ABSTRACTS For The Spring 2020 Online Meeting Of The New England Estuarine Research Society

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ENVIRONMENTAL DRIVERS OF CARBON EMISSIONS FROM TEMPERATE EELGRASS MEADOWS
Seagrass ecosystems play an important role in the marine carbon cycle by sequestering carbon, and they can store this carbon in their sediments for hundreds of years if left undisturbed. The same characteristics (e.g. high sediment organic matter content and low oxygen) that cause seagrass ecosystems to store carbon also make them ideal ecosystems for methane production. To date, the limited number of studies measuring methane fluxes from seagrass ecosystems have found that they emit methane to the atmosphere. Further, few studies have explored environmental controls of this emission. Here we examine drivers of methane emissions from two eelgrass (*Zostera marina*) meadows on Cape Cod, MA. We used *in situ* benthic chambers to measure methane fluxes across the sediment-water interface in the dark and light. We measured air-sea methane fluxes using the discrete water sampling method. We hypothesized that vegetation, density, light, and organic matter content would drive methane emissions from these systems. We found that vegetated areas emitted ~10x times more methane from the sediment into the water column than unvegetated areas (eelgrass: 60.2 µmol m^{-2} d^{-1}, unvegetated: 5.5 µmol m^{-2} d^{-1}; $p < 0.001$). Light had no effect on methane emissions (T-test: $p = 0.412$) indicating that photosynthesis was not driving methane emissions from this eelgrass ecosystem. We will present an analysis of all measured environmental drivers (e.g. inorganic nutrient concentrations, dissolved oxygen, salinity). Additionally, we will place our findings into a larger context of methane emissions from vegetated coastal areas.

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IDENTIFYING TIDAL RESTRICTIONS AND RESTRICTED SALT MARSH IN MAINE
Development of statewide coastal restoration efforts depends on the acquisition of data from which well-founded conclusions and confident investments can be based. To understand the full scope of challenges associated with tidal restrictions in Maine, Maine Coastal Program (MCP) created a Tidal Restriction Atlas. The Atlas merges existing crossing survey data from several sources with new assessments by MCP to identify and map all structures, such as culverts, bridges, and dams, that restrict natural tidal flow. To determine restriction status at each crossing site, MCP devised a tidal restriction assessment protocol using remotely sensed data and existing crossing survey data and photos. From this assessment, MCP calculated that 88% of all tidal crossing structures in Maine exhibit signs of tidal restriction. By combining this restriction analysis with mapped salt marsh, MCP generated a conservative estimate of statewide tidally-restricted salt marsh acreage. Sea level rise (SLR) and marsh migration scenarios were also added to the Tidal Restriction Atlas to calculate the number and location of currently nontidal crossings that may become tidal under different SLR scenarios, and those associated with marsh migration pathways. This online, public Atlas will be a useful tool in raising community awareness of crossings to which the CoastWise approach for tidal road crossing design can be applied. Likewise, we envision the Atlas as a means to jumpstart wetland restoration and community-based coastal resilience projects throughout the state.

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EFFECTS OF A LARGE-SCALE NATURAL SEDIMENT ADDITION EVENT ON MACROINVERTEBRATE COMMUNITIES IN NEW ENGLAND SALT MARSHES

Salt marsh invertebrates play a vital role in salt marsh ecosystems by aerating the marsh, cycling nutrients, and forming connections between trophic levels. Sediment accretion in marshes constantly builds substrate for invertebrates to exploit. However, large-scale, episodic sedimentation events may disrupt regular patterns. Since these events are rare, their influence on community structure and species composition is not well documented. During winter storm Grayson in January of 2018, ice rafting caused large areas of atypically thick sediment to deposit on a number of locations in New England, including significant areas of the Great Marsh in Massachusetts. We hypothesized that sediment addition would influence the abundance and diversity of invertebrates in the marsh since the literature suggests most marsh taxa are susceptible to disturbance and slow to recover. Sediment cores were taken from 3 sites in Massachusetts that received ice-rafted sediment to identify and quantify infaunal macroinvertebrates. Preliminary analysis shows that the sites had relatively low richness. A total of 21 taxa were found at the sites using purely taxonomic methods, with 5 taxa overlapping between the three sites. *Ecrobia truncata*, *Melampus bidentatus*, *Orchestia* spp, Oligochaetes, and Hydrophilidae beetles were found at every site. Genomic analysis will provide further context and richness to these results. At this stage of analysis, only one of the detected taxa was significantly affected by the addition of sediment. Further analysis will examine the relationships between sediment depth, salinity, and vegetation and invertebrate community.

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CHALLENGES FOR SCIENCE AND MANAGEMENT OF ESTUARINE MARSHES OVER 50 YEARS AT NEERS
A rapid-fire review of our perceptions and understanding of the role of tidal marshes in estuaries is presented as the scientific identification of threats and adaptation actions to guide management responses over 50 years. At the inception of NEERS, marshes were just getting protection from direct impacts (dredge and fill) and coastal management was being established through the Coastal Zone Management Act. Soon it was realized that our marshes needed more help than mere physical protection, we needed to address myriad human impacts of the past and this has consumed most of our efforts over the past 50 years. With new threats from climate change, we need to redouble our efforts because the added impact from Sea Level Rise has exacerbated hydrologic impacts hundreds of years old and SLR itself presents an existential challenge for marsh-dependent species, highlighting the need to plan for and implement new management actions now.

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50 YEARS OF EELGRASS (DID EELGRASS REALLY EXIST BEFORE FRED SHORT?)
This talk will review the evolution of eelgrass research and conservation in New England over the last 50 years. NEERS members have significantly shaped research and conservation of eelgrass over that time span. This talk will recognize the giants of the field in the past and highlight some mid-career and newer investigators as well.

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A SIMPLE METHOD TO DETECT AND IDENTIFY LABYRINTHULOMYCETES FROM ESTUARINE SAMPLES
Labyrinthulomycetes are a diverse, ubiquitous, and abundant group of marine fungus-like protists characterized by their use of ectoplasmic nets to attach to surfaces, increase the surface area of the cell, and support osmoheterotrophic nutrition; based on these features, most are thought to be free-living decomposers of particulate organic matter. Four distinct groups have been cultivated: the monogeneric labyrinthulids, aplanochytrids, and oblongichytrids, plus the many genera of thraustochytrids. To gain more insight into the ecology of these groups, we developed a simple, cultivation-independent, cost-effective method to detect the

presence and determine the genus-level phylogenetic diversity of labyrinthulomycetes in marine samples including seawater, flocculant detritus, hard clam pallial fluid and shell biofilms, and wracked macroalgae tissue and biofilms. After DNA extraction, we used labyrinthulomycete-specific primers targeting the 18S rRNA gene to detect the presence of labyrinthulomycetes by PCR, and Sanger sequenced the PCR products. Sequencing chromatograms that were "clean", containing a single dominant product, were directly used in downstream analyses, while chromatograms that were clearly mixtures of different amplification products were deconvoluted to separate the two or three main components. All sequences were compared against GenBank using Blastn for initial taxonomic assignment, which was further validated by phylogenetic analysis. Most of our environmental sequences could be assigned to the genus level with confidence, except for some sequences that branched outside of the cultivated labyrinthulomycete genera, consistent with the known limitations of cultivation-dependent methods.

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BURROWING CRABS' INFLUENCE ON TIDAL MARSH VEGETATION SPECIES COMPOSITION AND ABUNDANCE IN WAQUOIT BAY, MA, USA
Emergent vegetation in coastal marshes across the Northeastern United States is declining. Relative species composition of marsh macrophytes is changing due to abiotic factors such as accelerated sea level rise, storm intensity, excess nutrients, and other anthropogenic disturbances. A possible biotic driver of marsh vegetation decline is increased perturbation from burrowing crabs. *Uca* species' (fiddler crabs) populations are increasing in many marshes in the eastern US, likely due to food web disruptions and habitat expansion from rising sea levels. High densities of crab burrows contribute to creek bank erosion and other factors of marsh peat degradation. We conducted rapid surveys of crab burrows in a micro-tidal back-barrier marsh on Cape Cod, Massachusetts in a variety of marsh habitats and found a negative relationship between burrow density and live vegetation cover. We tested the impact of crab burrow density on marsh vegetation by excluding burrowing crabs from the marsh platform using a before-after-impact-control experimental design. After five months the crab exclusion treatment had significantly higher vegetation species richness, abundance of woody shrubs, forbs and dead vegetation cover. There was higher *S. alterniflora* cover and area of bare ground as compared to control plots where crabs had unfettered access. Our findings show that increasing crab burrow densities may be impacting marsh macrophyte species distribution and consequently decreasing coastal marsh resilience to sea level rise and other anthropogenic stressors. Stakeholders should consider mitigating burrowing crab densities to prolong the persistence of certain forb and woody shrubs and to maintain vegetated peat platforms.

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TAKING THE "X" OUT OF QPX (QUAHOG PARASITE UNKNOWN), A PARASITE OF THE HARD CLAM: A MICROCOSM EXPERIMENT
Quahog Parasite Unknown (QPX) is among the pathogenic members of the labyrinthulomycetes, which are a group of diverse marine fungus-like protists. Although QPX is the best studied of these pathogens, little is known about its basic biology and ecology. In a laboratory microcosm experiment using clams housed individually from a QPX-endemic population, QPX was detected in the initially sterile seawater of clams exposed to low temperature (13°C) at 2 through 9 weeks of the experiment and detected in shell biofilms at the end of the 9-week experiment. In contrast, QPX was never detected in seawater or shell biofilms of clams kept at 20°C. QPX was detected at similar prevalence in clam tissue and pallial fluid at both temperatures. It is unclear if the temperature effect on external QPX reflects biology of the clam, QPX, an interaction between them, or some

other external factor. Interestingly, QPX was detected in 82% of clam pallial fluid samples after 9 weeks, suggesting that QPX is a stable and perhaps permanent component of the pallial fluid microbiota. Labyrinthulomycete-specific PCR amplicons from pallial fluid, shell biofilm, and seawater samples obtained at the end of the experiment were Sanger sequenced. In pallial fluid, QPX and aplanochytrids were dominant in the 13°C treatment, while only QPX was found in the 20°C treatment. Aplanochytrids were dominant in seawater and shell swab samples, followed by oblongichytrids, with one QPX sequence identified in seawater from the 13°C treatment. This is the first study to confirm the release of QPX from live infected clams and suggests that QPX is a commensal of the hard clam, supporting its classification as an opportunistic pathogen.

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GENOMIC DATA REVEAL INTROGRESSION IN ATLANTIC SEA-STARS

Sea stars (Asteroidea) have been shown to be keystone species in many intertidal communities, which makes them a valuable system for asking questions about organismal responses to climate change as their population fluctuations can have rippling effects on their communities. *Asterias rubens* and *Asterias forbesi* are a sister species pair of sea stars that occur in the intertidal zone across the North Atlantic with an area of co-occurrence along the northeastern North American coastline. We collected Genome-wide SNP data from 190 individuals of both species to estimate the location and size of a hybrid zone on the coast of North America. We have also quantified spatial patterns of genomic diversity and estimated timing and magnitude of historical admixture. We also used species distribution modelling to project the impact of future climate change on the two species' distributions, their geographical patterns of genomic diversity and the potential movement of the North American hybrid zone.

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PREDATOR PRESENCE REDUCES OYSTER CONTRIBUTIONS TO DENITRIFICATION BUT NOT GROWTH OR BIODEPOSITION

Although prey responses to predator presence have become a major topic of ecological research over the past decades, these effects may not always exist. Predator presence may also influence different traits in different ways, and the full impact of predator presence on species and communities may be difficult to infer from single studies. Last year at NEERS we shared data demonstrating predator presence (Oyster drills, *Urosalpinx cinerea*) reduced eastern oyster (*Crassostrea virginica*) contributions to denitrification processes. In the fall of 2019 we concluded a 14-month project considering if the presence of oyster drills changed oyster growth. We also conducted a behavioral study to determine if drill presence changed filtration and biodeposition in oysters in the summer of 2019. Given links among these processes, our previous results, and work in other bivalves, we expected filtration, biodeposition, and growth to be reduced in the presence of predators. However, we found no effect of predator presence on any measured traits. Our results indicate predator presence in our study region may have differential impacts on traits related to important ecosystem services that oyster restoration attempts seek to improve.

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FIFTY YEARS OF BENTHIC INVERTEBRATE STUDIES IN NARRAGANSETT BAY

Benthic invertebrate communities of Narragansett Bay support important ecosystem functions and services including shellfish production, energy flow to fishes, water quality, and biogeochemical cycles. The decline of marine biodiversity worldwide has raised concerns about effects on ecosystems. We used multidimensional scaling and taxonomic distinctness (biodiversity) on benthic abundance data to analyze changes since the 1950s

(when collection of quantitative benthic data began). Changes correlated with changes in dissolved inorganic nitrogen, dissolved oxygen, and sediment contaminants. As inputs of some stressors have declined in recent years, there are signs of recovery of benthic biodiversity. However, other stressors such as water temperature and watershed development continue. Going further back, we compiled a list of all benthic invertebrate species collected from the bay since 1834. The list covers 104 studies spanning 182 years and currently holds 1,214 unique taxa from 21 phyla. Widely-varying sampling gear and sieve mesh sizes precluded use of abundance data for this analysis. Instead, we used taxonomic distinctness with presence-absence data to examine biodiversity trends. The decline of biodiversity is what would be expected in a community that gradually deteriorated in the face of increasing anthropogenic stressors from the Industrial Revolution and land use changes. Biodiversity had negative correlations with human population in the watershed, total nitrogen inputs, and inputs of metals. As some of the stressors waned in the last two or three decades, following passage of environmental legislation in the 1970s, biodiversity appeared to show a partial recovery.

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TIDERIDER: TOWARD A $1000 PROFILING FLOAT
The achievable spatio-temporal coverage from coastal ocean buoys/moorings, airborne surveys, and water sampling is constrained by the high capital and operational costs of these methods. Rapidly decreasing costs in consumer-grade robotics may present an opportunity to build active floats capable of operating as “virtual moorings;” floats of sufficiently low cost to enable deployment in large numbers. Such instruments could fill gaps in spatial coverage between relatively high-fidelity instrumentation, or, because the instruments they will carry will be of commensurately low cost, measurements may be most effective in an early warning capacity, for example the detection of near bottom hypoxic conditions. The TideRider is an easy-to-build $1000 profiling float that uses a bi-stable buoyancy engine to move between anchoring on the seafloor and drifting on the sea surface, timing its surfacings to take advantage of favorable drifts, either to move toward a waypoint or acting as a “virtual mooring” under suitable conditions. The TideRider is under development. So far undergraduate and high school students have designed and built two prototype units that have demonstrated guidance and control over the cellular network and short-term “virtual mooring” in a tidally flushed salt pond. We are looking for project partners to further develop the concept. In the near term we see TideRiders primarily as an education tool, but ultimately as a component of citizen science programs, with the recognition that generating actionable water quality data represents a high bar. We seek water quality professionals and scientists willing to discuss use cases, sensing needs and sensors, and to partner on proposal efforts.

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SEMI-AUTOMATED METHOD FOR PLANKTON RESEARCH AND MONITORING IN U.S. ESTUARIES
Responding to the need for the “rapid counting, imaging and measurement of individual plankton cells in natural populations”, researchers at the Bigelow Laboratory for Ocean Sciences in 1999 built and installed the first FlowCam, an imaging particle analyzer designed specifically to support aquatic microbial research. Since 1999, over 600 FlowCams in 50+ countries have been used to study and monitor microorganisms in freshwater, marine, and estuarine systems. Here we present an overview of FlowCam technology, including a candid discussion of its strengths and limitations, with an emphasis on applications (e.g. HABs, shellfish aquaculture) and field data from multiple U.S. estuaries.

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SALT MARSH DIEBACK ON NANTUCKET, MA HUMANS AS CRAB PREDATORS
Extensive salt marsh dieback, driven by intensive herbivory by the native purple marsh crab (*Sesarma reticulata*), represents a complete loss of stabilizing low marsh vegetation, particularly smooth cordgrass (*Spartina alterniflora*), leading to large expanses of exposed marsh soil sediment bordering harbors and marsh creeks. The loss of low marsh severely impacts marsh stability and function, leading to increases in soil erosion, sediment softening/subsidence and exposure to increased impacts of climate change and sea level rise. Recreational fishing decreased fish predator populations, potentially allowing purple marsh crab populations to explode. After over a decade of salt marsh dieback, marshes appear to be recovering although they have experienced significant erosion and subsidence. On Nantucket Island, MA salt marsh dieback began about a decade later than other areas, meaning that loss of salt marsh elevation and area is not as extreme. This gives us a unique opportunity to control the purple marsh crab and facilitate salt marsh revegetation before losing valuable soil sediments. This project examined using humans as predators of the purple marsh crab with active trapping and removal during the field season. Over the course of May-November 2019, significant numbers of purple marsh crabs were trapped and removed from two marshes in Polpis Harbor, Nantucket MA. As crabs were removed, smooth cordgrass began recolonizing areas of bare soil. As a pilot study, this project indicates the time and effort as well as success associated with one season of manual crab removal from salt marsh dieback areas.

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SHELLFISH AND NEERS: A FIFTY-YEAR EVOLUTION OF OUR INTERACTION WITH THESE SUCCULENT SHELLED CREATURES
Biome diversity in the NEERS region resulted in a fifty-year evolution of research, management, and vibrant industry, all shellfish related. Rocky shores, and boreal current influence transition to salt marshes, sand/mud substrates, and water warmed by the Gulf Stream. Research, at facilities such as the University of Maine Darling Marine Center and NOAA fisheries lab in Milford, CT and universities and institutions in between, built on pioneering work conducted in the region. Basic research and practical application coalesced, stakeholders joined together forming small neighborhood “Friends of..” groups and embayment-wide organizations formed, recognizing the value of maintaining water quality necessary for shellfish harvest and consumption. Land uses and contaminants, especially nutrients flowing into estuaries, became an important line of investigation. Mesocosms allowed intensive study by manipulating environmental conditions. Diversity and life histories of soft shell clams, mussels, sea scallops, quahaugs, bay scallops, razor clams, sea clams, oysters, produced a wealth of documentation. Both USDA and Sea Grant Extension provided conduits among researchers, managers and industry. Innovation is the hallmark of the shellfish aquaculture Industry. States exhibit diversity of management from full state control within their jurisdiction to full municipal control in areas classified as approved for harvest. Finally the role of shellfish has evolved from strictly providing food and jobs to add societal ecosystem benefits like harnessing their filtering capacity to assist in nitrogen reduction, and utilize their reef-building habits to attenuate wave energy in storm events.

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LIVING SHORELINES IN NEW HAMPSHIRE: IF YOU BUILD IT, WILL THEY COME?
Increasingly, regulatory agencies and restoration scientists are advocating for more innovative approaches, such as Living Shorelines (LSs) techniques, as a form of resilient shoreline stabilization to protecting fragile coastal

ecosystems. One popular type of LS is the restoration of fringe salt marsh habitat with the inclusion of a riprap sill at the low marsh edge. While LSs are growing in use, there is relatively little empirical data supporting its efficacy in New England. We designed a BACI study for the first three LSs constructed in New Hampshire to compare short-term restoration dynamics (< 5 years) to local reference marshes and degraded pre-restoration shorelines. We hypothesized the LSs would possess greater habitat structure than the degraded shorelines yet would lag in proper vegetation cover, invertebrate communities, and porewater chemistry of local references several years post-restoration. Vegetation and macroinvertebrate communities and porewater chemistry were plot sampled in August and September of 2019. The Restoration Performance Index (RPI) will quantify the restoration performance of the LSs by converting biotic and abiotic metrics to an objective, relative score compared to both the reference and pre-restoration shorelines. The construction of the LSs immediately improved existing salt marsh habitat with greater halophyte cover and halophyte richness compared to degraded shorelines. The LSs still require more time to reach local reference conditions seen in lower halophyte percent cover and invertebrate density and positive soil reduction-oxidation potential values. Further analysis will calculate the scores of the RPI to evaluate explanatory factors and set expectations for future LS projects.

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COASTWISE: A COMPREHENSIVE APPROACH FOR CLIMATE RESILIENT AND RESTORATIVE TIDAL ROAD CROSSING DESIGN

Most tidal road crossings in Maine restrict tidal flow. Consequently, tidal road crossing projects in Maine often represent opportunities for habitat restoration and raising community awareness about coastal processes. However, the reality is that most tidal road crossing projects are implemented in the absence of restoration objectives. Likewise, few projects benefit from the type of technical support and guidance necessary to integrate other important, but often overlooked kinds of performance objectives that are relevant to the design process. As a result, considerations like public well-being, structural longevity, sea level rise, and habitat enhancement are applied infrequently, unevenly, or not at all. The lack of a comprehensive decision-making approach during the design process hinders the likelihood of ideal project outcomes, resulting in infrastructure that is ill-suited to accommodating climate shifts, ecologically damaging, and possibly unsafe. Due to prohibitive replacement costs, these inadequate structures are likely to remain in place for the next 50-75 years. To address these concerns, a group of restoration-focused organizations is collaborating to develop and deliver the CoastWise Approach. The intent of CoastWise is to provide communities, restoration practitioners, and other professionals with best practices and decision-making tools that facilitate the design and construction of safe, climate resilient, cost-effective, and ecologically-supportive tidal road crossings. Our presentation will focus on key aspects of the CoastWise Approach.

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WATER QUALITY TRENDS IN A CHANGING CLIMATE: LESSONS FROM WAQUOIT BAY

The Waquoit Bay is a shallow, micro-tidal embayment located on the south side of Cape Cod, a region that has suffered significant estuarine water quality degradation associated with excess nitrogen from residential septic systems. Due to variations in residential density across the sub-watersheds of the estuary, Waquoit Bay offers a unique opportunity to investigate the effects of climate change on high and low nitrogen loading scenarios. In particular, the entire sub-watershed of Sage Lot Pond (SLP) is protected from development as a MA State Park, so the surrounding groundwater discharge has experienced little to no human wastewater influence for at least forty years. For this reason, SLP has been monitored as part of the Waquoit Bay National Estuarine Research Reserve's System-Wide Monitoring Program since 2002. From the long-term dataset, including 15-minute logger readings, monthly nutrient samples, and interannual benthic algae surveys, we see that water temperature, chlorophyll-a concentration, and macroalgae biomass have increased significantly although dissolved inorganic nitrogen and atmospheric deposition of nitrogen have stayed relatively constant or decreased, respectively. These results suggest that impacts from climate change, namely increasing

temperature and precipitation, are driving increased primary productivity in SLP. We see similar water quality trends in areas of the estuary with higher nitrogen loading where the cumulative effects of nitrogen pollution and climate change could lead to accelerated rates of declining estuarine health. Thus, reversing the impacts of eutrophication through mitigation efforts will likely require lower threshold targets for nitrogen than previously determined.

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MARINE NON-NATIVE SPECIES DON'T NEED PASSPORTS: A BRIEF HISTORY OF INVASIVES IN NEW ENGLAND ESTUARIES

Along with climate change and habitat loss, introduced species are the greatest threats to biodiversity and ecosystem functions. Marine bioinvasions are generally overlooked or more specifically out of sight and out of mind. Although concerns were raised much earlier in New England, it was not until the early 2000s that a coordinated effort to understand the extent and impacts of marine invasive species. Several concomitant efforts to address the lack of focus on marine bioinvasions resulted in the first International Conference on Marine Bioinvasions held at MIT, establishment of the Northeast Aquatic Nuisance Species Panel, initiation of Rapid Assessment Surveys and creation of citizen monitoring programs. Efforts focused on identification of species present in New England, prevention of new invasions, approaches to manage and control species already present, early detection and rapid response and ecosystem impacts. Quantifying successful impacts remain elusive, but new introductions may be slowing and outreach efforts have raised awareness with the public. This presentation will summarize what we know, what we have accomplished, and what challenges we face in the future.

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PLANT-SOIL RESPONSES TO EXPERIMENTAL THIN LAYER PLACEMENT IN A CONNECTICUT SALT MARSH

Thin Layer Placement (TLP) is a restoration method used in coastal marshes to stimulate plant productivity, soil accretion through plant-soil feedbacks, and resilience to accelerated sea level rise. While the accumulation of soil organic matter (OM) is critical to effective soil accretion, it is unclear how different depths of dredge material alter redox conditions and decomposition rates, especially in meso-tidal marshes in southern New England. To fill this gap, in spring 2019 we set up a TLP field experiment that manipulated soil surface elevation via dredge application (none: +0 cm, low: +5 cm, medium: +10 cm, and high: +15 cm) and examined several biological (above and belowground biomass, stem height, stem density, leaf area) and biogeochemical (EC, pH, redox, NH_4^+, C:N, decomposition, bulk density) responses in a Connecticut coastal marsh. Our preliminary analyses of the first growing season suggest that decomposition rates were greatest in the high treatment where reduction was the lowest, likely because oxygen in surface soils promote OM oxidation. Low and medium treatments increased stem heights, but reduced stem density compared to unmanipulated controls, resulting in the greatest aboveground biomass in low and control treatments. While no stems grew in the high treatment, we were surprised to see similar belowground biomass to medium treatments, suggesting that roots may be able to penetrate thick sediment and promote marsh resilience. We will continue monitoring plant and biogeochemical responses during the 2020 growing season. Collectively, our work will provide guidance to New England wetland managers as they develop restoration specifications to protect coastal marshes in the face of rising seas.

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A LOW-COST RADIO-TRACKED DRIFTER SYSTEM: DESIGN AND APPLICATIONS FOR COASTAL OCEANOGRAPHY
GPS-equipped drifters are commonly used to track currents over a variety of spatial scales. When used in open-ocean settings, data are telemetered back to shore without the expectation of recovering the drifters. Here, we describe a newly developed position telemetry system that facilitated the recovery of the drifters and their data. Long-range (LoRa) radio communication was selected as a low-cost, low-power alternative to more commonly used satellite and cellular options. This system was integrated into a small, rugged drifter body that can be used in shallow nearshore and coastal environments without modification. The low cost and high recoverability allow a larger number of these drifters to be repeatedly deployed, allowing physical processes to be described more robustly. Flexibility in the coding allows for the drifters to be deployed to study a range of phenomena, whether exact velocities or coarse trajectories are of interest. The data transmission protocol developed for these drifters can also be applied to other remote sensing projects, for real-time monitoring of environmental variables and sensor performance. We are using these drifters to investigate the roles of tide, wind, and river discharge conditions on exchange processes and surface currents in the Biddeford Pool-Saco Bay system. The swift currents, complex coastline, and rocky islands present in the area allow for rigorous testing of the drifter system. Based on our initial observations, wind speed and direction exert a clear influence on the ebb and flood tide trajectories of water flowing out of and into the Pool. Continued observation over a wider area will allow for more conclusive description of the sources and fates of Biddeford Pool waters.

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LONG TERM VEGETATION CHANGE AT BARN ISLAND, CT
Barn Island, a system of 6 valley marshes with a common bayfront, was ditched in 1932 and 5 of 6 valleys diked, four in 1946-47 and the last in 1968. Ditch maintenance ended in 1979; culverts returned tides to valleys between 1978 and 1989. Detailed analyses (1947, 1965 & 1976), decadal assessments, air photos, peat cores and photostations allow near continuous vegetation monitoring for ~90 years. High marsh is dominant with nearly continuous natural levees along tidal creeks and bayfronts and 5–15 cm lower elevation basins between levee and upland. This levee & basin topography is associated with all tidal creeks and eroding bayfronts. Plant communities of unditched and ditched marsh lie as discrete, nearly continuous, belts parallel to tide creeks. In ditched marsh, by 1947 *Juncus gerardii* (Jg) replaces *Spartina patens* (Sp) on levees and Sp replaces stunted *S. alterniflora* (sSa) in the basins. In 1976 a massive forb community occupied the levee, Sp and sSa were declining and increasing respectively in the basin. Today the dominant vegetation is sSa/salt panne and narrow belts of Jg or Sp creekside. The initial upper border was a belt of Jg. Four diebacks of this belt have occurred, roughly coincident with the 18.6 year metonic cycle. Since the 2008 dieback the freshwater *Panicum* belts above the Jg have been gradually replaced by tidal marsh species and the maximum increase elevation change is 20 cm. The principal factor likely driving these upper border changes is increasing tidal range driven by the metonic cycle. In contrast, unditched marsh has relatively stable vegetation including Jg belt and sits ~10 cm higher. One ditched (reverting) marsh has continuous levees that are 15-30m wide.

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A SYNTHESIS OF CASE STUDIES HIGHLIGHTING 40 YEARS OF WATER QUALITY IMPROVEMENTS IN NARRAGANSETT BAY EMPHASIZING THE CLEAN WATER ACT
Over the last 40 years, Narragansett Bay has experienced significant water quality improvements in response to

reductions in nitrogen, heavy metal and organic contaminants, and bacterial pathogen discharge. The sources of these pollutants stem from the long history of population growth and a manufacturing-based economy. These reductions were documented by decades of persistent research and are the product of implementing the Clean Water Act by cooperation between all levels of government, utilities commissions, industry, nonprofits, universities, and advocacy groups. Wastewater treatment facilities remain a significant nitrogen source to the bay and continuing evaluation will determine if further reductions are needed. Metals/organic contaminants in sediment remain at or below thresholds for negative biological impacts. In response to pathogen reductions, over 3,000 acres have been reclassified to approved for shellfish growing between 2010 and 2017.The watershed still faces significant challenges in addressing stormwater runoff of both nitrogen and pathogens, and legacy methylmercury contamination in fish. Changes in population and land use and climate change will need to be addressed as well. The highlighted case studies showcase the abilities of public and private entities to collaboratively identify indicators, define problems, track changes, and respond to watershed-scale problems through ongoing adaptive management. Widely sharing successes and lessons learned in Narragansett Bay – from processes to research to management actions – can inform other estuarine collaborative management efforts to address complex and challenging environmental issues.

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A PRACTITIONER'S PERSPECTIVE ON THE HISTORY OF ESTUARINE MANAGEMENT IN NEW ENGLAND
Management is defined as the human process of controlling things or people. Paradoxically, environmental management aims to control the undesired and often unanticipated environmental consequences of social management deemed necessary to sustain human needs – kind of a management of management. This dichotomy of purpose has yielded a divisive social-ecological arrangement that engenders structural and functional incompatibilities often resulting from mutually-exclusive space allocations between human and natural uses.
The philosophical, scientific and management underpinnings that sustainably balance and blend conservation and human natural resource needs have evolved over the last century coincident with increasing demands and competition for limited space, exacerbated by intractable pressures of population and climate change. Mace (2014) provided excellent perspective on human perception and the scientific foundation for conservation and management. She suggested a transition from species conservation (Nature for Itself) in the 1960s through the more ecosystem-based concepts (People and Nature) gaining traction today.
Using Mace's framework, I will highlight (from a personally-biased perspective) some of the key challenges, champions, science, programs and motivations that have obstructed and buttressed management practices and potential. What are the lessons from this very active period of social and scientific environmental awareness, change and activism? How will management transform and adapt to meet sustainability challenges for our estuaries in a very uncertain future of increasing space limitation? Is there a lesson to be learned from our response to the Corona virus pandemic?

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HOW ARE CLIMATE-INDUCED SHIFTS IN PHENOLOGY EFFECTING NEW ENGLAND ESTUARIES?
Changes in phenology, or the seasonal timing of recurring events such as breeding, feeding, and movements, have emerged as a primary indicator of species' responses to climate change. In terrestrial environments, shifts in phenology have been well documented; for example, earlier onset of spring and advances in the timing of emergence, flowering, and arrival times of migratory organisms have all been observed. Far fewer examples exist that provide direct evidence for climate-induced shifts in marine phenology. The Gulf of Maine is experiencing rapid and intense changes in temperature during all seasons, leading to widespread concerns of

possible phenological shifts in a variety of coastal organisms of conservation and management concern. This presentation will summarize the main findings of an interdisciplinary working group documenting: 1) key seasonal ecological and environmental processes, patterns, and events in coastal habitats; 2) direct evidence for shifts in timing across the Gulf of Maine ecosystem; 3) implications of shifts in timing for linked ecological-human systems; and 4) adaptation strategies and actions to increase resilience to shifting phenology in the region. Species-specific case studies including the spring spawning migration of anadromous river herring into coastal spawning areas, and seasonal prey availability of estuarine species such as sand lance (*Ammodytes* sp.) to colonial nesting seabirds will also be discussed.

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USING VIDEO IMAGERY TO AUGMENT BENTHIC MACROINVERTEBRATE SURVEYS AND MAP BIOTOPES
Video imagery can be a useful tool for surveying marine benthic epifauna and surficial habitat characteristics. The purpose of this research is to explore the efficacy of using video imagery in conjunction with macroinvertebrate surveys to quantitatively map biotopes. The study site is a near-shore, subtidal area off Herring Cove Beach, Provincetown MA. Benthic grab samples were taken at 24 stations in September 2017, using a Young grab sampler with an attached GoPro Hero 5™. Screen captures, taken from video footage, were analyzed for percent cover of substrate groups (sand, gravel, shell, and submerged aquatic vegetation [SAV]). Benthic grab samples were analyzed for grain size distribution characteristics and invertebrate abundances classified to family level (in progress). Environmental and preliminary invertebrate data were analyzed in PRIMER v7. Biotic-environmental resemblance procedures, distance-based linear modelling, a constrained binary divisive linkage tree routine, and a similarity profile permutation test were employed in analysis. Sample processing is ongoing, but preliminary results show that the environmental variables are significantly correlated with the invertebrate data. Depth and the percent cover of SAV were the most descriptive predictor variables describing 25.5% and 25.4% of the variation in invertebrate data, respectively. The best distance-based linear model included depth, % cover of SAV, % cover of sand, temp., kurtosis, and pH (AICc: 169.04; R2: 0.67). Results from the linkage tree analysis were used to create a full-coverage map of the 5 resulting biotopes. Preliminary results suggest an advantage of using video imagery to quantitatively augment benthic invertebrate sampling.

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AUGMENTING BIOLOGICAL MONITORING IN ESTUARINE SYSTEMS WITH ENVIRONMENTAL DNA
The National Estuarine Research Reserve System-Wise Monitoring Program (NERR SWMP) conducts standardized quantitative measurement of short and long term conditions in the NERRS. We present the results of augmenting the biological monitoring of the SWMP program at six partner NERRS (in Florida, New Hampshire, Hawaii, New York, Oregon, and Maine) with environmental DNA (eDNA) metabarcoding of water samples, with a focus on samples collected at Wells NERR in Maine, and Great Bay NERR in NH. This sampling effort provides a concrete example of how to include eDNA monitoring into an existing monitoring program, and of the power of a small eDNA program. The samples were run with the MiFish 12S fish primers to amplify fish, and 18S Eukaryotic primers to explore the populations of invertebrates, algae and other eukaryotes. Using these data we investigate the species assemblages at each SWMP site, and the differences between and within NERRS in relative abundance, diversity and richness of species. We will also introduce pilot projects comparing eDNA to traditional taxa identification in larval fish tows, and to provide baseline biodiversity in estuarine habitats.

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RE EVALUATING ECOSYSTEM SERVICES PROVIDED BY *PHRAGMITES AUSTRALIS* IN COASTAL ECOSYSTEMS OF THE U.S.
Negative impacts of nonnative *Phragmites australis* in North America are well-known. However, in tidal marshes it provides valuable ecosystem services and habitat for a diverse array of animals. In an era of global change, we should acknowledge the benefits, as well as the negative effects of the common reed. Perhaps the greatest threat to tidal marshes is sea level rise (SLR). Many marshes in New England and the mid-Atlantic are not keeping up with SLR, and there is often no space to migrate inland because there is development immediately landward of the marsh. Common reeds can enable marshes to elevate at rates exceeding SLR, allowing these systems to persist. They also sequester more nutrients, two to three times more carbon, and have better phytoremediation of metals. Like native marsh communities, they protect coastal communities from storm surge and flooding and provide valuable habitat for an array of fauna. Most studies indicate equivalent diversity and abundance of benthic invertebrates in sediments and on the surface of both types of marshes, while fishes in creeks may be somewhat reduced. Use by terrestrial organisms may be somewhat reduced, but it serves as important habitat for many mammals, birds, and insects. At a time when SLR threatens the very existence of tidal marshes it is past time that reed management practices (e.g. herbicides) be re-evaluated. Land managers and scientists need to address difficult questions: (1) Can *Phragmites*-dominated marshes be considered a viable alternate stable state in terms of management and policy goals? (2) Is there a scenario when management should prioritize maintaining marsh integrity (and keeping *Phragmites*) over maintaining native species?

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NEERS AT 50 – A HISTORICAL SYNOPSIS
NEERS was founded in December 1969 and the inaugural meeting was held in May 1970. We'll take a look at the founding and founders as well as other significant NEERSians such as Honorary Members and those for whom the Student Awards were named. To date there have been 79 NEERS meetings, not including ERF meetings, held in 7 states and 2 Canadian provinces. We'll reminisce about a few of the more memorable meetings.

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RIBBED MUSSELS CONTINUE TO FEED AND BIODEPOSIT IN THE PRESENCE OF INJURED CONSPECIFICS AND PREDATORS
Species interactions may mediate the ability of organisms and communities to provide valued services but are rarely considered in forecasting how service provisioning will change as restored communities mature and change in species composition. Bivalves are foundational species in many communities that contribute to services such as habitat provisioning, water filtration, and denitrification but that also may respond to predator presence by reducing activity. Filtering and biodeposition rates of ribbed mussels (*Geukensia demissa*) in the presence of predators (blue crabs (*Callinectes sapidus*), oyster drills (*Urosalpinx cinerea*)), injured conspecifics, or other local species (mudsnails, *Tritia obsoleta*) were compared in a set of experiments conducted in New York, NY, USA in the summer (July – August) of 2019. The effect of predator diet on ribbed mussel responses was also considered. Although mussels tended to be less active in the presence of predators and injured conspecifics, significant decreases were observed in few traits, and there was no evidence that predator diet influenced mussel responses. Variability in feeding rates and other factors such as water quality may play a larger role than predator presence in determining mussel activity. These results suggest that *G. demissa* will

continue to provide positive impacts on water clarity and quality and increase denitrification rates via biodeposition even as restored communities attract predators.