 1980s and 1990s coincided with the decline in fish abundance and with the lack of recovery of the populations after fishing pressure was decreased. The population increases were much higher on the east side of the greater Narragansett Bay system than on the west side in Narragansett Bay proper. A model was developed to estimate fish consumption by cormorants. The model includes estimation of fish consumption per bird, foraging areas utilized and the number of birds feeding in each portion of the Narragansett Bay estuary. The amount of fish consumed annually per cormorant in the population (on average) was estimated using modeling of fish consumption per bird based on age and reproductive status, population age structure and breeding rates. Estimated cormorant predation losses were compared to trends in fish populations and, for winter flounder, other sources of mortality.

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RECRUITMENT HABITAT, GROWTH, AND MORTALITY OF YOUNG-OF-THE-YEAR SCUP (*STENOTOMUS CHRYSOPS*)IN NEW BEDFORD HARBOR, MASSACHUSETTS.

Young-of-the-year (YOY) scup (*Stenotomus chrysops*) first recruited to an otter trawl at a minimum length of 18 mm total length in early August 1998 in New Bedford Harbor, Massachusetts. Catch per unit effort (CPUE) was highest at a station in the outer harbor with a complex habitat characterized by coarse to fine sand with pebbles and shells present, and a relatively high sediment oxidation level. CPUE of YOY scup was near 0 at an inner harbor station with soft anaerobic silt substrate. The mean growth rate of YOY scup during the three months after recruitment was 20 mm per month. Growth increments were greatest immediately after recruitment and generally decreased with age. CPUE of YOY scup steadily decreased from August through October. Total daily mortality (Z) was estimated at 0.05, based on the significant slope of a regression of the natural log of YOY CPUE on days after recruitment. New Bedford Harbor appears to be an important habitat for YOY scup based on comparisons of year class strength and CPUE from nearby estuaries.

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ASSESSING THE IMPACTS OF FISHING AND BRAYTON POINT POWER STATION ON LOCAL STOCKS OF WINTER FLOUNDER USING A NESTED, BIOMASS DYNAMIC MODEL

Assessing power plant impacts to aquatic resources subject to other stressors using conventional approaches inevitably bogs down in disagreements over data quality, model configurations, and uncertainty surrounding the compensatory reserve of the resource. Larval impacts from entrainment are often assessed using an empirical transport model (ETM) which estimates the proportion of larvae killed in the plant. Thermal degradation of habitat and direct impingement losses of juvenile and older life stages are generally inferred using time series analysis and before-after control-impact (BACI) analysis of abundance indices. These approaches are lacking in that they are purely statistical with no underlying population dynamics and it is difficult to interpret the overall impact of the facility in the context of other stressors such as fishing mortality. These deficiencies can be largely avoided by applying a biomass dynamic model (BDM) that includes explicit terms for fishing and plant mortality and is configured as an impacted subpopulation nested within the total population. The model is fit to abundance indices from fishery surveys conducted in both areas. BDM results indicate that power plant mortality is proportional to waste BTU output and is generally less than fishing mortality rate. Over fishing is occurring with current fishing mortality rate about twice that needed for maximum sustainable yield. The results also show that the Mt. Hope Bay subpopulation has declined more relative to it's carrying capacity than has the greater Rhode Island population. Projections indicate that substantial reductions in both fishing and power plant mortality are needed to rebuild the Mt. Hope Bay subpopulation.

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ECOLOGICAL PARAMETERS OF FRINGING MARSH INVERTEBRATE COMMUNITIES

This study examined the ecological parameters of the benthic macroinvertebrate community residing in coastal fringing salt marsh systems in Casco Bay, Maine. Sampling occurred in June, July, and September of 2002 in fringing marshes that were identified as pristine, moderately impacted (e.g., upland development or tidal restriction), or heavily impacted (e.g., presence of invasive species or culverts). Peat core samples were taken from 9 sites and invertebrates were then sampled from the top 4 cm. Core samples were taken in triplicate at low and high marsh areas and areas dominated by *Phragmites sp*. or *Typha sp*. if present. We will present invertebrate densities, diversity, and community composition from the month of July.

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COUPLED NITRIFICATION-DENITRIFICATION MEASURED IN SITU IN VEGETATED SALT MARSH SEDIMENTS WITH A NITROGEN-15 AMMONIUM TRACER

A new N-15 ammonium tracer approach was developed to measure coupled nitrification-denitrification rates in undisturbed New England *Spartina alterniflora* salt marsh sediments. Current techniques are unable to assess denitrification rates under in situ conditions of plant growth and tidal inundation. Tracer was injected directly into undisturbed sediments, and its loss through coupled nitrification-denitrification was followed during a 1?5 d timecourse where denitrification was the only significant loss route. Initial tracer recovery was >98% in unfertilized sediments and in sediments receiving long-term (16?23 yr) organic fertilizer loads (8.9 mol N/m^2 yr). Denitrification rates determined by our approach ranged from 0.4?11.9 mmol $N/m^2/d$ in unfertilized sediments to 22?77 mmol $N/m^2/d$ in fertilized sediments. The annual denitrification flux was 0.73 mol $N/m^2/yr$ in unfertilized, and 10.1 mol $N/m^2/yr$ in fertilized sediments (similar to results from long-term sediment N retention). Coupled nitrification-denitrification was controlled primarily by N availability, regulated by plant uptake or fertilizer N loading rather than temperature. During the growing season, denitrification in unfertilized sediments was limited by competitive interactions with plant N uptake, but underwent a brief ~4-fold increase after plant N uptake slowed in late summer. In fertilized sediments, plant N uptake played little role in controlling denitrification rates, which were instead controlled by the availability of fertilizer N (added in excess of plant demand). Our results emphasize the importance of in situ measurements of denitrification in understanding the dynamics of salt marsh N cycling.

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A SUSTAINABLE EELGRASS INDEX

The results of many summers of mesocosm experiments with living models of Rhode Island salt ponds have led us to develop a set of indicators of health for eelgrass*, Zostera marina*, as it responds to nutrient loading and light and temperature stress. Among these indicators is a promising new "Sustainable Eelgrass Index" that uses measurements of above- and below-ground biomass, in combination with asexual reproduction rates, to evaluate eelgrass meadow health. Results from field tests using this index will be compared with water temperatures and estimates of nitrogen loading to the relevant site watershed. In contrast to some techniques commonly used to monitor the current condition of seagrass habitat, we present the SEI as a predictive monitoring tool.

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NUTRIENT RELATED HABITAT QUALITY OF MOUNT HOPE BAY

Mount Hope Bay is one of the largest estuarine systems in Massachusetts and a major tributary system to Narragansett Bay. Mount Hope Bay, like many estuaries throughout the U.S., has become nutrient enriched as the population of its watershed increases. At present, about 1/3 of the total watershed area has been developed. The shift from forest to urban and residential development has enhanced nutrient inputs through wastewater, fertilizers and runoff. The primary mechanism for watershed nitrogen to enter Mt. Hope Bay is through surface fresh water inflows. Mount Hope Bay receives direct freshwater discharges primarily from the Cole River, Lee River, Kickamuit River and the Taunton River System. Of these the Taunton River System has the largest watershed, > 600 mi^2, freshwater discharge and nitrogen load. In addition, there are multiple direct discharges of treated wastewater to the Bay. At present, the central region of the lower estuary appears to be receiving nitrogen inputs beyond its capacity to assimilate them without declines in habitat quality. During summer, the central Bay periodically shows phytoplankton blooms (>30 ug chlorophyll a L^{-1}) and low bottomwater dissolved oxygen (< 4 mg L^{-1}), indicative of eutrophic conditions. Analysis of the spatial and distribution and composition of animal and plant communities and comparison with historic records, supports the contention that the central bay is currently eutrophic. Quantitative evaluation and nitrogen management modeling of this system is part of the ongoing Massachusetts Estuaries Project.

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THE MASSACHUSETTS ESTUARIES PROJECT: EMBAYMENT RESTORATION USING A LINKED WATERSHED-EMBAYMENT NITROGEN MANAGEMENT MODELING APPROACH

Embayment health is connected to the concentrations of nutrient species such as nitrogen. N is the limiting nutrient in coastal marine waters. The increasing N-load to estuaries results from changing watershed land-uses. This land-use shift results in increased wastewater discharges, fertilizer applications, and surface runoff, all of which contain high concentrations of N. N reaches the estuaries through stream and groundwater pathways. The stimulation of plant production (algae, phytoplankton and nuisance plants) by the increased N inputs results in oxygen depletion in the bay waters and loss of diverse animal and plant populations. It is critical to quantify the sources and sinks for N in its multiple forms and manage N-loading to an embayment. The Massachusetts Estuaries Project (MEP) is providing the scientific and technical support to the Massachusetts DEP for development and implementation of policies on

N sensitive embayments. The 6-year program will perform the data collection and modeling required for the management and restoration of southeastern Massachusetts' 89 embayment systems. Technical experts through the University of Massachusetts ? Dartmouth School of Marine Science and Technology (SMAST) are working with the DEP to class the N sensitivity of the coastal waters of the region including Nantucket, Martha's Vineyard and extending to Mt. Hope Bay. N sensitivity of coastal embayments is determined through quantitative linked watershed-embayment water quality modeling and site-specific nutrient thresholds analysis. The MEP will put forward available options for meeting N goals for implementation of conservation and restoration objectives within these important coastal systems.

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META-ANALYSIS OF STUDIES BASED ON THE EFFECTS OF ENGINEERED AND NATURALLY OCCURRING LARGE WOODY DEBRIS IN ANADROMOUS SALMONID STREAMS OF THE PACIFIC NORTHWEST

Engineered and natural variations of large woody debris play a key role in the diversity and enhancement of habitat for anadromous salmonids in the Pacific Northwest. There have been few studies that evaluate cross comparisons on the effects of engineered and natural variation of large woody debris on anadromous salmonids. Meta-analysis was used to provide a statistical summarization through a cross comparison of studies reviewed. The meta-analysis was performed by examining the frequencies of studies, and a vote count that was conducted using a sign test. The criteria for article selection was: 1) geographic location was limited to the Pacific Northwest 2) species evaluated had to contain anadromous salmonids 3) the article must specify that engineered large woody or natural wood debris was evaluated in the context of their study 4) methods for evaluation of outcomes are identified. Thirty-one articles were obtained that met the literature search criteria. Results of the meta-analysis indicated a lack of consistent methodology and reporting of results with biases identified among studies reviewed. However, the results also indicated that there was a significant direction for a positive effect in the literature reviewed for this study. This type of analysis was important to determine similarities and discrepancies in the methods for evaluating natural and engineered large woody debris on Pacific anadromous salmonids.

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CIRCULATION, MIXING AND WATER QUALITY IN THE MASSACHUSETTS AND CAPE COD BAYS: CURRENT STATUS AND FUTURE DEVELOPMENT

A hydrodynamic and water quality model for the Massachusetts and Cape Cod Bay system (MBS) is maintained and further developed by the modeling team at the University of

Massachusetts Boston (UMB). The model intends to address the questions raised from the anthropogenic impacts and climate change. The modeling results indicate the more frequent occurrence of clockwise circulation in the MBS during recent years, which leads to a shorter residence time in Massachusetts Bay but a longer residence time in Cape Cod Bay. Corresponding to the change in the circulation patterns, the observations indicate that the ecosystem shows more frequent occurrence of fall algal blooms, and abundant gelatinous carnivores. These new physical and biological phenomena are studied and addressed using both existing and newly developed models. The results indicate that zooplankton play a key role in the variability of the abundances of both lower and higher trophic organisms.

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SIZE-SELECTIVE MORTALITY AND GROWTH OF A 1995 GEORGES BANK LARVAL COD COHORT

The presence or absence of size-selective mortality and instantaneous growth rates were examined for March-June of a 1995 Georges Bank cohort of larval Atlantic cod, *Gadus morhua*. Back-calculated lengths at age were obtained through otolith microstructure analysis and the use of the Biological Intercept Method. Through the use of back-calculation, size-selective mortality and growth rate trends can be observed. Size-selective mortality was directed towards the smaller of the individuals until May when the mortality shifted towards the larger individuals. Instantaneous growth rates of the back-calculated individuals indicated a trend of poor growth with monthly rates high except for June. Total population instantaneous rates were similar to historical rates observed, at $0.288mm^{-1}$. Back-calculated monthly growth rate trends were similar to a biological-physical coupled model that sought to estimate the larval cod growth rates for Georges Bank 1995 and 1998. Further development of coupled models will aid fisheries managers in more accurate prediction of recruitment levels for commercially important species.

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THE ALLOMETRY OF CANNIBALISM IN PISCIVOROUS FISHES

Cannibalism is a widespread phenomenon which can have strong population and community effects. In this study I compare the prey-size predator-size relationships of diets with and without cannibalized prey for four piscivorous species that are commonly cannibalistic and where large databases exist. I then examine the resultant trophic niche breadths (range of relative prey size consumed) to quantify whether inclusion of cannibalized prey in the diet slows down the decline in trophic niche breadth that many large predators exhibit as they grow. When comparing diets including cannibalized prey to those without, consistent differences

were found among all predator species. In all cases the slope of the upper bound was larger for cannibal predators compared to non-cannibals suggesting selectivity for larger cannibal prey which may be driven by higher rates of size-dependent capture success with familiar prey. The slopes of the upper bounds of the cannibal relative prey size vs predator size scatter also tended to be larger than the non-cannibal slopes. Finally, for all species, mean trophic breadth of diets including cannibalized prey were larger than those not including cannibal prey suggesting that relatively large prey sizes may always be available for cannibals.

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MAPPING SEWAGE EFFLUENT IN THE THAMES RIVER USING STABLE ISOTOPE ANALYSIS

The Thames River, in Southeastern Connecticut, experiences point source nutrient loading from several sewage treatment plant outfalls. This study attempted to map the sewage effluent using isotope ratios along a transect of the river. ^{15}N values of macroalgae growing along the rocky intertidal zone and on navigational buoys were measured. The technique relies on there being an isotopic difference between sewage treatment plant derived nitrogen and other sources. Preliminary analysis suggested that *Ascophyllum nodosum* growing in the rocky intertidal zone within 1 km of the outfall of the New London sewage treatment plant had ^{15}N values that were 2‰ more positive than Ascophy*llum nodosum* growing approximately 6 km away at Bluff Point State Park, in the Long Island Sound, just east of the mouth of the Thames River. The algae growing on navigational buoys form an 8 km transect extending upstream of the site of preliminary samples. Results from these analyses will be presented at the meeting.

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THE SMAST HIGH RESOLUTION TRAWL SURVEY: A CASE STUDY IN THE DESIGN AND DEVELOPMENT OF COOPERATIVE TRAWL SURVEY PROGRAMS BETWEEN COMMERCIAL FLEETS, ACADEMIC INSTITUTIONS AND GOVERNMENT

The High Resolution Trawl Project at the School for Marine Science and Technology (SMAST) is a collaborative exercise between the commercial bottom trawl fishing fleet and researchers at SMAST and the Massachusetts Department of Environmental Protection Division of Marine Fisheries. The primary focus of the project has been the development of methods of gathering fishery, oceanographic, and meteorological data through the commercial

fishery operations. One important component of the program is developing methods for training commercial fishermen to record scientifically acceptable data during normal fishing operations. Another component is in the development of technologies to enhance data transfer from the fishermen to researchers and managers. To date, the project has primarily utilized New Bedford Harbor based bottom trawlers that fish on the North Flank of Georges Banks. In the first year, SMAST technicians trained the crew of twenty vessels that logged 4508 hauls over 721 fishing days. In year two the project has logged 1411 hauls in 37 trips over 251 fishing days. The design and implementation of the project relied on the ability of technicians to design a data collection system that made sense to fishermen and was useful for analysis and processing by SMAST scientists. The technicians worked closely with fishermen on Georges Bank during normal fishing operations and at SMAST in order to create the data collections methods currently used.

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MACROALGAE IMPACTS ON THE NURSERY HABITAT OF YOUNG-OF-THE-YEAR WINTER FLOUNDER (PLEURONECTES AMERICANUS), MOUNT HOPE BAY.

In the summer of 2002 we collected data on the density and distribution of the macroalgae *Ulva lactuca* in Mount Hope Bay to assess its potential impact on the nursery habitat of young-of-the-year winter flounder (*Pleuronectes americanus*). Macroalgae was sampled from four tributaries in the Mount Hope Bay that serve as a nursery habitat for winter flounder, with four sites in the Kickmuit River, two sites in the Cole River, three sites in the Lee River, and eight sites in the Taunton River. Triplicate macroalgae samples were taken using a * m^2 quadrat to determine macroalgal biomass at each site. Winter flounder were sampled using a beach seine at the same time and sites as the macroalgae sampling. An estuary 'wide' survey of macroalgae was conducted in the four tributaries of Mount Hope Bay in August using a combination of visual and benthic grab observations in an effort to determine overall percent coverage of macroalgae in each system. Dissolved oxygen was monitored in each estuary using paired YSI units, one placed in an *Ulva* dominated habitat, the other in a site with bare sediment. YSI units were deployed for 1-2 weeks at each station. Finally, benthic samples were collected from areas with heavy macroalgal beds and from areas with relatively clear bottom in each estuary to assess the impact of dense macroalgae accumulations on benthic communities. Overall, this data will be used to determine if the heavy macroalgal densities observed in Mount Hope Bay result in the loss of potential habitat for young-of-the-year winter flounder.

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SITE UTILIZATION AND MOVEMENT OF ATLANTIC COD AS DETERMINED BY

ACOUSTIC TELEMETRY

We quantified the site utilization of offshore landscapes by Atlantic cod (*Gadus morhua*) using acoustic telemetry. A four-node, omni-directional receiver array was deployed inside Stellwagen Bank National Marine Sanctuary during Summers 2001 and 2002 in an area that excluded commercial fishing for demersal fishes. Fish were collected using hook and line, tagged externally with coded acoustic pingers, and released on the seafloor using an ?elevator? within the range of the receiver array. In Summer 2001, cod movement behavior was studied over a low-relief gravel feature. Observations were made over 120 days. The total number of days that individual fish were recorded was up to 120 days and a total of 37% of all tagged fish showed high site fidelity to the study area. In Summer 2002, cod movement was investigated at four piled boulder reefs, where high site fidelity was observed in 47% of the tagged fish. Among those fish not showing site fidelity, individual fish were observed to move among each of the piled boulder reefs, traveling as much as 24 km to do so.

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THE ECOLOGICAL FUNCTION AND VALUE OF SALT MARSH POOLS (PANNES) ON THE SURFACE OF SOUTHERN MAINE SALT MARSH SYSTEMS

Secondary production of resident nekton as well as stable isotopes were used to determine the ecological function and value of salt marsh pools (pannes). Four treatment types were created during the summer of 2002 that manipulated fish movement onto the marsh surface. These treatments included: 1) nekton restricted to pools, 2) nekton with access to enclosed marsh areas adjacent to pools, 3) un-enclosed controls, and 4) partially enclosed procedural controls. Growth rates and secondary production of nekton were then calculated for each ^{13}C) were used to construct a food web occurring in these pools. The ^{15}N isotopic signatures of food sources in salt marsh pools (i.e., submergent plants, epiphytic algae) were altered by adding trace levels of $K^{15} NO_3$ > (5% of natural NO_3 levels) to the pools during neap tidal periods in June through August. Various components of the food web (e.g., marsh plants, phytoplankton, benthic algae, macroinvertebrates, fish) were then sampled and analyzed for both ^{13}C and ^{15}N. Isotopic signatures will be used to determine where organisms fed and thus identify energy sources supporting the high marsh food web.

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MARINE RESOURCE AND IMPACT CHARACTERIZATION ASSOCIATED WITH THE PERMITTING OF TWO OFFSHORE NATURAL GAS PIPELINES IN NEW ENGLAND

Due to recent expansion of the interstate natural gas transmission system in the New England area, recently proposed natural gas pipeline construction projects have been sited in the coastal waters of Massachusetts Bay and Long Island Sound. The HubLine Pipeline Project consists of about 35 miles of gas pipeline being constructed between Salem and Weymouth Massachusetts in water depths up to 130 feet. The Islander East Pipeline Project consists of about 22 miles of gas pipeline being permitted for construction across Long Island Sound between Branford CT and Wading River NY. A substantial amount of pre-construction data collection has been performed as part of the permitting of these projects. Surveys have been completed on eelgrass, softshell clam, scallop, ocean quahog, soft sediment infauna, hard substrate epifauna, and sediment characteristics using a variety of techniques. In addition, historical information was gathered to support the resource characterization and impact assessments that were part of permit applications submitted to the MA and CT DEPs, US ACOE, and the FERC. Information on the studies, the marine resources associated with these project areas, the pipeline construction methods, and impact assessments will be presented.

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NOWHERE TO SWIM, NOWHERE TO HIDE: CONSEQUENCES OF WITHIN-SYSTEM STRIPED BASS PREDATION FOR ESTUARINE PREY

Although estuaries have traditionally been viewed as refuges for prey, an increase in estuarine predator abundance could influence prey vulnerability and predation pressure. In Massachusetts estuaries, migratory striped bass, currently at record numbers, are a critical component of the predator community. Consequently, where and how striped bass forage could have important implications for estuarine prey. Herein, to understand how striped bass foraging could affect potential refuges for prey, we tested the effects of habitat (hard vs. soft substrate), tide (flood vs. ebb), estuary location, and season (spring to fall) on relative abundance, diet, and consumption of striped bass. In 2000, fish and diets were collected using controlled angling and gastric lavage respectively, in three Massachusetts estuaries. Striped bass foraged in all estuaries under all habitat, tide, and time conditions; however, striped bass foraged most intensely during ebbing tides (mean CPUE = 6 fish / hour, all seasons combined). *Crangon septemspinosa* was a consistently important prey, but numbers and taxa of juvenile fish varied with other conditions. In summary, for prey inhabiting Massachusetts estuaries, the threat of predation by striped bass is ubiquitous, and predictable prey refugia are severely limited.

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FISHERIES ACOUSTIC RESEARCH AT THE NORTHEAST FISHERIES SCIENCE CENTER

The Northeast Fisheries Science Center (NEFSC) implemented the use of fisheries acoustic technology during their surveys in recent years (1998-present) to provide more accurate, cost-effective, and timely fisheries-independent populations estimates for fisheries management. Research efforts have been focused primarily on conducting annual fisheries acoustic surveys to derive population estimates for Atlantic herring in the Georges Bank and Gulf of Maine regions. Fisheries acoustic data has also been collected from more than half of the sea-days from the various NEFSC research cruises (e.g., bottom trawl and marine mammal surveys). Multi-frequency acoustic, midwater trawling, and underwater video technologies are used during the NEFSC fisheries acoustic surveys. In-situ, laboratory, and theoretical research are ongoing to improve the acoustic measurements and associated variability, and to evaluate the application of advanced technologies (e.g., multibeam and broadband acoustics). The NEFSC fisheries acoustic methodology has recently undergone a successful peer-review by the Center of Independent Experts, and the acoustic population estimates have been incorporated into this year's US/Canadian herring assessment. Future goals of the NEFSC Fisheries Acoustic Research Program are to expand ongoing research to derive acoustic population estimates for other commercially important species, and to enhance fisheries acoustic science with the application of advanced technologies.

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THE TEMPERATURE OF MT. HOPE BAY

Temperature is a fundamental property of estuarine systems and imparts strong influences on biological function. We have completed detailed studies of the temperature of Mt. Hope Bay as a function of season and tide using a combination of in situ and remotely sensed data. These show that the top 2 meters of Mt. Hope Bay is on average 1 degrees C warmer in the summer and fall than comparable regions elsewhere in the Narragansett Bay estuary, but that this anomaly increases to approximately 3 degrees C near Brayton Point. The thermal anomaly can be directly tied to the effluent from the Brayton Point Power Station. During the winter and spring when Mt Hope Bay is typically stratified, the thermal effluent flux is small relative to the heat losses and mixing in the bay. During the summer and fall, the bay is well mixed and the plume from the power plant is observed at the surface over large regions of the bay. The thermal effluent flux during these times of the year is a significant contribution to the overall heat budget of the bay. The overall distribution of the thermal anomaly observed with these data is supported by 3-dimensional hydrodynamic modeling.

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A TAGGING STUDY OF WINTER FLOUNDER (*PSEUDOPLEURONECTES AMERICANUS*) IN MT. HOPE BAY, RHODE ISLAND

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ASPECTS OF MACROBENTHOS IN MOUNT HOPE BAY

Conclusions from two historical studies and a description of a long-term data set are offered as bases for understanding the macrobenthic invertebrate populations of Mount Hope Bay. In the historical studies, comparisons were made between the major arms of Narragansett Bay as part of the Narragansett Bay Project. A study of *Mercenaria mercenaria* in closed waters was carried out in 1985. Quohogs were most abundant in shallow, sandy habitats; the presence of very large (old) individuals contrasted with the Providence River and indicated acceptable conditions for growth over a long period of time. A survey of macrobenthos was carried out in 1992. In undredged portions of Mount Hope Bay macrobenthos assemblages were similar to those in Greenwich Bay. Species found in deep portions of Narragansett Bay extended into the dredged channel. As part of Brayton Point Power Station monitoring, benthic samples were obtained in Mount Hope Bay over a 23-year period at intervals as short as three weeks. This valuable data set shows seasonal recruitment pulses with some interruptions and long-term changes in pattern.

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SPATIAL AND TEMPORAL PATTERNS OF THE FISH ASSEMBLAGES IN THE GREATER NARRAGANSETT BAY ESTUARINE SYSTEM: IS MT. HOPE BAY DIFFERENT?

Winter flounder abundances have experienced dramatic declines throughout the greater Narragansett Bay estuarine system, including within Mt. Hope Bay. However, a controversy has developed as to whether or not the decline has been more severe in Mt. Hope Bay. To address this issue, we chose to use data from the long-term Seasonal Trawl Survey conducted by the Rhode Island Department of Environmental Management (RIDEM). This is the only data set that both encompasses a time frame (1979-2001) that includes the period before and after the decline of winter flounder, and has good spatial coverage of all of the greater Narragansett Bay system, including Mt. Hope Bay. We analyzed the RIDEM Seasonal Trawl Survey data to examined time trends in the abundance of winter flounder and 28 other species from 9 different areas within the greater Narragansett Bay system. No significant difference

was found in the decline of winter flounder in Mt. Hope Bay compared to other areas. In fact, the trend for Mt. Hope Bay was intermediate to other areas, with several areas exhibiting stronger decline trend. The fish assemblage was observed to have undergone a dramatic shift from benthic to pelagic species in all areas of Narragansett Bay. This pattern is strongest in the shallow embayments (Greenwich Bay, Sakonnet River, Mt. Hope Bay, Wickford Harbor and upper Narragansett Bay), and weakest in the deep central bay areas. In conclusion, we find that changes in winter flounder abundance and in the fish assemblage between 1979 and 2001 in Mt. Hope Bay are similar to those observed in other parts of the greater Narragansett Bay system, and reflect processes operating on a Narragansett Bay-wide scale.

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THE SMAST COD-TAGGING PROGRAM.

The University of Massachusetts Dartmouth School for Marine Science and Technology (SMAST) cod-tagging program, begun in 2001 and funded through the Massachusetts Fisheries Recovery Commission (MFRC), has tagged over 20,000 fish to date within the Gulf of Maine and Cape Cod Bay. So far we have received over 600 tag returns ranging from 0 to 695 days at large. Most fish were recaptured within 21 km of the release point, though returns as far away as 283 km were recorded. A subset of 105 fish were tagged with temperature and depth recording archival tags. Data from 16 recovered archival tags suggest that some cod undertake daily migrations from deeper water (>60 m) into shallower depths (<30 m) during which they may experience up to a 7ÁC change in water temperature. Continued analysis seeks to determine whether the pressure changes recorded by the archival tags are due to vertical migration or movement on or off shoals. More recently, the SMAST cod tagging program has been expanded to target Georges Bank as part of the NOAA Fisheries Northeast Region Cooperative Research Partners Initiative (CRPI). The main goal of this large cooperative effort is to determine the large-scale seasonal movement patterns of cod in the region.

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WHEN IS A SALT MARSH NOT A SALT MARSH?

The estuarine waters of Long and Fishers Island Sounds and their tributaries are brackish or mixohaline according to the USFWS Classification of Wetlands and Deepwater Habitats of the United States. Salt marshes are classified as emergent wetlands of the estuarine system and occur in polyhaline waters and are largely free of the invasive plant, *Phragmites australis*. At the highest halinities for the emergent wetlands of mesohaline waters, the vegetation bears

semblance to salt marshes but there are some particularly notable differences. As halinities decrease, the 'salt marsh' grasses give way to *Agrostis stolonifera* and a variety of sedges. In the oligohaline waters, the brackish cat-tail *Typha angustifolia* is replaced by the tall but diffuse hybrid *Typha X glauca*. Nichols (1920) described the vegetation of the salt and brackish marsh series. The application and utility of the FWS classification and Nichols paradigm for southern New England tidal wetlands are discussed. The boundary between mesohaline and polyhaline waters (18 ppt) was proposed as a guide for the limits of *Phragmites australis*. It is likely that for halinity measurements to be meaningful, such data must be acquired in the early part of the growing season (until plants reach full maturity) and measured with the rhizosphere. In places where two to three feet of fill have been removed from former tidal wetlands dominated by *Phragmites*, the initial dominant plant is usually *Phragmites* which is growing from existing, buried rhizomes. Soil surface measurements of halinity will certainly have value to shallow rooted species, but may have little bearing on the halinity tolerances of *Phragmites*.

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BIOGEOCHEMICAL CONTROLS ON THE EFFICIENCY OF FRESHWATER SYSTEMS TO INTERCEPT AND ATTENUATE GROUNDWATER NITROGEN LOADING TO ESTUARIES

We investigated the role of fresh water lakes in the interception and attenuation of nutrients carried by groundwater into estuaries on Cape Cod in southeastern MA. Ashumet Pond, characterized by seasonal density and redox stratification receives, nitrogen, phosphorus and manganese inputs from an anaerobic groundwater plume that impacts several estuaries. Phytoplankton uptake of nitrogen in ponds can attenuate watershed nitrogen loading to estuaries. Interception of groundwater nitrogen entering Ashumet Pond was moderated by the reduced transport of phosphorus to the photic zone where primary production during summer thermal stratification was phosphorus limited. Water column profiles, sediment incubations and microbial rate measurements indicated that manganese moderated the effects of external nitrogen and phosphorus loading both directly and indirectly through iron. Manganese inhibited the enzymatic process of iron phosphate reduction and dissolution. Manganese also created an oxidation buffer in the shallow water discharge areas preventing iron phosphate dissolution from the sediments and maintained an oxidation buffer zone within the metalimnion preventing iron and phosphorus movement from the hypolimnion into the photic zone. Manganese moderates the effects of groundwater inputs of phosphorus to this lake by maintaining an oxidized iron pool sufficient to bind and precipitate excess phosphorus; through interactions with phosphorus, manganese reduced phytoplankton growth thereby decreasing nitrogen interception and limiting attenuation of watershed nitrogen loading.

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COMPETITION FOR SHELTER BETWEEN THE ASIAN SHORE CRAB (*HEMIGRAPSUS SANGUINEUS*) AND NATIVE MUD CRABS

Based on preliminary knowledge of habitat preference in native areas, some ecologists initially believed the Asian Shore crab (*Hemigrapsus sanguineus*) would not impact resident mud crab species occurring in the lower intertidal zone along the Atlantic Coast of the United States. However, competition for shelter between these two types of crab might be occurring since *H. sanguineus* can be found throughout the rocky intertidal zone from Maine to North Carolina and is often the most abundant decapod species in areas such as Southern New England. The aim of this project was to provide information on competitive interactions and shelter use between *H. sanguineus* and native mud crabs by 1) performing laboratory trials in which shelter was limited, and 2) quantifying interspecific shelter use in the natural environment. Laboratory trials involved placing various crab pairs into translucent plastic jars fitted with a small cave-like shelter and recording behavioral interactions for 30 minutes. In the field, crab densities under the largest rocks in a $1m^2$ area were quantified and compared to densities in the rest of the quadrat to determine if density of *H. sanguineus* was greater under larger rocks. Laboratory results revealed H. sanguineus established shelter occupancy first and maintained occupancy for the duration of the trial, while observations in the natural environment revealed the density of *H. sanguineus* was significantly greater under large rocks than neighboring small rocks. Results suggest *H. sanguineus* has the potential to displace mud crabs from a portion of their native habitat.

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EFFECTS OF HERBICIDE TREATMENT AND MOWING OF *PHRAGMITES AUSTRALIS* ON FISH AND CRUSTACEAN USE OF AN OLIGOHALINE MARSH SURFACE

An invasive strain of *Phragmites australis,* introduced from Europe, has been rapidly invading tidelands of the lower Connecticut River and much of the east coast of the United States for almost 40 years. Herbicide followed by mowing has been shown to be an effective treatment for controlling *Phragmites*; however, little is known about the animal community responses to these treatments. This study investigated results of such herbicide/mow treatments on fish and crustaceans use of oligohaline tidal marshes along the Lieutenant River, a lower Connecticut River tributary. P*hragmites* stands were sprayed with glyphosate in September 2001 and mowed in January 2002. In the summer of 2002, fish and crustaceans were captured in Breder traps on the flooded surface of *Phragmites, Typha*, and treated marsh areas. In July, diversity and abundance of fishes and crustaceans using the marsh did not differ among *Typha, Phragmites* and treated areas. Mean fish captured per trap was directly related to hydroperiod. Fewer and smaller fish were caught in T*ypha* and treated areas in August and September than in July, most likely due to lower than predicted tidal flooding depths for those spring tides.

Abundances, size distributions, and diets of *Fundulus heteroclitus*, the numerically dominant fish, did not differ in the three marsh types. It therefore appeared that herbicide/mow treatment of *Phragmites* marshland had little effect on the use of these marshes by fishes and crustaceans.

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SIMULATED THERMAL VARIATIONS IN MT. HOPE BAY AND APPLICATION TO ASSESSING ECOSYSTEM EFFECTS

The thermal variations in Mt. Hope Bay were simulated with the use of a state-of-the-art hydrothermal model and PC-based interface. The model solves the three-dimensional conservation equations for water mass, momentum, heat and salt on a boundary fitted grid of cells. The model is coupled with a thermodynamic heat flux model that solves the heat balance with the environment and also incorporates a submodel that simulates the operation of the Brayton Point Station as a point source of heat. Quantitative comparisons with field data indicated successful calibration and confirmation of the model. Seasonal and yearly simulations were performed using actual plant and environmental loads to hindcast bay thermal conditions for the last forty years. Additional cases were run to evaluate the effects of different plant loads based on reductions of discharged heat. Results indicated that the temporal variations ranged from tidal times where the lateral movement of plumes from the plant and the Taunton River repeated over the flood and ebb cycle, to the daily cycle of heating and cooling affecting thermal stratification. Seasonal variations were most discernible in the shallow upper reaches of the bay showing warmer than average temperature during summer and cooler during winter. Model output was processed for these hindcast and simulation cases to assess thermal conditions in both the water column and along the bottom. Estimates of the fraction of the bottom area and water column volume at different temperatures during different ecologically important times were made. Spatially varying frequency estimates of different temperature regimes were also calculated so that avoidance areas could be determined.

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INTEGRATION OF A WINTER FLOUNDER HABITAT SUITABILITY INDEX MODEL AND GEOGRAPHIC INFORMATION SYSTEM TO PRIORITIZE NARRAGANSETT BAY SALT POND RESTORATIONS

Declines in the commercial and recreational winter flounder fisheries of southern New England have been well documented. Many causes for the declines have been suggested, including overfishing, pollution, predation and alteration of critical habitats. Shallow tidal wetlands and salt ponds are critical spawning and nursery sites for winter flounder. Unfortunately, over the past 50 years many of these important sites have been altered, and in many cases made

unavailable for winter flounder. Recent efforts have identified more that 100 restorable coastal sites in Narragansett Bay. Protocols, which take into account socioeconomic and environmental concerns, have been established to prioritize restoration of eelgrass beds, salt marshes and anadromous fish runs. However, no formal process has been established to integrate winter flounder critical habitats into prioritizing salt pond restoration. This presentation reports on our efforts to develop a geographic information system (GIS) that: 1) integrates existing habitat component maps into a Habitat Suitability Index (HSI) map for Narragansett Bay, 2) can overlay the HSI map with an existing map of restorable sites, and 3) can prioritize restorable salt pond sites based on their overall HSI scores.

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THE RECOVERY OF BOSTON HARBOR: TWO YEARS AFTER TRANSFER OF WASTEWATER OFFSHORE

Boston Harbor has recently been subjected to a massive reduction in N and P loadings, following the transfer of wastewater discharges from the City of Boston and surrounding communities, offshore. Wastewater transfers such as these provide unique 'before-and-after' opportunities, to quantify the relationships between N and P loadings and eutrophication of coastal bays and estuaries. In this paper we compare conditions in the Harbor water column during the first 24-months after transfer, with conditions during a 3-7 year baseline period before transfer. The paper necessarily identifies only the large changes after transfer, that fell outside of the range seen during the baseline period. For most of the eutrophication-related variables that we monitored, values during the 24-months were significantly different from baseline. The changes included a small but significant increase in salinity, larger Harbor-wide decreases in N, P and molar N:P, localized decreases in chlorophyll a, and localized increases in water clarity and bottom-water dissolved oxygen (DO). For certain variables (including N, P and N:P), the changes were similar during each of the 12-months making up the 24-months. For others (e.g. chlorophyll a and attenuation coefficient), the improvements were larger during the first 12-months than during the second. For DO and secchi depth, the improvements were largest during the second 12-months.

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PREDATION OF WINTER FLOUNDER EGGS BY THE SAND *SHIRMP CRANGON SEPTEMSPINOSA* IN MT. HOPE BAY

Predation on the early life stages of marine fish is recognized as one of the most important factors regulating recruitment. Winter flounder (*Pseudopleuronectes americanus*) spawn demersal, adhesive eggs that could experience high rates of epibenthic predation during

incubation. The objective of this study was to determine if the sand shrimp (*Crangon septemspinosa*) is a source of predator-induced mortality of flounder eggs. Laboratory experiments quantified the ingestion rate of shrimp feeding on flounder eggs as a function of shrimp size (34 to 62 mm TL) and water temperature (2, 4, 6, and 10 ^{1} C). Shrimp were also collected from Niantic River, CT (n = 600) during peak flounder spawning periods (Feb to Apr 2002), and their stomach contents were analyzed with the …uchterlony double-diffusion immunoassay to detect the presence (or absence) of flounder eggs in the diet. Shrimp consumption of eggs significantly increased with increasing shrimp size. Moreover, elevated temperatures resulted in the significant increase in egg predation. Results from stomach content analysis revealed that, on average, 7.2% of the field-collected shrimp had flounder eggs within their guts. The incidence of shrimp egg predation was greatest in late February (20%) and decreased at a decelerating rate over time (< 1% by early Apr). Integrating results from this study with estimates of annual flounder egg production in Mt. Hope Bay, RI, shrimp could consume 3.4 to 100% (average = 37.0 $\pm$8.0%) of the total eggs spawned in a given year. Thus, shrimp predation on flounder eggs may be a significant mortality factor and ultimately have important consequences for flounder year-class strength.

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BENTHIC COLONIZATION OF RED CLAY DREDGED MATERIAL IN THE NEW YORK BIGHT

In 1997, approximately one million yd^3 of consolidated red clay dredged from Newark Bay was deposited on the seafloor at the former Mud Dump Site (MDS), located on the inner continental shelf of the New York Bight. Due to concerns about the ability of benthic organisms to colonize this stiff red clay, surveys involving a variety of sampling methods were conducted in 1998 (one-year post-disposal) and 2002 (five years post-disposal). These surveys were designed to characterize physical and biological conditions over the red clay deposits compared to nearby reference areas. Coring and acoustic sub-bottom profiling data showed that in the area where most of the red clay disposal activity had taken place, the resulting deposit on the seafloor had a thickness ranging from 5 to 7 m. Sediment-profile imaging (SPI) and sediment plan view photographs collected in summer 2002 indicated that the surface of the red clay deposit had become much smoother than it was in 1998, and also indicated that this deposit had become colonized by a relatively abundant and diverse infaunal and epifaunal communities. Taxonomic analysis of the benthic grab samples confirmed the imaging results and indicated relatively high organism abundance at the red clay stations compared to nearby reference areas. However, the structure of the benthic community inhabiting the red clay deposits was fundamentally different from communities in the reference areas, due to the significant differences that existed in the texture and composition of the red clay compared to the reference area sediments.

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ASSESSMENT OF THE SEAL POPULATIONS OF MT. HOPE BAY AND SURROUNDING WATERS

Seals have been protected in United States waters since the Marine Mammal Protection Act took effect in 1972. As a result of that protection, the number of seals found in southern New England has increased dramatically over the past few decades. While much of this increase has occurred on coastal areas and nearshore islands, increasing numbers of seals have been seen in estuarine regions, including Narragansett Bay and Mt. Hope Bay in Rhode Island. The most common seal species in these areas are harbor seals (*Phoca vitulina*), while increasing numbers of gray seals (*Halichoerus grypus*) and some ice-breeding seals including harp seals (*Phoca groenlandica*) and hooded seals (*Cystophora cristata*) are becoming more common, with a few hundred seals present in the area at peak abundances. The seals are most abundant in these areas during the winter and early spring months, where they will remain before moving north to breed in the summer. While the exact diet of these seals remains largely unknown, their increasing numbers may have the potential to impact local fish stocks.

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THE USE OF ZERO-VALENT IRON AS A GEOCHEMICAL BARRIER TO TRAP GROUNDWATER-BORNE PHOSPHORUS IN THE SURFICIAL SEDIMENTS OF A KETTLE POND, CAPE COD, MA

Zero-valent iron filings were applied to the shallow surficial sediments of Ashumet Pond, Cape Cod, MA, in the area of the footprint of a groundwater-borne sewage plume, to act as a geochemical barrier to trap phosphorus from the plume before it enters pond waters. Lysimeter cores were taken from the pond sediments in the footprint of the sewage plume, transported to the laboratory at SMAST and maintained at field conditions. Artificial groundwater was continually pumped through each lysimeter. Water flowed upwards through the sediments, into the head space above each core and out an opening in the lysimeter wall to a collection bucket. Four triplicate sets of treatments with zero-valent iron filings were established in the lysimeters: 1) control, no treatment; 2) 10% by weight zero-valent iron mixed to a sediment depth of 5 cm; 3) 20% by weight zero-valent iron mixed to a sediment depth of 5 cm; and 4) 20% by weight zero-valent iron applied to the sediment surface. Water samples were taken weekly from the artificial groundwater source and from the head space of each lysimeter, and analyzed for ortho-phosphate. Results show that sediments containing zero-valent iron at 10% or 20% by weight, either applied to the surface or mixed in with sediments, effectively retained greater than 90% of the phosphate pumped through the lysimeters over a period of 500 days. Control lysimeters retained less than 10% of the phosphorus over the same time period. Results indicate that zero-

valent iron applied to surficial sediments has the potential to enhance sediment retention of groundwater-borne phosphorus and reduce the deleterious effects of nutrient loading to aquatic ecosystems.

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MICROBIAL SOURCE TRACKING IN TWO SOUTHERN MAINE WATERSHEDS

E. coli has long been used to indicate potential pathogens in shellfish beds and recreational waters. Current methods indicate bacterial concentration but not source, which is essential for effective, cost-efficient remediation. This two year study of the Webhannet and Little River watersheds uses genetic analysis (ribotyping) to identify the strains of E. coli in these estuaries and their tributaries. The strains are compared to a database of known source bacterial strains, and close matches are used to indicate source animal type (e.g. dog, human, deer, etc). This application of ribotyping to address bacterial contamination is new, and this study's primary goal is to evaluate its validity and suitability in Maine. A key secondary goal is to determine the sources of bacteria which have closed some of the Webhannet and all of the Little River estuaries to clamming. As of March, 2003, ribotyping of bacteria from the Webhannet watershed is complete, allowing researchers to evaluate the process from start to finish. Sampling in the Little River watershed is ongoing. Ribotyping is one of several innovative Microbial Source Tracking techniques that are gaining attention nationally for their potential to dramatically improve the ability to solve problems of fecal contamination in estuarine environments.

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SIMULATING THE EFFECTS OF THE HEATED WATER DISCHARGES FROM BRAYTON POINT POWER STATION TO MOUNT HOPE BAY IN FINITE VOLUME COASTAL MODEL

The Mt. Hope Bay lies partially within both Massachusetts and Rhode Island. The bay is located in the northeast corner of Narragansett Bay and connected to the Narragansett Bay by the Narragansett Bay East Passage and the Sakonnet River. Using the finite volume coastal ocean model (called FVCOM) developed by Chen et al. (2002), the effects of the heated water discharges from the Brayton Point Power Station (BPPS) to the Mt. Hope Bay are being

studied. This study involves exploration of the pre- and post BPPS conditions, i.e., with and without the heated water discharges to the Mt. Hope Bay. The pattern of the water circulation in the Mt. Hope Bay, the water exchange between Mt. Hope Bay and the Narragansett Bay are also being explored in detail.