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ABSTRACTS

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A SPATIAL AND TEMPORAL ANALYSIS OF WATER QUALITY INDICATORS IN JAMAICA BAY, NY
The urbanization of the Jamaica Bay (NY) watershed resulted in a system in which the primary freshwater input is nitrogen-rich wastewater discharge from 4 water pollution control plants (WPCPs). The high nitrogen loading to the bay is often cited as a contributor to marsh island degradation and ecosystem changes. An extensive investment in WPCP upgrades has significantly reduced nitrogen loading relative to 1995, though the response of the bay to this reduction is not well defined. The purpose of this research was to identify significant spatial and temporal responses of water quality (WQ) to WPCP upgrades. We examined temporal and spatial trends in a 22-year dataset of summertime surface WQ data from 10 stations monitored by the NYC DEP. A changepoint analysis was used to identify significant temporal changes, while a combination of a principal component analysis (PCA), cluster analysis (CA), and linear regression was used to examine relationships in WQ indicators. Using this approach, Jamaica Bay divides into 3 zones: the mouth in the west, the middle portion, and the inner portion in the east. These 3 zones were then analyzed separately for temporal trends. When applied before and after a significant changepoint, the PCA and CA identified significant changes in the site membership of those clusters. The PCA loading indicated weak to no correlation between nutrients, dissolved oxygen, and chlorophyll a concentration. A linear regression analysis of summertime WQ indicators over time revealed that from 2010-2017, all clusters exhibited significant decreases in total Kjeldahl nitrogen and total phosphorus. These findings indicate that WPCP upgrades in Jamaica Bay have had an impact on spatial and temporal WQ patterns.

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DEVELOPING COST EFFECTIVE MONITORING FOR RAINBOW SMELT USING EDNA.
Environmental DNA (eDNA) tools developed at the University of Maine, Orono were successfully deployed in four streams in Casco Bay, ME in spring 2018 to detect the presence of anadromous rainbow smelt (*Osmerus mordax*), the first such application of this emerging technique. Field methods were refined and tested at sites with documented high (2) and low (2) spawning productivity. Samples were collected below known spawning areas near head-of-tide approximately 2-3 times each week during the spawning season. Samples were filtered and preserved for eDNA analysis. Initial efforts to extract DNA from samples were hampered by the presence of environmental inhibitors. Use of soil extraction kits appears to have overcome this problem and eDNA samples have been replicated successfully using quantitative polymerase chain reaction (qPCR). In partnership with a qualified lab, these tools provide a low-cost and user-friendly method for monitoring the presence of rainbow smelt, a priority species for fisheries managers and conservation organizations.

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EFFECTS OF WATER QUALITY ON OYSTER GROWTH AND SURVIVAL IN CAPE COD, MASSACHUSETTS ESTUARIES
Coastal communities are faced with determining solutions to remove excess nutrients, namely nitrogen from their estuaries and bays. A major contributor to eutrophication is septic tanks, but cost and infrastructure demands (e.g. collection and treatment of wastewater) are a limiting factor. The search for soft solutions to augment nitrogen removal in creative ways beyond sewering whole towns, are currently being tested. Oyster aquaculture has become a growing practice in many areas across Cape Cod, and provides an excellent opportunity for biological field research on the interactions between level of nitrogen enrichment and organism response. The effectiveness

of shellfish aquaculture as a way to remove nitrogen was examined in twenty sites located in eight estuaries within the Town of Falmouth. Starting in spring 2017 oysters were deployed in surface and bottom mesh bags and monitored for shell length, wet weight, mortality, and water quality parameters every two weeks throughout the growing season. Environmental parameters, specifically, salinity, total nitrogen, total suspended solids, particulate carbon and nitrogen, and chlorophyll concentrations were found to vary along the horizontal gradient from the headwaters to the inlets of each estuary. These parameters were compared to oyster growth rates and mortality. A strong relationship was found between oyster growth and salinity. Results from this study are providing guidance for optimal siting of future large-scale oyster deployments for nitrogen removal.

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CANINE DETECTION OF FECAL COLIFORM BACTERIA FROM HUMAN SOURCES IN THE PETTAQUAMSCUTT ESTUARY, RI.- PRELIMINARY RESULTS

In 1979, sections of the Pettaquamscutt Estuary (Narrow River) in southern Rhode Island were closed to shellfishing and in 1994, the whole river was closed due to high fecal coliform levels. Identifying the sources of these bacteria is crucial for good management of the waters and watershed. Most methods that measure levels of fecal coliform bacteria are not able to identify sources but there is a relatively new method available now. A joint project between Narrow River Preservation Association, RI Department of Environmental Management, US Fish and Wildlife Service, and The Nature Conservancy, with cooperation from the towns of South Kingstown RI and Narragansett RI, took place conducting human bacteria source tracking in key areas within the Pettaquamscutt Estuary watershed. Environmental Canine Services uses dogs that are trained to detect whether human contamination exists in water samples, stormwater systems, and/or surface water. This method has been used nationally since 2009 in 14 different states with much success. An advantage of this method is that human sources can be immediately identified while in the field and additional areas can be sampled. The dogs can detect human sources in water with low levels of bacteria (less than 10cfm/100 ml), in old sewage (which may not have much bacteria), in sewage that has had UV treatment, and in dry areas that previously had sewage. The canine detection was supported by laboratory analysis of fecal coliform bacteria in water samples collected at some of the same locations. The goal of the project is to determine whether these areas with elevated bacteria concentrations are impacted by illicit human sources of bacteria. If so, remedial measures can be implemented.

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CITIZENS AS SCIENTISTS:LESSONS LEARNED AFTER 30 YEARS AT MASS AUDUBON

Mass Audubon has engaged in a variety of citizen science projects over the past 30 years. Projects where we have trained volunteers to regularly go out in the field to collect data on a topic of environmental interest have encompassed water quality monitoring and biodiversity monitoring. Volunteers have included interested citizens as well as students and their teachers. Our water quality monitoring studies were carried out to support efforts associated with upgrading wastewater treatment facilities in Boston Harbor, Salem Sound, and Gloucester Harbor. Biodiversity studies have included a wide variety of taxa: birds, butterflies, tide pool invertebrates, amphibians, and salt marsh vegetation. These generally have had the theme of examining long-term trends in biota. The projects that have been most successful have had realistic and attractive goals, the strong support of the sponsoring institution, adequate training and oversight, relatively simple data collection and entry protocols, and regular feedback to the volunteers. Some examples. The Breeding Bird Atlas project highlighted some dramatic changes in the avifauna of Massachusetts over the past 30 years, and these have focused conservation efforts on the state level. Results of the Salt Marsh Science Project has been incorporated into management initiatives. Our Tide pool volunteers helped document the northern spread of invasive tunicates before it was widely recognized. Tide pool and winter waterfowl monitoring are no longer being carried out by Mass Audubon due to staff changes, however, the methods developed in these projects have been incorporated into other monitoring initiatives.

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THE ROLE OF NITRATE AS AN ELECTRON ACCEPTOR IN SALT MARSH ORGANIC MATTER DECOMPOSITION

Salt marshes efficiently store carbon due to large inputs of organic matter (OM) from primary production concurrent with slow decomposition rates. As nitrate loading to coastal waters continues to rise, it is unclear what effect it will have on carbon storage capacity of these systems. This uncertainty is largely driven by the dual role nitrate plays in biological processes, where it can serve as a nutrient for primary production or a powerful electron acceptor fueling heterotrophic microbial metabolism. Here we present controlled flow through reactor experiments that tested the role of nitrate as an electron acceptor and its effect on OM decomposition in salt marsh sediments. We exposed sediments from varying depths and prior nitrate exposure to 500 µM nitrate and measured biogeochemical parameters to monitor metabolism. We also collected sediment prior to and following the experiments to examine OM properties and changes in the microbial community using 16S rRNA gene sequencing and metagenomics. We observed a significant increase in OM decomposition in response to nitrate, particularly as denitrification, and found that this pattern persisted at sediment depths typically considered less labile. Nitrate altered both the microbial community and its associated functional potential, selecting for taxa belonging to groups known to reduce nitrate and oxidize complex forms of OM. This pattern was not as pronounced in sediments chronically exposed to nitrate, suggesting the effect of nitrate on OM decomposition is limited. These results suggest that nitrate can serve as an electron acceptor in metabolism and may expand the decomposable OM pool, effectively reducing overall carbon storage potential in salt marsh systems.

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SALTY CRANBERRIES? RESTORING RETIRED CRANBERRY BOGS TO TIDAL WETLAND

Cranberry farms are being retired around southeastern Massachusetts for a variety of reasons, providing an opportunity to restore them to native stream and wetland ecosystems. Many of these cranberry farms were constructed on top of historic peatlands and many others were constructed in tidally-influenced areas. This talk will investigate some of the complexities of restoring retired cranberry bogs to functional salt marsh with a specific focus on the Cold Brook Ecological Restoration Project in Harwich, MA on Cape Cod. Restoration efforts here are currently in the design phase with the multiple goals of removing fish passage barriers, improving aquatic and wetland habitat, reducing nitrogen loads to Saquatucket Harbor, and restoring the downstream portion of the project to salt marsh. We will discuss these efforts in the context of estuary restoration elsewhere in the region and on the west coast, where removing tidal barriers are providing a wide range of ecological benefits to aquatic, marine, and terrestrial plant and animal species.

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RISING GROUNDWATER TABLES THREATEN COASTAL SEPTIC SYSTEMS

Historically, communities in the rapidly developing southern Rhode Island coastal region have relied on individual septic systems to treat and disperse household wastewater. Septic system design is predicated upon a certain separation distance between the drainfield's infiltrative surface and the seasonal high water table, so that there is an adequate volume of unsaturated soil below the drainfield to attenuate both nutrients and pathogens, before wastewater percolates into the groundwater. However, a survey of historical depth-to-groundwater table data, submitted to the Rhode Island Dept. of Management with septic system permit applications, indicates that groundwater tables along the southern RI coast are rising at a rate of 14 mm per year since 1960. These rates are greater in some regions of the coast than in others. Communities where potable water is imported via municipal water or monthly deliveries to cisterns seem to be facing greater rates of rising groundwater tables. Our estimates indicate that per capita human inputs to groundwater aquifers from septic systems account for 70-87% of this rise, while sea level rise and increased precipitation associated with climate change make up the remaining proportion of groundwater rise. If current groundwater table rise trends persist, groundwater levels may rise to within 50 cm of the soil surface by 2100, or could reach the surface by 2050 if the current trends accelerate. As water inputs change in the coming decades, increasingly shallow water tables will greatly affect septic systems' ability to treat human wastewater, threatening coastal drinking water aquifers and ecosystems with nutrient and pathogen pollution.

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HISTORIC ECOLOGICAL INVESTIGATIONS OF ESTUARIES FROM NEW BEDFORD TO THE WEST BRANCH OF THE WESTPORT
At least 25 years ago, at USEPA-AED we were tasked to develop methods to determine ecological differences between anthropogenically impacted and pristine estuaries. We chose New Bedford Harbor(NBH), which was likely the most anthropogenically impacted estuary in New England. The major pollutants were PCBs and metals. Our approach were benthic surveys in which we took benthic sediment grabs in a uniform grid from the top to the bottom of the estuary. Sub samples were taken for pollutant analysis. And the rest of the sample was sieved to separate the benthic fauna from the sediment in order to determine the individual species and number of each species. We chose the Slocums River Estuary (SRE) as our first reference estuary; however, we were surprised that we could barely detect any statistical differences between the SRE and NBH using benthic statistical indices. There were no detectable anthropogenic pollutants i.e., such as PCBs or high concentration of metals. So, we decided to move on further west to the West Branch of the Westport Estuary (WBWE) as another possible reference estuary and found there were statistical differences between WBWE and NBH. We also explored the East Branch of the Westport Estuary (EBWE) and found benthic statistical differences between south and north of the Hix Bridge. Lastly, we later returned to reinvestigate the SRE and now postulate that this system was impacted by anthropogenic nitrogen inputs.

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TIME-SCALE DEPENDENCE OF RESPONSE OF AN ESTUARINE WATER-QUALITY MODEL TO NUTRIENT LOADING
We evaluate a water quality model being implemented for Narragansett Bay to quantify the response of concentrations of nutrients, phytoplankton chlorophyll *a* and dissolved oxygen in the Bay to loading rates of nutrients and other boundary conditions. Model capabilities are evaluated in the context of suitability as a management tool in Narragansett Bay and similar estuaries. The model, the U.S. Environmental Protection Agency's Water Quality Analysis Simulation Program (WASP), simulates concentrations of nutrients, chlorophyll *a*, and dissolved oxygen. It uses hydrodynamic transport simulated by the Environmental Fluid Dynamics Code (EFDC), observed loads of nutrients, biochemical oxygen demand, and freshwater, as well as boundary conditions for benthic nutrient and oxygen fluxes. Model oxygen and phytoplankton chlorophyll *a* are compared with data from a network of fixed-site sensors in the Bay that provide oxygen and chlorophyll *a* concentrations at 15-minute intervals, generally from late May through late October. WASP represents monthly and seasonal dynamics of near-surface dissolved oxygen and phytoplankton chlorophyll *a* well, but underestimates diurnal excursions of dissolved oxygen concentrations. Sensitivity analyses show that while near-surface chlorophyll *a* concentrations react linearly to modifications of incident light and nitrogen loading rates, dissolved oxygen concentrations are relatively insensitive to these manipulations, suggesting that physical processes are the dominant factor influencing modeled oxygen concentrations. We discuss factors that may contribute to the weak coupling between phytoplankton and dissolved oxygen concentrations in this model.

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CITIZEN SCIENCE TO ACHIEVE BOTH RESEARCH AND ENGAGEMENT OBJECTIVES: EXAMPLES FROM THE COASTAL RESEARCH VOLUNTEERS AND NATURE GROUPIE
Given limited resources available to support research and monitoring, NH Sea Grant Extension's Coastal Research Volunteer (CRV) program is a community/citizen science program created to increase research capacity as well as to provide community members with authentic research and stewardship experiences along the coast. The CRV program is a novel model of citizen science that trains both adult and student volunteers to work with university researchers and state and local partners on a variety of projects related to the coastal watershed. CRV assists in projects such as horseshoe crab surveys, monitoring blue mussels for toxic contaminants, eel monitoring, sand dune restoration and research, *Ascophyllum* phenology monitoring, and beach profiling, among others. Nature

Groupie is a broader-scale effort of which CRV is a collaborating partner. Nature Groupie mobilizes volunteers to care for and study lands and waters in New Hampshire and neighboring states. Collaborating with over 75 different partner organizations since its launch in 2014, Nature Groupie serves as a citizen science hub to provide capacity to programs through a collective volunteer management system, including an online calendar, registration system, weekly e-bulletins, and a student internship program. This presentation will highlight these two collaborative programs for achieving both community engagement and research objectives through citizen science. We will detail Nature Groupie resources for citizen science program as well as CRV program impacts in terms of research and management outcomes and volunteer learning.

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MARINE INVADER MONITORING AND INFORMATION COLLABORATIVE: CRITICAL LINK FOR EARLY DETECTION

New England is home to an ever-growing suite of marine invasive species, defined as non-native species that cause or are likely to cause harm to ecosystems, economies, and/or public health. Successful marine invaders have wide-ranging detrimental impacts and when established in an ecosystem, management options are extremely limited. Because new species may arrive at any moment, one of the best protections against negative impacts is an organized monitoring network to detect species soon after introduction. The Massachusetts Office of Coastal Zone Management established the Marine Invader Monitoring and Information Collaborative (MIMIC) in 2006 to serve this need. What began as a small pilot program to educate and train volunteers has resulted in a far-reaching network of citizen scientists who monitor marine invasive species across New England. Training volunteers to monitor is important in a number of ways: it provides citizens a chance to actively engage in the scientific process, allows for a wider area of monitoring to track range expansions, and enhances the possibility of early detection as citizens that are familiar with species present in their region are better equipped to detect new arrivals. The program continues to evolve through time to incorporate new technologies for data collection and distribution along with updates to monitored species lists to reflect changing environmental conditions. Due to its successful network of partnerships locally and throughout the region MIMIC has become a critical source for marine invasive species information as well as an excellent outreach tool.

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QUANTIFYING THE POTENTIAL FOR NITROGEN REMOVAL THROUGH THE HARVEST OF AQUACULTURE OYSTERS FROM SOUTHEASTERN MASSACHUSETTS EMBAYMENTS

Increasingly, water quality management plans are incorporating oyster aquaculture and oyster reef restoration as a means of reducing nitrogen (N) from estuarine ecosystems. One method of permanent N removal from embayments is through grow out of oyster seed and subsequent harvest of the adult oysters. Previous studies have looked at N content of oyster tissue and shell; however, data are quite variable as several factors appear to affect oyster nutrient assimilation capacities, e.g. oyster size, deployment method, time of harvest, and water quality conditions. This study focused on oysters raised in southeastern MA embayments. Aquaculture oysters were collected from multiple embayments with varying water quality. Embayments were selected based on the presence of on-going multi-year water quality monitoring programs. Water quality samples were analyzed for temperature, salinity, total nitrogen, chlorophyll-a, pheophytin-a, orthophosphate, dissolved oxygen, and transparency (secchi depth). Oysters, spanning a range of sizes and deployment methods, (e.g. floating cages, bottom cages, artificial reefs), were processed to determine N content of the tissue and shell. Water quality data and N assimilation capacities were analyzed to quantify the potential for N removal through oyster harvest. Results are used examine differences in nutrient assimilation capacities that could affect water quality management plans involving oyster aquaculture as a means of reducing N levels in estuaries. An overarching goal is to develop a comprehensive data set that encompasses the variability in eastern oyster N assimilation capacities over a wide geographic range.

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UNIFIED APPROACH TO WATER QUALITY MONITORING LONG ISLAND SOUND EMBAYMENTS

Historically it's been difficult to compare water quality conditions in the Long Island Sound's (LIS) numerous embayments because the monitoring work is conducted by various groups with different monitoring procedures. Launched by Save the Sound in 2017, *Unified Water Study: Long Island Sound Embayment Research* (UWS) is a new

water quality monitoring study developed so local monitoring groups can collect comparable data on the environmental health of LIS embayments. Participating monitoring groups are provided with equipment, training, Standard Operating Procedures, a custom study design for their monitoring site(s), and other resources they need to successfully collect high quality data. The UWS is conducted under an EPA-approved Quality Assurance Project Plan (QAPP) which includes all of the participating groups. This groundbreaking initiative will dramatically increase available data on the environmental health of Long Island Sound. The data will further our understanding of the Sound while informing and supporting actions to assess, preserve, and protect it.

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SALT MARSH ABOVEGROUND PRODUCTION IN NEW ENGLAND ESTUARIES IN RELATION TO NITROGEN LOADING AND ENVIRONMENTAL FACTORS
Aboveground production responses of *Spartina alterniflora* and *S. patens* in estuaries in Massachusetts, USA were assessed in relation to temporal (date) and physical (elevation and distance from creek edge) factors as well as nitrogen loading using stem $\delta^{15}N$, water column dissolved inorganic nitrogen (DIN), and upland nitrogen loading as nitrogen input proxies. All nitrogen input proxies had negative relationships with *S. alterniflora* stem density while stem height and biomass increased or were unaffected. Nitrogen content of *S. alterniflora* increased with stem $\delta^{15}N$ but was not related to DIN or upland nitrogen loading proxies. For *S. patens*, stem density, biomass, and height all increased with stem $\delta^{15}N$ while nitrogen content decreased. Stem density and biomass also varied with elevation. For *S. alterniflora*, this relationship was parabolic for stem density and declined linearly for biomass. Both stem density and biomass increased linearly for *S. patens*. Across the growing season, *S. alterniflora* stem density decreased, *S. patens* biomass increased, and nitrogen content declined for both *Spartina* species. *S. alterniflora* stem height also decreased with distance from the creek edge. Results show different responses for *Spartina* species to upland and water column nitrogen inputs and provide complementary information to results from controlled fertilization experiments.

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DREDGING FOR ENVIRONMENTAL BENEFIT: MODELS OF FLUSHING DYNAMICS IN THE PROVIDENCE RIVER ESTUARY
It has been well-established that the physical processes of an estuary have a direct link to the water quality. Edgewood Shoals is a shallow region of chronic low dissolved oxygen. Observational data and model results demonstrate that the shoal's geometry causes the it to be incapable of proper hydrodynamic exchange with the main estuary, leading to poor water quality. The US Army Corps of Engineers (USACE) is creating a Dredged Material Management Plan (DMMP) in the plans for their next dredging cycle in order to determine if there are in-river disposal options in regions of the Providence River. Edgewood Shoals is under consideration for the placement one of these CAD (Confined Aquatic Disposal) Cells. The purpose of this project is to use a 3D hydrodynamic model to test how an Edgewood Shoals CAD Cell can be used as an opportunity to alter the bathymetry of the shoal in such a way that would enhance hydrodynamic exchange. Observational data have been used to calibrate the Regional Ocean Modeling System (ROMS) model to exhibit the circulation dynamics of the Providence River in Narragansett Bay. Bathymetric alterations (dredging scenarios) created in this study and tested using ROMS will cover two objectives. The first is to potentially increase the amount of exchange between Edgewood Shoals and the adjacent deep channel of the Providence River, improving the flushing dynamics on Edgewood Shoals. The second is to do this while still remaining cost-beneficial to the project. Results indicate that dredged channels significantly modify the way the shoal circulates. Increased flushing is discovered to coincide with channels that span the northern-most area of the shoal and have an east-west orientation.

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CHANGING POPULATION DENSITIES OF INTERTIDAL LITTORINID SNAILS IN COBSCOOK BAY, MAINE FROM 2000-2018. Population densities (number per m^2) of three different species of Atlantic periwinkles, *Littorina littorea, Littorina obtusata*, and *Littorina saxatilus*, as well as two potential predators of these snails, dog whelks (*Thais, Nucella lapillus*) and green crabs (*Carcinus maenus*) were measured at three locations of the Cobscook Bay region of Maine over an 18-year period as part of a long-term intertidal survey project. The intertidal sites were: 1) at the shore of the (former) Friedman Field Station in Edmunds TWP, 2) at Reversing Falls Park in Pembroke, and 3) at West Quoddy Head State Park in Lubec (not all sampled each year). Abundance data were recorded by various

student groups resident at the Freidman Field Station in Maine during the summer months ranging from 2000 to 2015 or by us alone or with Lesley University (ETL) students (in July 2016-2018). Depending on number and training of participants, one, occasionally two, and rarely three m^2 quadrats were sampled on two or more dates during the summer. Densities were determined at vertical positions randomly chosen each date along a transect of each site during these summers. All members of each of these species found to be present within each quadrat were counted and, in some instances, measured. This report focuses on densities of two of these periwinkles in particular, *Littorina littorea* and *L. obtusata*, one (*L. littorea*) because it is heavily harvested by humans and the second (*L. obtusata*) because it is potentially important as prey of shore birds and mammals, and its density appears to be in decline.

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QUANTIFYING NITRIFICATION AND AMMONIFICATION FROM SITES IN A NORTHERN MASSACHUSETTS SALT MARSH
Coastal vegetated wetlands, like salt marshes, are incredibly valuable ecosystems, in part because of their ability to sequester and store large stocks of carbon in their inundated soils. However, eutrophication threatens these costal ecosystems and their long-term carbon stores by delivering excess nutrients that alter their geomorphology and trophic webs. Decomposition of organic matter affects primary marsh function as well as global carbon stores. General controls of decomposition rates include both carbon and nitrogen availability, and the ratios that these nutrients exist in their organic and inorganic forms. Thus, an important process to measure is nitrogen mineralization. The TIDE project is a 15-year study that examined the effects of controlled eutrophication on ecosystem processes in a northern Massachusetts salt marsh. Now in a period of recovery from nutrient loading, the rate at which ecosystem processes can also recover is unknown. The goal of this study was to determine how long-term nutrient loading affected rates of nitrification and ammonification in soils. Rates of mineralization were compared across three dominant plant communities as well as during both spring and neap tidal cycles during the growing season. These data provide insight to soil nutrient cycling within the marsh, as well as establish an understanding of how quickly these processes may return to their original rates and functions.

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TRACKING LEVELS AND POTENTIAL IMPACTS OF NITROGEN OVER THE LAST 6 YEARS IN NARRAGANSETT BAY SALT MARSHES
Although nitrogen has historically been a limiting nutrient, excess nitrogen inputs dramatically alter coastal wetland structure and function. Nitrogen has been implicated as a driver of salt marsh loss and, in some cases, can stimulate emissions of greenhouse gases. Since 2012, plant community composition has been measured annually at two ends of the bay-wide nitrogen gradient in Narragansett Bay, in Passeonkquis (Warwick, RI) and Fox Hill (Jamestown, RI) salt marshes. Porewater ammonium concentrations and potential denitrifying enzyme activity rates (DEA) have been determined on multiple fall dates between 2012 and 2018 from *Spartina alterniflora* zones. Initial comparisons were made (in 2012) of belowground biomass and soil organic matter between the two marshes using computed tomography and loss-on-ignition methods, respectively. Results show greater above- and below-ground plant biomass in nitrogen-rich Passeonkquis Cove than at Fox Hill but generally similar plant communities. Passeonkquis Cove soils had greater organic matter content but lower bulk density than Fox Hill. However, visible collapse of a creek within Passeonkquis Cove in 2013 signaled marsh degradation. Porewater ammonium levels and DEA rates were highly variable without clear temporal trends over 6 years. DEA rates did not significantly differ between marsh sites despite contrasting histories of N loading. These results suggest salt marshes generally maintain a high capacity for nutrient removal via denitrification but is not consistent across the marsh landscape. Further, reactive nitrogen levels remain high in Narragansett Bay marshes and are likely contributing to multiple stressors that may limit long-term persistence.

Naik, A. T. (1, 2), Smithers, M. (3) and Moisander, P. H. (1, 2). (1) School of Marine Science and Technology, University of Massachusetts Dartmouth; (2) Department of Biology, University of Massachusetts – Dartmouth; (3) Boston Engineering Corporation. EFFECTIVENESS OF UV-C AS AN ANTIFOULING SOLUTION. Marine microbial biofilms are assemblages of surface-associated microorganisms surrounded by a protective exopolymer matrix.

Biofilm settlement on ship hulls (biofouling) can induce steel biocorrosion, influence settlement of larger fouling organisms and diminish vessel hydrodynamic performance. There is a need to develop affordable and effective antifouling strategies. We show results from culture- and in-situ biofilm tests suggesting that a UV-C emitting device may be an effective antifouling solution. Upon UV-C exposure, biofilms grown on non-antifouling-paint coated aluminum plates in liquid cultures established from intertidal locations in Buzzards Bay showed a dose-dependent increase in clearance strength, with significant clearance and temperature-dependent reduction in chlorophyll a at 14 days post-UV. Preliminary data from microbial community analysis (16S rRNA gene amplicon sequencing) suggest that compared to the control, there are order-level shifts in relative abundances of certain bacterial and diatoms groups in UV-exposed biofilms. Sequence data from similar plates submerged in situ in Buzzards Bay shoreline over 28 days in July 2018 showed presence of communities dominated by diatoms, and bacterial groups commonly associated with microalgae and specialized in surface association. We are currently analyzing high resolution chlorophyll a and transparent exopolymer particle (a component of the biofilm-secreted polymer matrix) samples from these experiments. Our results suggest that UV-C is a potentially effective antifouling method in marine environments.

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LANDSCAPE STRUCTURE AND LAND USE AFFECTS ESTUARINE BENTHIC INVERTEBRATES IN THE VIRGINIAN BIOGEOGRAPHIC PROVINCE, USA. Estuaries are dynamic transition zones linking freshwater and oceanic habitats. These productive ecosystems are threatened by a variety of stressors including human modification of coastal watersheds. In this study we examined potential linkages between estuarine condition and the watershed using landscape condition attributes and benthic invertebrate communities. We sought to determine if the spatial arrangement of watershed attributes was important in predicting benthic invertebrate condition. We examined attributes at the watershed scale as well as those associated with riparian areas. We also examined whether attributes closer to the estuary were more strongly related to benthic invertebrate condition. Since riparian and watershed variables were highly correlated at the biogeographic province scale, either riparian or watershed variables were adequate for assessing estuarine invertebrate condition. Modeling estuarine condition indicated that inherent landscape structure (e.g., estuarine area and watershed area) is important to predicting benthic invertebrate condition and needs to be considered in the context of watershed/ estuary planning and restoration. As shown in other studies, anthropogenic geospatial attributes (development, agriculture) are associated with adverse impacts. Previous studies demonstrated the importance of land use closer to the estuary, but this relationship was not observed in this study, perhaps due to the watershed heterogeneity in our study area.

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COMPARING HISTORIC OYSTER POPULATIONS TO PRESENT DAY RESTORATION ACTIVITIES IN EAST COAST ESTUARIES
From the 17th to the 19th centuries the large oyster populations that had grown in areas all along the East Coast of the United States were overharvested and subject to other threats. These include habitat loss mostly due to pollution, channel dredging and disease such as dermo and MSX. As the human population and demand for shellfish increased, the number of oysters decreased. By the end of the 20th century poor management, unstainable harvest practices and disease caused almost all the region's oyster populations to disappear. Recently, the importance of oysters as a commercially harvested food source and its importance to marine ecosystems are being recognized by many towns along the East Coast. As a result, oyster restoration has become a growing practice in the Northeast and Mid-Atlantic region. In this study we will explore how and why oyster populations have changed from pre-colonial times to the present day. Data from these studies may be used to inform locations of future larger oyster restoration sites as well as improved management strategies.

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PHOTOMETER ANALYSIS OF NITROGEN IN EFFLUENT FROM ADVANCED ONSITE WASTEWATER TREATMENT SYSTEMS

Wastewater from onsite wastewater treatment systems (OWTS) can serve as a source of nitrogen (N) to coastal watersheds. Because excessive N loads can cause eutrophication in coastal ecosystems, advanced OWTS technologies have been used to mitigate their impact on these ecosystems by reducing N inputs. These systems require consistent monitoring and maintenance to ensure that they are removing enough N to meet the Rhode Island Department of Environmental Management's standard for final effluent total N concentration of 19 mg/L or less. In situ rapid tests that quantify effluent N levels have the potential to provide monitoring staff with real-time information about system function. In this study, we assessed the capability of a portable photometer to accurately assess effluent N concentrations. We analyzed ammonium and nitrate concentrations of 47 advanced N-removal OWTS (Orenco Advantex AX20, Orenco Advantex RX30, BioMicrobics MicroFAST, and Norweco Singulair Models TNT, 960, and DN) in Charlestown, Rhode Island. Each system was sampled at least 3 times during 2017. To assess photometer accuracy, we compared measurements made using the photometer with those made using standard laboratory methods. We investigated the effect of test setting (field vs. laboratory) on photometer accuracy, as well as overall photometer accuracy when quantifying effluent ammonium and nitrate. Finally, we analyzed whether the sum of ammonium and nitrate concentrations measured using the photometer could be used to predict effluent total N concentrations. These data will allow us to determine the viability of photometer analysis as a fast, user-friendly method of evaluating system performance.

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METHODS FOR IDENTIFICATION OF POTENTIAL ARTIFICIAL REEF SITES IN CAPE COD BAY

Cape Cod Bay provides a variety of coastal resources including commercial and recreational fishing, and recreational diving. Sediment mappings of the area by Coastal Zone Management and others have indicated that much of the seafloor is composed of featureless areas of sand and mud with small isolated areas of hard substrate. Fisheries benefit from the presence of hard substrate and vertical relief; therefore, it is proposed that artificial reefs be developed in the area to increase the habitat value. Exclusion mapping was used to identify areas of conflict such as resource tow lines and shipping lanes. Four areas encompassing more than 12,000 acres of seafloor were then mapped via side-scan sonar to help depict bottom features. Using this data, fifty 250m^2 boxes were drawn and classified as experimental or control sites for further evaluation. Boxes classified as experimental are featureless areas for potential reef siting. Control boxes are rocky or featureless areas and are used to compare potential reef sites to natural bottom. Thirteen reference boxes were also chosen outside the side-scan-mapped boxes as areas mapped as rocky, wrecks, or featureless for additional comparison. The 250m^2 boxes were then photo groundtruthed and analyzed for substrate type, features, and softness. As a final step, two 200m diver transect surveys will collect additional sediment and biotic within a smaller sampling of sites. All steps will be used in determining a suite of potential locations to submit for permitting artificial reefs in Cape Cod Bay.

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WARMING TEMPERATURES AND FISH COMMUNITIES IN BOTH ESTUARINE AND FRESHWATERS OF THE NARRAGANSETT BAY WATERSHED. Changing climate is predicted to include warming temperatures. In Narragansett Bay, estuarine waters have warmed by about 2 degrees Celsius overall since the early 1960s. Air temperature in Providence has warmed by about the same amount of the same time period. Regional studies show concurrent warming for freshwater in the region. In the estuarine waters, this warming, combined with the effects of many other stressors, has led to changes in fish community structure including high abundances of warm-water species and changes in the pelagic-demersal ratio. The changes in community structure have implications for the food web (including humans). In freshwaters of the Narraganset Bay watershed, few coldwater habitats exist, and they occur far away from urban centers. In addition, a greater percentage in abundance of cool-cold and fluvial freshwater species have been found in the upper reaches of the watershed. Cold- and coolwater habitats appear to

be declining due to overall temperature increases, driven by climate change and urbanization. Monitoring changes to these estuarine and freshwater fish communities is vital to understanding how changing climate is impacting natural resources, and their habitat.

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UTILITY OF ABUNDANCE ESTIMATES DERIVED FROM CITIZEN GROUPS FOR THE MANAGEMENT OF RIVER HERRING POPULATIONS
In response to declining stocks coast-wide, river herring were listed as a Species of Concern by the National Marine Fisheries Service, and the most recent stock assessment demonstrated the need for improved stock indices as a high priority for federal and state management agencies. Monitoring of herring abundances is essential to the management of these important fisheries, and in recent years, public interest in the status of river herring in Massachusetts has been growing. Community watersheds and local citizen groups have established herring visual counting programs at several rivers along the Massachusetts coast. However, without adherence to and use of proper sampling techniques, run size estimates derived by these counting programs may not be useful to biologists and managers. A herring counting workshop was conducted by the Massachusetts Division of Marine Fisheries to establish criteria for conducting visual counting programs. The workshop reviewed basic statistical concepts and various sampling designs required for the estimation of herring run size, as well as consequences of departures from sampling requirements. Provided proper sampling methodologies are followed, watershed and citizen groups can produce statistically-sound estimates of herring run size. Furthermore, a time-series of these estimates can provide a level of accuracy needed to infer population trend and can be useful for river herring stock assessments.

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TIDALLY INDUCED WELL WATER LEVEL VARIABILITY AND VERTICAL GROUND MOVEMENT IN WAQUOIT BAY SAGE LOT MARSH
Monitoring the typical marsh accretion rates of 1 mm/yr during the annual Surface Elevation Tables (SET) surveys may be overwhelmed by the marsh ground vertical movement caused by the swelling due to rising and falling tides. The marsh top peat-rich layer can be considered as a self loaded spring or sponge (representing the intertwined plant remnants mixed with sediment) partially submerged in water. We found that, with rising and falling tides, this layer is swelling and subsiding as much as 10mm in places close to the drainage creek. Investigation of the mechanical properties of the peat core in the lab revealed that the ground water percolation rate is sufficiently rapid, with the time scale of 2 hour, for the tidal signal to propagate several meters from the creek thus to affect some SET sites. During this field season we conducted in-situ measurements of the ground movement accompanied by simultaneous measurements of water level in the creek, nearby salt pans and pools, and in 5cm diameter wells located along the section perpendicular to the creek. The amplitude of the water level fluctuations in the wells was about 50% of the tidal range 2m from the creek and attenuated with distance, there was also a considerable phase lag. The design of the ground movement instrumentation was improved and is argued to be incorporated as supplemental measurements to the SET protocol.

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MAKING NATURE GREAT AGAIN: EPISODE 3 – TRAGEDY OF THE COMMONS REDUX
Fifty years ago, Dr. Garrett Hardin alleged in *The Tragedy of the Commons* (1968 Science 162:1243-1248) that acting in our individual best interests, i.e. “freedom of the commons”, “brings ruin to all.” Dr. Ian McHarg in *Design with Nature* (1969, Doubleday, NY) wrote of “a great erosion…which has diminished nature” and warned of “the necessity of sustaining nature as a source of life” and not simply “a decorative background for the human play”. He harshly but perceptively called humanity “the single agent of evolutionary regression”. We continue to grapple with these same issues of land overuse and management insufficiency though with new concepts: exploitation of natural capital and ecosystem services and viability of “green” management practices as remedies. Sustainable consumption is becoming more space-limited: Global Footprint estimates 1.7 Earths are necessary to meet our demands. Multiple drivers of change (climate, development, agriculture) further complicate prospects for defining, let alone attaining, healthy watershed ecosystem status. McHarg’s ingenious vision for designing with Nature is overwhelmed by competing land uses and our social inability to act for the common good. My analysis of 160 CT watersheds identifies a collaborative approach that might sustainably meet these challenges. Environmental

outcomes that share human socioeconomic and well-being benefits may be a viable solution. I discuss incentive-based remedies using a salient, Nature-based recovery indicator to set watershed sustainability targets. I propose an implementation path with transparent and fair tracking and accountability for engaging broad participation from all sectors.

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FARMERS IN THE MARSH: A NEW APPROACH TO SALT MARSH RESTORATION
Extensive human modifications (i.e. agricultural diking, mosquito ditching, Open Marsh Water Management) have occurred in mid-Atlantic and New England salt marshes beginning with early settlement in the 1600s. Diking companies became prevalent in the 1800s and a series of embankments, ditches, and water control structures were installed in this region to increase agricultural production by restricting tidal inundation. These agricultural alterations persist in modern marshes and may obstruct tidal drainage, resulting in high-marsh platforms vegetated by *Spartina patens* being converted into extensive areas of standing water with *Spartina alterniflora* or large salt pools. In southern Maine, embankment heights can range from <50 cm to 1 m and a series of collapsed ditches and water control structures have been found in marshes with embankments. Our study site, Furbish Marsh in Wells, Maine, lies within the Rachel Carson National Wildlife Refuge system. To determine whether agricultural features at the site are hindering tidal flow and drainage, we mapped marsh surface elevation (5 m grid) using RTK GPS. Additionally, a series of preliminary peat cores (0-50 cm) were taken to determine if a sedimentary signature that differentiates embankment soils from high-marsh peat soils is present. This may provide a secondary identifier for embankments that are less visible (<1m tall). Knowledge of these embankments and ditches may provide a new perspective on salt marsh hydrology and offer a new approach for salt marsh restoration.

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SUPPORTING SCIENTIFIC EXPLORATION AND ENGAGING COMMUNITIES THROUGH THE CITY NATURE CHALLENGE
The City Nature Challenge (CNC) is an annual, international 4-day biodiversity observation competition. In 2018, 68 cities in 16 countries on 5 continents engaged people in the discovery of urban biodiversity; those numbers are expected to grow significantly over the coming years. Observations are shared on the iNaturalist app and website, an observation platform and community of naturalists. In Boston, the CNC is focusing efforts on studying both aquatic and terrestrial biodiversity located within the Route 495 corridor and includes marine habitats out to Stellwagen Bank. The CNC provides a tremendous opportunity for local organizations to engage their members and communities to help address local research interests and contribute to global open biodiversity projects.
The CNC is unique in both the scale (e.g. the number of cities and countries) and the potential to address biodiversity-related research and monitoring efforts within greater metropolitan areas. As an annual event it is an opportunity that organizations, educators, and conservation managers can build upon from year-to-year. This model can be used for areas other than cities. In 2018, Boston CNC organizers set goals to increase and diversify participation, improve quality of observations and identifications, and use “Data Quests” to help investigate changes in biodiversity along the urban to rural gradient and engage participants throughout the year. Results from Data Quests were used by resource managers and graduate students. We will share the results from the 2018 CNC, new education resources, research objectives and Data Quest templates, and how you can get involved in the 2019 CNC or simply use iNaturalist and CNC resources for your own project.

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BRINGING COMMUNITY-BASED STEWARDSHIP TO THE GULF
At its annual summer conference, “Bringing Community-Based Stewardship to the Gulf”, the Gulf of Maine Institute (GOMI) met with educational partners spanning the region from Massachusetts to Nova Scotia. Along with some exciting new local programs being launched by individual teachers and schools, the conference led to the

implementation of two new Gulf-wide initiatives, with lesson plans that can be adapted for elementary through high school levels. The central activity will be "10X10", sampling and cataloging plastics near the students' home institutions: 10 pieces in 10 minutes. An associated activity will be collecting red algae, *Gracilaria*, for analysis using a newly developed DNA technique to determine if it is the native species *G. tikvahiae* or the invasive *G. vermiculophylla*; the difference cannot be determined by sight. Protocol details and any available results will be presented. These programs follow GOMI's philosophy of community-based stewardship: 1.) immersion in experiences that emphasize biota, history, culture, economy, literature, and art of a specific place, 2.) civic engagement that results in concrete, beneficial actions to promote a healthy ecosystem, and 3.) connection of local community efforts to the larger bioregion. GOMI's initiatives employ three overlapping strategies: teacher professional development, civic engagement, and amplifying voices through its on-line journal, which publishes articles from students, teachers, naturalists, managers, and scientists in each issue. GOMI seeks to expand its network throughout the region and offers many ways to participate.

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DIAGNOSTIC ASSESSMENT OF A EUTROPHIC FRESHWATER POND AND ITS CAPABILITIES TO REMOVE NITROGEN FROM THE WATERSHED

Nitrogen and phosphorus loading from coastal development has respectively caused impairment to many of the southeastern MA estuaries and up-gradient freshwater ponds. Restoration of estuaries has been at the forefront of coastal research. However, improvement to these systems comes from a holistic watershed management approach. Data suggests that watershed nitrogen loading can be reduced by increasing natural nitrogen attenuation in freshwater ponds within the watershed transport path. Nutrient and flow data collected in Mill Pond, Falmouth, MA from 2003-2007 indicated that this eutrophic freshwater pond was able to attenuate as much as 65% of the nitrogen load passing through it, before being discharged to down-gradient Green Pond estuary. It is hypothesized that the main mechanism for nitrogen uptake is from denitrification and sediment burial. Citizen concern for the ecosystem decline of the Mill Pond system sparked the 2015-2017 diagnostic assessment to determine the cause of nutrient impairment, investigate the main pathway for nitrogen removal, and propose solutions to improve water quality while maintaining the high level of nitrogen attenuation in Mill Pond. Nutrient loading, in-pond water quality, sediment nutrient regeneration, sediment burial, sediment and plant denitrification were measured to create a nitrogen and phosphorus budget of the pond. This budget will provide an understanding of the nutrient dynamics and significance of this eutrophic freshwater pond as it attenuates nitrogen in the watershed.

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SEAWEED SURROUNDS US: AN UPDATE ON MACROALGAE BLOOMS IN LONG ISLAND SOUND

Macroalgae blooms are common occurrences in shallow, eutrophic embayments, but the reports of blooms are often anecdotal. This state is common around the globe, in terms of both the incidence of blooms and inadequate monitoring of blooms. Data from the last ten years will be used to characterize the state of monoculture seaweed blooms (harmful algal blooms) in Long Island Sound embayments, highlighting the many incidences of increasing frequency and area of blooms. The varying methods of monitoring used in Long Island Sound and around the globe are assessed in terms of effort versus goal of sampling, ranging from intensive estimates of area and biomass to qualitative assessments by citizen scientists to identify trouble areas. Blooms are common throughout the shallow embayments of Long Island Sound, making management of the nutrients fueling the blooms a high priority. Options for control include nutrient load reductions and removal of nuisance seaweed; both with pros and cons.