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Abstract Booklet

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GREEN CRAB POPULATION DYNAMICS IN GREAT MARSH, MA IN RELATIONSHIP TO TEMPERATURE
The European green crab, *Carcinus maenas*, is an invasive species that has been linked to the decline of the soft-shell clam industry in New England, as well as the degradation and loss of critical eelgrass and salt marsh habitat. To support the development of effective management strategies for this invasive species in Great Marsh (MA), the largest salt marsh system in New England, we conducted seasonal trapping surveys at 22 sites from April 2014 to October 2018 and collected information on population characteristics and environmental conditions. A total of 31,576 crabs were trapped (19,364 females; 12,230 males; and 335 native rock crabs) during the study period. Average catch per unit effort (CPUE) was highest in the summer of 2014 (186), and significantly decreased in the fall (99) and during the spring (5) of 2015. The population rebounded in the summer of 2015 (35), but did not reach 2014 levels until the fall of 2017 (194). Abundance of male and female green crabs also varied, with female populations highest in the summer and fall months. Fluctuations in green crab populations were also shown to be largely driven by changes in temperature. Our study is the first continuous long term data set on green crabs for the Great Marsh system and confirms reports that abundances are driven by temperature and comparable to other regions in New England experiencing shellfish declines and habitat destruction. We recommend continuing management efforts to reduce green crab abundance in the system and focusing efforts during key times of the year, such as late summer and fall months when abundances are typically high and females are prevalent.

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METHANE EMISSIONS FROM VEGETATED COASTAL SYSTEMS
Seagrass meadows, mangroves, and salt marshes bury 10x more carbon (C) than temperate forests. Currently, research is focusing on quantifying C storage and burial in shallow coastal systems in order to use restoration of these systems for carbon trading credits. However, few studies take the remineralization and release of organic C into account when making their calculations. Out of the few studies that do try to account for organic C loss, most focus on fluxes of carbon dioxide (CO2) from coastal sediments putting little emphasis on methane (CH4) fluxes even though coastal ecosystems may be ideal environments for CH4 production (i.e., their sediments are organic rich and anoxic). Release of CH4 is of particular concern, as CH4 has a global warming potential 25x that of CO2. Without measurements of CH4 release from coastal systems, their actual value in terms of C-sequestration remains largely unconstrained. This review summarizes current knowledge of methane fluxes from salt marsh, mangrove and seagrass ecosystems, identifies drivers of these fluxes, and quantifies the impact of CH4 emissions on C-sequestration. We found that globally, productivity and organic matter content and quality drive CH4 emissions from vegetated coastal systems. Mean CH4 emissions represent an 11%, 7% and 0.2% loss of C buried in mangrove, salt marsh, and seagrass ecosystems, respectively. However, maximum emissions due to ebullition, can account for >100% of C burial in mangrove and salt marsh ecosystems. These data highlight the importance of constraining the pulse dynamics of methane in salt marsh, mangrove, and seagrass systems.

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BATHYMETRIC MODEL AND FLOOD-TIDAL DELTA SEDIMENTATION OF THE NAPATREE LAGOON, WATCH HILL, RHODE ISLAND

The 9.9 acre Napatree Lagoon, located within the Napatree Point Conservation Area (NPCA), (Watch Hill, Rhode Island), is an important habitat for shorebirds and various finfish and shellfish. A bathymetric survey of the lagoon was originally conducted in 2014; this project updated the bathymetric model of the lagoon and analyzed sedimentation of the flood-tidal delta and inlet. Elevation measurements were recorded for all wadable areas of the lagoon using a Trimble R10 Real-Time Kinematic Global Positioning System (RTK-GPS) mounted on a modified SECO All-Terrain Rover Rod 'Big Wheel'. The deeper areas of the lagoon were measured through lead line soundings deployed via kayak. Surveys of the flood-tidal delta, located on the eastern end of the lagoon, were conducted approximately monthly from May-July of 2018 with an additional survey in January 2019. Overall the lagoon is shallow (generally < 0.5 m); the eastern portion of the lagoon is the deepest area with a maximum depth of 0.93 m relative to MLLW. The lagoon has shoaled and decreased in area since 2014 through a combination of tidal delta deposition and spit migration. The overall sediment volume of the flood-tidal delta did not change significantly between May and January. Channel migration redistributed sediment onto the flood-tidal delta and adjacent barrier spit. Apparent sediment volumes in the summer months may be skewed higher due to the presence of macroalgae on the lagoon floor, masking the true volume of sediment deposited. Understanding and monitoring the changing morphology of the Napatree Lagoon provides insight into how the lagoon may continue to change in response to future storms, aiding in science-based management of the NPCA.

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HOW HIGH SHOULD WE FLY? EXPERIMENTING WITH A DRONE TO CHARACTERIZE SALT MARSH VEGETATION IN THE PLUM ISLAND ESTUARY.

Salt marshes are one of the natural communities most vulnerable to sea level rise resulting from climate change. The increasing amount of inundation makes the high marsh habitat dominated by *Spartina patens* (salt marsh hay) particularly at risk and threatens the viability of species, such as the saltmarsh sparrow, that depend on the drier parts of marshes. We have been using transects at Rough Meadows Wildlife Sanctuary in Rowley MA to determine whether the low marsh *Spartina alterniflora* has expanded and *S. patens* has retreated over the past 20 years. Although the transects provide a precise estimate of vegetation, they can only measure a limited amount of marsh area. This past field season, we experimented with the use of a drone to characterize salt marsh vegetation on a much wider scale. The questions we tried to address were (1) How easy is it to distinguish different species of salt marsh vegetation from a drone, (2) What is the optimum height at which to fly in order to be able to identify individual species yet not have an overwhelming number and sizes of images to process. To answer these questions, we selected a 1 acre section of marsh dominated by *S. patens* and flew over it at heights ranging from 65 to 400 feet. It took 62 images to cover the one acre site at 65 feet, 11 images at 200 feet, and one image at 400'. We concluded that images taken at 200' provided a reasonable balance of accuracy and efficiency.

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EXAMINING THE PROCESSES THAT SHAPE MICROBIAL COMMUNITIES AND THEIR FUNCTIONAL POTENTIAL IN DEEP SALT MARSH SEDIMENTS

Salt marshes sequester carbon at rates that are an order of magnitude greater than terrestrial counterparts due to slow rates of decomposition. Microbes mediate this critical ecosystem service, yet we know virtually nothing about their distribution and interaction with buried organic matter in deep salt marsh sediments. Further, there is evidence that nutrient enrichment stimulates organic matter decomposition and alters surface sediment microbial communities, though it is unclear if this pattern holds in deeper salt marsh sediments, where long term carbon storage occurs. To address these critical knowledge gaps, we collected three-meter-deep cores spanning ~3000 years of sediment accumulation. We characterized sediment organic matter in parallel with high throughput sequencing of the 16S rRNA gene to assess microbial community diversity, abundance, structure, and functional potential along a depth gradient between an experimentally nutrient-enriched marsh and its paired reference marsh. We found that both microbial diversity and gene abundance decreased with depth and that associated changes in organic matter explained a large portion of microbial community structure in shallower sediments. However, in deeper sediments, changes to the community could no longer be attributed to parameters we measured. The only detectable differences between the reference and enriched marshes occurred in deeper sediments, suggesting that these differences resulted from stochastic processes rather than experimental nutrient enrichment. Overall, this work highlights the stability of salt marsh sediments, and provides novel information on the microbes mediating carbon cycling in these critical ecosystems.

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INTEGRATING POINT INTERCEPT AND OCULAR COVER PLANT DATASETS: PART OF A NEW ENGLAND NATIONAL ESTUARINE RESEARCH RESERVE SYNTHESIS OF SALT MARSH SENTINEL SITES.

Sea level rise and climate change present major threats to salt marshes nationwide. In an effort to better track and understand their impacts on marsh vegetation and sediment accretion, the NERRS has established Sentinel Sites at reserves around the country. However, most reserves have not yet analyzed their Sentinel Site data. In addition, there has been no attempt to conduct regional syntheses, despite the fact that regional-scale processes can strongly influence marsh vulnerability to sea level rise. Regional synthesis, in part, entails assessing differences in vegetation monitoring methodologies between reserves such as Point Intercept (PI) vs Ocular Cover (OC). PI and OC synthesis is conducted by statistical analysis of differences between methodologies, converting PI to OC through standardization, and using plant archetypes to develop algorithms for PI conversion. This work is done as part of the larger project to work with New England Reserves (Wells, Great Bay, Waquoit Bay, and Narragansett) to conduct the NERRS' first vegetation analyses and first regional trend analysis of Sentinel Site vegetation and marsh surface elevation change in response to sea level rise. Ultimately, this project will inform the management and protection of New England salt marshes and stimulate other regional analyses nationwide.

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EVALUATION OF CHANNEL EVOLUTION IN RESPONSE TO INCREASED TIDAL EXCHANGE IN ESTUARINE HABITATS

Tidal exchange within historical, present and future estuarine habitats is constrained in many locations due to an array of factors, which may include anthropogenic features such as undersized road crossings, channelization, tidal dams and barrier levees. Removal of tidal restrictions is a common practice in restoration of estuarine habitats and conservation planning for future coastal resiliency in the face of sea level rise, changing hydrologic regimes, and species conservation needs. Tidal reconnection efforts may result in positive increases in wetland habitat quantity, quality and function, resulting in part from the substantial increases in tidal exchange. The increase in tidal exchange may also initiate evolution of the bounding tidal channels, which may lead to positive increases in intertidal habitat, but in some cases may lead to potential new interactions with the built environment and critical infrastructure. There are a range of tools that can be used to evaluate potential evolution of tidal channels resulting from notable increases in tidal exchange, including geomorphologically-derived hydraulic geometry relationships, and hydrodynamic modeling tools. With this presentation, we will use two restoration case studies to demonstrate application of these tools to evaluate channel response to tidal restriction removal within an overall restoration planning framework.

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CROWDSOURCING EELGRASS MONITORING: LESSONS LEARNED IN A PILOT PROJECT

Eelgrass beds have experienced severe declines over several decades in the Duxbury-Kingston-Plymouth (DKP) embayment, and there is a need and local interest in better tracking these changes. In 2018, the authors developed and tested an eelgrass monitoring protocol that could be implemented by trained citizen scientists with the goal of establishing rapid assessment standards that can be executed annually or biennially by volunteers. To supplement existing mapping efforts, scientists and local citizens monitored eelgrass extent and condition in DKP using a novel sampling methodology in August 2018. Over the course of six sea days, 250 stations were sampled for eelgrass presence and percent cover using an underwater camera mounted to a standardized quadrat frame, in addition to depth and water clarity data. Of the 250 stations, 100 “indicator” stations, or stations where eelgrass was expected to exist based on historic mapping data, were chosen to also include eelgrass shoot collection to measure plant height, width, disease and epiphytic cover. Results of the sampling, lessons learned, and next steps will be presented.

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THE EFFECT OF VARYING INITIAL NON-STRUCTURAL CARBOHYDRATE CONCENTRATIONS ON SHORT TERM EELGRASS TRANSPLANT SURVIVAL AND GROWTH

Eelgrass restorations efforts have a mixed track record, with improper site selection, bioturbation and physical disturbances as the major explanations for failure. There has been limited quantitative consideration of donor population vitality as a contributing factor to eelgrass transplant survival and growth. This study manipulated initial non-structural carbohydrate (NSC) concentrations and then measured shoot NSC concentrations, shoot length, and shoot survival at 1,2,3,4 and 12 weeks post transplanting. For the first 3 weeks of the experiment survival was equal among all the treatments. By week 12, the treatment with the highest initial NSC concentrations showed significantly higher shoot survival, likely due to greater rhizome development and lateral shoot generation.

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UNDERSTANDING SEASONAL AND INTER-ANNUAL WATER QUALITY TRENDS WITHIN THE TIDALLY RESTRICTED HERRING RIVER ESTUARY, WELLFLEET, MA

The Herring River Estuary, historically trenched and its entrance diked in 1909, has since seen severely reduced tidal exchange. This reduced tidal flushing has been associated with salt marsh loss, build up of fine-grained organic sediment and reduced water quality conditions both up and downstream of the dike. Reduced water quality conditions have contributed to a reduction of environmentally and economically beneficial organisms, leading to the planned removal of the dike and restoration of the estuary to its previously tidally influenced state. For successful restoration of this system through the adaptive management process, it is important to understand seasonal and inter-annual trends in water quality. Using data from ongoing long-term monitoring projects, this study evaluates the effects of precipitation and drought on spatial and temporal trends in water quality pre-restoration in an effort to set a baseline reference for monitoring during and post-restoration. In general, pH, total suspended solids (TSS), ammonium and dissolved oxygen (DO), showed responses to precipitation, with DO and pH showing inverse relationships, and TSS and ammonium showing direct relationships, with precipitation. These relationships were strongest in the middle and upper basins of the estuary. These results show that precipitation patterns are significantly impacting Herring River water quality and that drought indices can act as viable indicators to assist in understanding water quality events at different spatial and temporal scales. For this restoration project, climate variables may be an important consideration during and post-restoration in the evaluation of restoration progress and success.

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VULNERABILITY FACTORS OF THE FRINGING SALTMARSH OF NAPATREE LAGOON: WESTERLY, RI

Erosion of salt marshes is linked to many factors (i.e. sea level rise, wave erosion, biological processes), and poses a risk of habitat loss for many species. Anecdotal observations of the fringing salt marsh is eroding. The 260 m long fringing marsh examined here is narrow (12 m), and located within the 0.04 km^2 Napatree Lagoon, part of the Napatree Point Conservation Area (NPCA) in Watch Hill, Rhode Island. Loss of the marsh jeopardizes an important part of the lagoon ecosystem. Multiple factors assessed to determine the vulnerability of the marsh include: elevation, platform stability, sediment composition, and crustacean burrowing. Monthly crab surveys in 2017/2018 indicated a population of green crabs (*Carcinus maenas*) live within the lagoon. The marsh platform and edge were observed and monitored for green crab and fiddler crab (*Uca*) activity using time-lapse cameras. The average elevation of the marsh platform based on RTK-GPS Elevation data from 2017 is 0.18 m NAVD88, compared to the elevation of MHW (0.36 m), suggesting the marsh platform is underwater during most high tides. The marsh stability determines its resilience to erosion from wave action. Stability and marsh composition data was gathered using a modified AgraTronx Soil Compaction Tester and Oakfield Soil Probe along 17 transects. The soil probes provided ~0.3 m cores of the marsh platform and indicated the marsh is primarily composed of sand with very little to no peat, supporting the interpretation that the marsh is a former back barrier beach. Mapping the marsh edge morphology found burrows and undercuts at many of the transects, and 5 showed erosion within the last two years.

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PROTECTION OF *MYA ARENARIA* FROM NEMERTEANS AND *CARCINUS MAENAS* WITHIN SEDIMENTS AT CAT COVE MARINE LABORATORY

Soft shell clams or “steamers” are commercially important bivalves in New England. Although soft-shell clams are abundant intertidally, they are susceptible to predation especially as juvenile clams by green crabs and ribbon worms. Green crabs are invasive predators in New England, while ribbon worms are a native predator that eat bivalves within sediments. A study using nylon window screening (mesh size: 0.84mm) as a predator barrier was conducted at the Cat Cove Marine Laboratory at Salem State University. Plastic screw cap containers were used as an artificial habitat for the clams in the study. Clams were divided into two sets of containers: one set was filled with sand, while the other set was filled with a local ‘muddy’ sediment, representing the sediment types commonly found in New England clam flats. Containers were filled with a combination of small (10-14mm) and large clams (20-22mm). The screw-top containers were effective in preventing green crabs and ribbon worms from preying on the juvenile clams. Over time, a clear pattern of clam survival emerged within the experimental containers. Juvenile clams, smaller than 20 mm, survive better in sandy sediments with minimal organic matter. Surface barriers are more effective against the crabs. The results of this study suggest that a completely enclosed nursery system may be the only effective method for cultivating juvenile soft-shell clams in areas with ribbon worms. Future studies examining the clam size as a limiting factor on worm predation could provide a better understanding of worm predation relative to clam aquaculture.

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SUCCESSIONAL STATE OF BENTHIC COMMUNITIES IN TEMPERATE CORAL DOMINATED HABITATS IN RHODE ISLAND; WITH NOTES ON PREY AVAILABILITY AND CORAL QUIESCENCE

Settlement plates were deployed in a subtidal site in lower Narragansett Bay for 19 months (July 2017 to February 2019) to observe and document the patterns of recruitment and settlement of encrusting marine organisms in areas dominated by the temperate coral *Astrangia poculata*. Photos and videos were examined for percent cover of most common sessile invertebrates on horizontal and vertical substrates. Percent cover on settlement plates in a vertical orientation showed a successional state of first encrusting macroalgae followed by erect macroalgae and hydroids, and settlement of tunicates. Analysis of percent cover of settlement plates in a horizontal orientation displayed a settlement pattern of first encrusting macroalgae, followed by erect macroalgae and sediment impacted hydroids, and settlement of tunicates. No coral settlement was noted on any plates. Coral quiescence was noted during winter data collection. To examine the effects of light and thus prey availability on quiescence an underwater programmable light rack was engineered to increase food availability for *Astrangia poculata in situ* for 5 months (November 2018 to February 2019). Observational data and measurement of quiescence through probe touching indicated *Astrangia poculata* colonies in the surrounding area entered quiescence in January 2019 prior to the colonies under the light rack which were observed in January 2019 as not dormant.

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POTENTIAL DENITRIFICATION RATES AND MICROBIAL COMMUNITIES DIFFER IN TWO SALT MARSH RESTORATION PROJECTS IN OAK ISLAND, MA AND NEPONSET, MA
Marshes provide numerous valuable ecosystem functions including storm surge protection, habitat for biodiversity, and nutrient cycling. Both erosion and sea level rise of these systems pose threats to many of these important services. Wetland restoration acts as a plausible solution to reestablish the function degraded coastal marshes. However, restoration efforts often fail to raise ecosystem services to the equivalent levels provided by natural systems. Microbial processes, such as nitrogen removal via denitrification, are important to restoring ecosystem services and are heavily dependent on microbial community structure. We assessed microbial community composition in two natural, two restored, and one marsh that was about to undergo restoration in Neponset, MA and Oak Island, MA in August 2016 and August 2017 using 16S rRNA gene sequencing to determine differences in community structure based on restoration stage. Potential denitrification rates were determined using labeled $^{15}N\text{-}NO_3^-$ intact core assays in tandem with microbial community collection. Bacterial communities at the intact sites were significantly different from the restored sites at both locations. The restored and to be restored microbial communities at Oak Island were similar, but significantly different than the restored community at Neponset. Denitrification rates at the intact sites were significantly higher than both the restored and the yet restored sites. Continuing to monitor changes in the microbial community and denitrification rates over time will allow us to assess the trajectory of restoration among the critical marsh ecosystem services facilitated by the microbial community.

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ADVENTURES IN EELGRASS RESTORATION FROM GREAT BAY TO MASSACHUSETTS BAY.
Dr. Fred Short, with the help of his students, developed at least two innovative eelgrass transplant methods and was one of the first to stress that long-term monitoring of restoration sites was necessary in order to understand the development of functions in recovering systems. Fred spearheaded the NH Port Authority Piscataqua River eelgrass restoration, the largest successful eelgrass restoration of its time in the Northeast (1993 and 1994, 6.2 acres planted) which included an unprecedented 15 year monitoring program. By 2000, there had been only two large-scale, successful eelgrass restorations in the northeast, both led by Fred; the NHPA restoration and the NOAA New Bedford Harbor restoration. Now over 20 years later what have we learned? Fred's legacy of eelgrass restoration continues through the work of the Division of Marine Fisheries Habitat Program and our collaborators. Together we have successfully restored eelgrass to outer Boston Harbor and Salem Sound and have test transplanted Plum Island Sound, Essex River and West Falmouth. Collectively we should establish ongoing restoration programs that will target suitable planting areas in Massachusetts and other parts of the region each year and continue to build collaborations with other groups working towards eelgrass recovery.

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OYSTER SETTLEMENT ON LONG ISLAND
Most shellfish populations on the east coast of the United States have declined dramatically. Although still economically important the eastern oyster, *Crassostrea virginica*, has been thoroughly depleted in several regions due to overharvesting and disease. Healthy populations of eastern oysters offer many ecosystem services such as improved water quality, coastal buffering, food supply, and habitat. Restoration of oysters to New York coastal areas requires substantial effort and an understanding of local oyster population dynamics. Sustainable populations of oysters require natural set of juvenile oysters, or "spat". In this experiment we

followed oyster settlement at eight locations on the north and south shores of Long Island, New York, by sampling with bags of oyster shell every 1-3 months for a year and looking for spat. Oyster settlement was found in two locations, Lloyd Harbor and Laurel Hollow. Further research should be done to determine the viability of restoring oysters in these areas. We suggest that areas with oyster settlement may be viable for restoration, even without hatchery-derived spat-on-shell.

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SEAGRASS MONITORING AND RECOVERY FROM THE GREAT BAY ESTUARY TO PUGET SOUND AND BEYOND
The Rio (1992) and Bolinao (1998) Declarations, among other initiatives, underscore the need for sustainable development to protect coastal communities, their social, economic and ethical heritage, and the ecologically significant marine resources people depend on. Fred Short's focus and passion precedes and emulates these declarations, specifically to understand, protect, and restore seagrass ecosystems worldwide and builds the knowledge base on which we rely for scientifically informed decision making. Fred's comprehensive seagrass research program continues to cover a wide range of topics over various spatial and temporal scales and generates results that highlight the importance of seagrasses, educate others, and guide policy change towards resource conservation and protection. This knowledge supports actions to manage and restore seagrass in the Great Bay Estuary, Puget Sound, and elsewhere throughout the world. In Washington State, the Department of Natural Resources monitors seagrass area and depth distribution as an indicator of ecosystem health throughout greater Puget Sound. Soundwide seagrass is relatively stable, yet there is evidence of change at smaller spatial scales. Results from SeagrassNet sites in Puget Sound show similar patterns: overall stability with localized declines. Site specific declines in seagrass and concurrent declines in salmonid populations prompts the need to mitigate stressors and to explore ecosystem-wide recovery strategies for both species. Puget Sound seagrass restoration efforts reflect Fred's research and experimentation and lead toward promising solutions for recovery.

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FEAR LIMITS CONTRIBUTIONS OF OYSTERS TO DENITRIFICATION
While previous research has indicated that the fear of predation can limit growth in oysters, the impact of these non-consumptive effects on the ecosystem services provided by oysters has been debated. We used the novel approach of including predator cues in core incubation studies in order to consider the impacts of fear effects on denitrification. We added oyster drills (*Urosalpinx cinerea*) to the water source entering some continuous-flow cores with oysters (*Crassostrea virginica*) while leaving the water source for other oyster cores free of predators. After 24 hours we measured nutrient and gas composition, calculated fluxes, and compared results for cores with and without predators. Predator treatments showed significant increases in ammonium production, reductions in oxygen demand, and decreases in denitrification rates compared to predator-free treatments. Together these studies suggest that predator presence may impact denitrification on oyster reefs and lead to other changes in nitrogen cycling. Considering these predator-prey interactions may be vital for estimating the long-term impacts of management plans that hope to increase both biodiversity and denitrification rates via oyster reef restoration.

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SALT MARSH SENTINELS: ENGAGING DOCK OWNERS TO MONITOR WETLAND CHANGE
The Salt Marsh Sentinels Program engages dock owners along the North and South Rivers on the South Shore of Massachusetts in monitoring the marshes adjacent to their docks as citizen scientists. Dock owners collect basic data annually on changes in zonation using their dock as a fixed transect. Among the potential changes the project is designed to detect are shifts from high marsh to low marsh vegetation, upland to high marsh, brackish marsh to salt marsh, and bank loss. The project also acts as an outreach tool to dock owners and the community at large. As of summer 2018 nineteen dock owners had joined the program, some of whom will be on their third year of data collection this coming summer.

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SULFUR- AND CARBON- CYCLING IN THE SEDIMENTS OF A NITROGEN-ENRICHED EELGRASS MEADOW
Increased organic matter deposition in eutrophic basins may exacerbate the reduction of sulfur by microbes and lead to elevate levels of sulfide in porewaters and subsequent declines in seagrass health. We examined the C- and S- cycles in the sediments underlying an eelgrass meadow in order to link sediment chemistry to eelgrass health in West Falmouth Harbor (WFH), a N-enriched estuary in Cape Cod. In WFH, we hypothesized a system where eutrophic conditions coupled with seagrass sediment trapping leads to high levels of sediment organic matter (SOM), which then leads to high levels of porewater sulfide, and seagrass health impacts. We expected to see the highest levels of sulfide and organic matter in the sub-basin of WFH called the Middle Harbor (MH), as it contains eelgrass to trap sediments, as well as high N inputs. We assessed this hypothesis in the field using sediment cores, porewater peepers, and seagrass sampling, followed by lab analysis of sulfides using an adapted methylene blue method, SOM via loss on ignition, and seagrass above- vs. below-ground biomass and sulfur stable isotope composition. We found very high levels of porewater sulfide in MH, with an average rooting zone value of 2320 μM sulfide, as well as SOM values as high as 15%, and saw a significant relationship between SOM and sulfides. Lending support to our hypothesis, we found indications of poor plant health in MH, demonstrated by high above- vs. below-ground biomass values and depleted $\delta^{34}S$ leaf tissue values. This study indicates a possible negative feedback cycle wherein seagrass sediment trapping in eutrophic conditions may suffocate the plant's rhizome and root structure, leading to potential mortality.

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UNEXPECTED RESPONSES OF AUTOTROPHS TO NUTRIENT LOADING: INFLUENCE OF WATER RESIDENCE TIME ON EUTROPHICATION EXPRESSION

Water residence time may critically influence the expression of estuarine eutrophication symptoms such as phytoplankton blooms, anoxia/hypoxia, build-up of organic matter, and altered community composition. While a conceptual model was developed in the late 1990's; pioneering empirical studies were conducted with long RT and warm temperatures. Few studies have evaluated response to a range of RT treatments. We used mesocosm experiments to evaluate autotroph community response to nutrient loading at 3 different residence times (1, 3 and 10 d respectively). Nutrient loads to all tanks were 20 mM N d^{-1} and 1.2 mM P d^{-1}, representing inputs to Yaquina Estuary, OR during upwelling conditions. Biomass and growth responses of *Z. marina*, *Enteromorpha* spp., phytoplankton and microalgal flora were assessed along with biogeochemical factors in experiments conducted at both 10 and 20 °C. Phytoplankton were present throughout the experiments and responded to system RT treatments, exhibiting short term blooms in the 3 and 10 d RT treatments. Nutrients accumulated in tanks with long residence times, while DO rapidly increased in all tanks and became continuously supersaturated. Likewise, pH increased above 8.5 and pCO2 measurements suggested substantial carbon limitation, particularly in long RT treatments. *Z. marina* plant mortality only occurred at 20 °C. Seagrass growth, *Enteromorpha* spp biomass and growth and microalgal flora exhibited patterns consistent with C limitation especially in the 20 °C, long RT treatments. Preliminary results suggest that carbon limitation may have been a factor influencing alterations in autotroph community structure and dynamics under high nutrient loads.

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TRACE METAL CONCENTRATIONS IN *MERCENARIA MERCENARIA* FROM NARRAGANSETT BAY

Narragansett Bay (RI, USA) has a long history of metal contamination, and an even longer history of harvesting the hard clam (*Mercenaria mercenar*ia) for food. Hard clams can be used as environmental monitors because of their relatively rapid accumulation and slow excretion of toxins. Their shells are often well-preserved, allowing pollutant conditions to be traced over the course of time. In this study, we used clam shells from Native American middens, museum collections, and field sampling to estimate loading of heavy metal pollutants to Narragansett Bay from pre-colonization to present. We determined shell chromium, cobalt, silver, tin, nickel, manganese, lead, zinc, iron, cadmium, and copper content from a collection of 75 clam shells from Narragansett Bay using inductively coupled plasma atomic emission spectroscopy (ICP-AES). The ages of the clams range from -750 to 2015, allowing long-term pollution trends to be quantified. We hypothesize that metal contamination will be highest in the shells collected from the Providence River Estuary and lowest in the oldest shells.

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DOES BAY SCALLOP DRAGGING IMPACT EELGRASS?

Commercial and recreational fisheries for bay scallops *Argopecten irradians* occur seasonally in late fall and winter in southern New England. As eelgrass *Zostera marina* provides important bay scallop habitat, fishing effort often targets eelgrass beds. While bay scalloping has persisted in coastal waters of southern New England since the late 1800s, surprisingly little data exist to assess potential habitat impacts of this fishery. To address this data gap, we initiated a field study in 2018 consisting of surveys in Massachusetts of 1) a recently scalloped bed in the Westport River and 2) an experimentally scalloped site. For the experimental site, we used a pan dredge typical of gear used by commercial and recreational scallopers in southern New England and, following a randomized complete block design, subjected treatment plots to low intensity (single day) and high intensity (four days) dragging. To quantify potential dragging effects on eelgrass, we counted the number of live blades collected in the dredge. We also measured percent cover in treatment and control plots at the end of the first season of experimental dragging using drop camera images of 0.25 m^2 quadrats. Additionally, we performed a sidescan sonar survey over the experimental array to test for the presence of scars from dragging activity. For the Westport River site, we also used a combined sidescan sonar and drop camera approach to characterize a heavily-scalloped bed in relation to several nearby beds that had not been targeted for scalloping. Preliminary results and anticipated future work will be discussed.

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IMPACT OF CANADA GOOSE (*BRANTA CANADENSIS*) ON CHARLES RIVER WATER QUALITY

The Charles River has an interesting history of water quality, with a general positive trajectory over the last twenty years. However, summer harmful algal blooms (HABs) have raised concerns as they can negatively impact animal and human health. We are interested in the impact resident populations of Canada Geese (*Branta Canadensis*) have on the water quality of the Charles River. Specifically, we wanted to quantify how the passage of grass (their primary food source) through their digestive system alters the concentrations and ratios of nitrogen (N), phosphorus (P), and silicon (Si). This can be used to better understand nutrient inputs into the Charles River, the composition and abundance of phytoplankton communities, and may lend insight into the recurrence of HABs. To determine the impact of Canada Geese we collected guano and grass samples along the Charles River Esplanade. We quantified concentrations of biogenic Si in the goose food and guano. Additionally, we conducted dissolution experiments to quantify the rates of nutrient mobilization by the geese. We found no difference in concentrations of biogenic silica between grass and guano ($p > 0.1$). Preliminary data analysis of the dissolution experiment demonstrates that Canada geese increase the rate at which Si becomes available compared to leaching from grass alone with rates of 7.15 ± 1.07 SiO_2 (μ mol l^{-1} $hour^{-1}$) for guano and 5.74 ± 0.33 SiO_2 (μmol l^{-1} $hour^{-1}$) for grass. Future work will compare Si release rates to those of N and P to develop a full picture of how the Canada Geese impact Charles River water quality.

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SURVIVING THE THUNDERDOME OF ENVIRONMENTAL CONFLICT
The term “Thunderdome” comes from a movie about gladiator-style fighting in a post-apocalyptic world. I use the term here to refer to the conflict that can occur as scientists engage with industry to wrestle with environmental management issues. As development and climate change continue to make their impacts felt, scientists may feel even more compelled to “raise their voice” with regard to their perspectives on what citizens and managers should do to improve the prognosis for ecosystems. Common messages heard by scientist-authors today are “get off the sidelines,” “don’t be such a scientist,” by which they mean…what? Don’t be structured? Don’t be careful in how you speak? Don’t be boring? Yet if scientists are not structured and careful in how they communicate, what does that do to people’s trust in science? How do we scientists maintain balance as we’re being pulled in different directions? Since 2015, I have been debating these questions with my mentor, Fred Short, in the context of how to present and interpret data on eelgrass health in the Great Bay Estuary. We have rarely agreed in these past years and we still don’t agree, though I believe we may be a bit closer than before: now that I, like Fred, have been through a Thunderdome myself and see how theoretically “ideal” processes can be quickly disrupted by motivated industry representatives. I will use my time to briefly explain the essence of my debate with Fred, how our common experience over the last few years impacted the debate, and some Best Practices to consider for those scientists who feel that they, too, might end up, advertently or inadvertently, in the Thunderdome.

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BENTHIC METABOLISM ALONG A NUTRIENT GRADIENT IN LONG ISLAND SOUND, NY
Excess nitrogen (N) loading to coastal areas can stimulate surface water productivity and subsequently increase rates of organic matter deposition to sediments. Here we study how organic matter decomposition and nutrient cycling change along a gradient of N loading in Long Island Sound (LIS), NY, a heavily impacted, tidal estuary on the eastern coast of the United States. We collected sediment cores seasonally in 2016/17 from five sites along a transect ranging from high nutrients and frequent hypoxia in the west to low nutrients and no hypoxia in the east. To quantify benthic metabolism, cores were incubated at *in situ* field conditions for sediment oxygen demand (SOD), net N_2 fluxes (i.e., net denitrification or net nitrogen fixation), fluxes of inorganic nutrients including ammonium (NH_4^+), nitrate (NO_3^-) and nitrite (NO_2^-) and sediment %C. We observed a strong gradient in summer SOD and NH_4^+ flux across the sites with the highest rates occurring at the western most sites exposed to high nutrient loading. Both mean SOD and NH_4^+ flux were positively correlated with %C ($R^2 = 0.69$, $p = 0.05$; $R^2 = 0.77$, $p = 0.03$, respectively). Sediment NO_3^- and NO_2^- effluxes were highest from the moderately impacted mid-LIS site, while the high and low impacted sites were dominated by uptake. N_2 fluxes were variable and did not differ between sites (mean: 10 &mumol N_2-N m^{-2} h^{-1} (SE ±8) Overall, LIS sediments have a 28% N removal efficiency, yet this can only remove 6.5% of total N loading to the system.

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NATIVE AND NON-NATIVE OYSTERS AS A SOURCE OF NITROUS OXIDE BUT NOT METHANE IN A NEW ENGLAND ESTUARY

Invasive species are associated with a range of ecosystem changes such as habitat destruction, competition with native species, and biodiversity losses. Less well known is the role they play in altering biogeochemical processes such as the emission of greenhouse gases (GHGs). In this study we compared seasonal GHG release from native (*Crassostrea virginica*) and non-native (*Ostrea edulis*) oysters collected from Duxbury Bay, MA. We hypothesized that *O. edulis* would emit more GHGs as they have a greater shell surface area per gram of tissue that could host GHG producing microbes compared to the native oyster. Using a series of laboratory incubations, we found that neither species emitted methane, but both emitted significant amounts of nitrous oxide, a greenhouse gas 298 times more powerful than carbon dioxide. Contrary to our hypothesis, *C. virginica* emitted more nitrous oxide than *O. edulis* (mean = 0.39 ± 0.16 nmols $hr^{-1}g^{-1}$ and 0.16 ± 0.06 nmols $hr^{-1}g^{-1}$ respectively), suggesting that the area available for microbes to live on the shell does not control nitrous oxide emissions. In addition, *C. virginica* consumed more oxygen than *O. edulis* (least square means, $p = 0.03$) but both species consumed food at the same rate (least square means, $p = 0.95$). We did not find relationships between metabolic rate (e.g., oxygen and food consumption) and GHG emission for either species, demonstrating that nitrous oxide emissions are not regulated by metabolism. Our results suggest that, in a large-scale aquaculture system, *O. edulis* could be a lower GHG emitter than *C. virginica*.

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DEPLOYMENT OF A CONTINUOUS WATER QUALITY AND COASTAL ACIDIFICATION MONITORING STATION IN CASCO BAY, ME.

Twenty five years of discrete monitoring in Casco Bay, ME, have revealed that water quality and acidification are growing concerns for that region. In order to improve our understanding of water quality and acidification issues in Casco Bay, we determined that high frequency data collection was required. We addressed that need through the deployment of a Continuous Monitoring Station that collects hourly measurements of water temperature, salinity, dissolved oxygen, pH, chlorophyll fluorescence, and the partial pressure of carbon dioxide. Additionally, dissolved inorganic carbon, total alkalinity and the saturation state (omega) of aragonite are calculated from measured data. This station is deployed year round and undergoes rigorous bi-weekly maintenance and calibration. Data from the first two and a half years of operation reveal strong seasonal variability in all parameters except salinity. DO, pH and pCO2 show diurnal variability as well. A strong negative correlation between dissolved oxygen and pCO2 suggests that a secondary driver of carbonate chemistry is the balance between productivity and respiration. In addition, the saturation state of aragonite dropped below 1.5 for at least half the year, indicating conditions under which shell development in larval bivalves may be impacted. Generally, the lower levels occurred in the winter and spring, and higher values prevailed during the summer.

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UNRAVELING THE MYSTERY OF DUNE DIE-OFF IN NEW ENGLAND: POTENTIAL CAUSES AND A STRATEGY FOR RECOVERY.

Coastal dunes are valued for habitat provision and their ability to protect properties from storm surges. The dominant dune plant in New England, American beachgrass (*Ammophila breviligulata*), helps to stabilize dunes by trapping sand and slowing erosion. This ecosystem service may be threatened by dune die-off, a rapidly spreading blight impacting dunes from Maine to Virginia. Believed to be caused by pathogenic nematodes, die-off results in death of *A. breviligulata*, threatening the systems' ability to stabilize dunes and protect coasts from the erosional effects of storm winds, waves, and surges. In a two-part study, we sought to 1) resolve the organisms specifically present in die-offs using genomic screening, and 2) determine whether soil amendments limit the impact of die-off and aid recovery. In part 1, we conducted metagenomic analyses on the entire rhizosphere community of beachgrass habitat, while in part 2 we applied slow-release fertilizer, lime, and a combination of both amendments to dunes at sites that had recently been defoliated by die-off and subsequently replanted. Principle components analysis of extracted DNA show that nematode communities are not distinct in die-off vs control plots, while some groups of fungi are uniquely linked to treatments. Preliminary results suggest that nematodes are not likely to be the sole causal agent of die-off. Meanwhile, we found that the combination of fertilizer and lime resulted in significantly greater survival (% live plants) and percent cover of *A. breviligulata*, as well as greater total plant cover. We conclude that the combined application of lime and fertilizer to restored dunes may hasten recovery from die-off and improve restoration success in New England.

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LEARNING TO TACKLE COMPLEX PROBLEMS IN THE GULF OF MAINE: THE COMMUNITY-BASED STEWARDSHIP INITIATIVE

The Gulf of Maine (GoM) is faced with numerous, complex problems, many of which are associated with climate change. These include sea level rise, increased extreme weather events, eroding shorelines, warming waters, declining fisheries and ocean acidification. Preparing young people to deal with these complicated issues must be part of an overall strategy for the future of the GoM. We worked with the Gulf of Maine Institute to develop a Community-Based Stewardship Initiative, which aims to engage students in learning how to tackle environmental problems in local communities by using the changing GoM as a laboratory. Students learn about the GoM from a variety of perspectives, with a focus on climate change-related issues and solutions. They then employ research methods in the natural and social sciences to address a specific problem or issue important to local citizens. Field research and interactions with community members, scientists and other professionals are important components of this initiative. At our pilot site in Cape Porpoise Harbor, students at Kennebunk High School and the University of New England are working with the Kennebunkport Conservation Trust to determine the feasibility of using solar, wind or tidal power to supply the energy needs of Goat Island. Other sites in New Hampshire, Massachusetts and Nova Scotia are in the development phase, as we work to expand this model to communities throughout the GoM watershed.

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EFFECTIVENESS AND FEASIBILITY IN SEAGRASS MONITORING: RESOLVING THE PARADOX
Seagrass monitoring is widely recognized as essential to seagrass conservation. Ideally, monitoring programs will detect trends in seagrass condition and diagnose causes underlying perceived changes, and yet be feasible to implement at spatial and temporal scales that are relevant to decision making. Fred Short led seagrass science in incorporating simple condition metrics and permanent sampling locations into long-term monitoring programs. These improvements in monitoring efficiency helped resolve the paradox between feasibility and effectiveness, leading to more widespread implementation of seagrass monitoring worldwide with greater ability to detect change. A hierarchical framework for seagrass monitoring was built upon these concepts to address conservation goals at multiple scales. This approach includes three tiers of monitoring that are integrated across spatial scales and sampling intensities: (1) maps of seagrass extent; (2) system-wide assessments of seagrass meadow structure; and (3) high-resolution measurements of functional attributes at index sites. Adoption of tiered monitoring to assess condition of northeastern seagrass systems and performance of Gulf of Mexico seagrass restoration projects suggests that this approach is useful to address a variety of conservation needs.

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ENVIRONMENTAL SIGNIFICANCE OF LEAF REDDENING IN SEAGRASSES
Seagrass meadows around the world are declining due to natural and anthropogenic stressors, including global climate change. Recently, more attention has been given to identifying responses that offer resistance to stressors so that researchers can better manage seagrasses for resilience to environmental change. Leaf reddening, the expression of red coloration in leaves, is a well-documented response in terrestrial plants that has been shown to increase resilience to stress, but has been poorly understood in seagrasses. To increase our understanding of the prevalence, causes, and function of leaf reddening in seagrasses, surveys were conducted at SeagrassNet sites established by Dr. Fred Short within the world's six seagrass bioregions and a series of experiments were performed with green- and red-leafed *Thalassia testudinum* shoots in the lower Florida Keys. Results show that leaf reddening is prevalent in seagrasses, occurring in numerous species growing in shallow waters with high light intensities around the world. In addition, experiments with *T. testudinum* demonstrate that the expression of red coloration is caused by the accumulation of anthocyanins, acts as a sunscreen during periods of high UV and visible light intensities, can be an indicator of UV-B exposure, and may be either transiently or permanently expressed in leaves. The findings of this study imply that leaf reddening could increase seagrass resilience to changes in atmospheric UV levels caused by global climate change by acting as a sunscreen and protecting photosynthetic mechanisms from damage.

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NUTRIENT DYNAMICS IN A TROPICAL URBAN ESTUARY—A CASE STUDY FROM SAN JUAN, PUERTO RICO

Coastal cities in tropical areas are frequently low-lying and vulnerable to the impacts of flooding and storms. San Juan, Puerto Rico is a good example of this. The city is built around the San Juan Bay Estuary (SJBE), a complex of lagoons and channels. A critical stretch of the estuary, the Caño Martín Peña (CMP), has filled in with sediment and debris and now frequently floods the surrounding communities with sewage-enriched waters, causing a series of human health and ecological problems. Fecal coliform levels in the SJBE typically exceed acceptable limits, often by several orders of magnitude. But, dissolved inorganic nitrogen (N) levels are lower than expected, even in areas known to be enriched with sewage. A biogeochemical analysis of surface sediments from throughout the SJBE surprisingly indicated that N-fixation may be the primary source of bio-available N in the most impaired region, the CMP. Although sewage is characterized by high N stable isotope values (>8 ‰), they were low in this area (~2 ‰) and sulfur isotope values were the greatest in this stretch of the system (> 0 ‰), consistent with the presence of pyrite and reduced conditions. Similarly, mangrove peat adjacent to the CMP was characterized by high rates of nitrous oxide fluxes and high concentrations of N in the microbial biomass. We suggest that biogeochemical cycling in nutrient enriched tropical urban estuaries and associated wetlands may yield additional unaccounted for N that further contributes to eutrophied conditions and poor water quality.

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INVESTIGATIONS ON THE ROLE OF POPULATION GENETICS AND SUMMER WATER TEMPERATURE ON EELGRASS RESILIENCE

Small-scale experiments and long-term monitoring in the Northeast US have advanced our understanding of eelgrass response to stressors on a regional scale. Two such studies completed under the guidance of Dr. Frederick Short have furthered these efforts: investigating eelgrass responses to coastal eutrophication and warming coastal waters. The first study tested the resiliency of genetically different eelgrass populations to stresses associated with eutrophication i.e. reduced light and increased sediment organic content. This outdoor mesocosm experiment showed that eelgrass resiliency to eutrophic conditions is improved by genetic diversity, with implications for transplantation, conservation and management. The second study examined the effects of summer water temperatures on eelgrass abundance at eight SeagrassNet sites from Maryland to New Hampshire. Significant relationships were found between increased summer water temperature and reduced eelgrass percent cover on a regional scale. However, local site-specific factors appeared to outweigh the influence of temperature at some sites. The regional responses to increased temperature foreshadow future impacts of warming coastal waters and likely future trends in seagrass communities throughout the region. Together these studies provide a better picture of the future of eelgrass in our warming oceans and can better evaluate how increasing genetic diversity as a management strategy could help mitigate the effects.

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DOES OYSTER AQUACULTURE DRIVE SEDIMENT NITROGEN CYCLING PROCESSES TO CHAOS?
Bivalve aquaculture is increasing rapidly in New England. As bivalves feed, they transport large quantities of particulate matter from the water-column to the benthos, stimulating biogeochemical processes. It remains unknown how this pressure changes sediment-mediated nitrogen (N) recycling and removal in coastal ecosystems over time. Using an in situ approach we measured rates of N cycling for two years across an oyster aquaculture chronosequence in a temperate coastal lagoon (Ninigret Pond, RI). We quantified fluxes of dinitrogen, ammonium, and combined nitrate-nitrite (NOx). We expected to find high release of ammonium due to remineralization at the younger sites, followed by a switch to denitrification (sediment dinitrogen release) as rates of nitrification increased, and more NOx became available in the sediment. Our results did not follow this pattern. We found that bare sediment switched from net N-fixation (-14 ± 20 &mumol N m^{-2} hr^{-1}) to net denitrification beneath oyster aquaculture (554 ± 138 &mumol N m^{-2} hr^{-1}; p = 0.038), but this switch was driven by the two-year old site. There was no difference in ammonium or NOx flux between bare sediment and oyster aquaculture. However, we did observe a range of high uptake and release events of ammonium, suggesting intense competition for NOx between denitrification and dissimilatory nitrate reduction to ammonium (DNRA). Our results demonstrate the difficulty in predicting whether bivalve aquaculture drives sediments toward N removal (denitrification) or recycling (remineralization and DNRA) processes. Instead, increased resource availability from oyster feeding appears to drive N fluxes towards chaos.

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UNDERSTANDING RELATIONSHIPS AMONG ECOSYSTEM COMPONENTS IN A SUBMERGED HABITAT STUDY IN CAPE COD NATIONAL SEASHORE
Human population growth has resulted in increased nutrient enrichment through land clearing, production and use of fertilizers, and fossil fuel combustion. Coastal areas are particularly threatened due to their density of population. Approximately 40% of Cape Cod National Seashore (CCNS) is submerged coastal habitat, making water quality monitoring and a baseline inventory of its marine habitats critical. Benthic habitat mapping can be used to identify changes when they occur, allowing for better management of our resources. The habitats at CCNS range from sand flats to sea grass beds, in areas of both high and low flow. These differing conditions allow for a better understanding of the drivers influencing benthic composition. During the summer of 2014, benthic grabs, sediment samples, and sediment cores were collected throughout 48 stations in the Pleasant Bay system within and adjacent to CCNS. In addition, mapping surveys and vessel-based acoustic data were collected to map the seafloor. Through the CCNS NPS Estuarine Nutrient Enrichment (ENE) monitoring, long-term water quality data has been collected in Pleasant Bay. Water quality and sediment composition were important factors in determining benthic species composition. Understanding these drivers can help explain the impacts of nutrient enrichment on coastal habitats and benthic invertebrate communities. These organisms, although low on the food web, are the foundation supporting higher trophic levels. Analyzing the physical and biological data alongside water quality parameters provides a detailed baseline understanding of the ecosystem, and, in the event of future changes to our coastline, helps us to predict its effect on benthic community structure.

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ASSESSING NITROGEN INPUTS TO THE CHARLESTOWN COASTAL WATERSHED 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. Advanced N-removal OWTS can facilitate the processes of nitrification and denitrification before the effluent is applied to the soil treatment area and percolates to the groundwater. In this study, we selected 50 advanced N-removal OWTS in Charlestown, Rhode Island to determine the capacity of six different N-removal OWTS technologies (Orenco Advantex AX20, Orenco Advantex RX30, BioMicrobics MicroFAST, and Norweco Singulair Models TNT, 960, and DN) to meet the Rhode Island Dept. of Environmental Management's standard for final effluent total N concentration of 19 mg/L or less. Twenty-four of the systems are for houses occupied year-round, while 26 are for seasonally-occupied houses. The year-round systems are sampled quarterly and the seasonal systems are sampled four times over the summer occupancy period. For all systems, field measurements are made of effluent pH, temperature, and concentration of dissolved oxygen (DO), ammonium ($NH4^+$), and nitrate ($NO3^-$) in the final effluent. Final effluent is also analyzed in the laboratory for pH, alkalinity, biochemical oxygen demand, $NH4^+$, $NO3^-$, and total N. These data will allow us to quantify rate of compliance with state effluent standard as a function of technology, seasonality/temperature, and home occupancy pattern, and help identify conditions that may be adjusted within each technology to optimize N-removal treatment performance.

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A MODEL FOR THE FUTURE: USING SYSTEM DYNAMICS TO UNDERSTAND IMPACTS OF THE RANGE EXPANDING FIDDLER CRAB *UCA PUGNAX* ON MARSH ECOSYSTEM FUNCTIONING

The marsh fiddler crab *Uca pugnax* is expanding its range northward, and is now permanently established in the Plum Island Estuary (PIE), MA for the first time in its history. Experiments show the burrowing behavior of this novel crab disrupts soil strength and integrity in PIE. If these alterations cause decreased marsh area over time, altered food web dynamics and increased economic burden for people living near PIE (i.e., impacts to ecosystem services) could occur as *U. pugnax* continues to expand north. To determine how *U. pugnax* will impact this complex coupled human-natural system in the future, we asked the following questions: 1) how will current effects on ecosystem functioning influence PIE functioning and services through time; and 2) how will this impact human well-being for local residents at multiple time horizons? We utilized a System Dynamics Modeling framework, using both quantitative and qualitative data at various time scales, to better understand current and future interactions in this system. Preliminary models show declines in human well-being (i.e., increased storm costs) and decreased area available for feeding and reproduction for species throughout the marsh. Our study provides compelling insight for managers in PIE, and offers a framework applicable to various ecosystems worldwide.

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HYDRODYNAMIC DRAG ON GRASS IN SALT MARSH FROM DIGITAL IMAGES WITH IMPLICATIONS TO TURBULENCE ATTENUATION AND SEDIMENT DEPOSITION

During annual vegetation surveys in Waquoit Bay Sage Lot Marsh complementary clippings of grass from 10cm x 10cm plots were collected from several low-high marsh spanning transects. Plants were photographed and images digitally processed. The cross sectional area of the plants (mostly *Spartina alterniflora*) as a function of height was derived along with the stem density counts and mass density distribution with height. This allows us to directly estimate the hydrodynamic drag dependent on the height above bottom associated with the vegetation. The average cross sectional area has a sharp maximum at 5cm height and vanishing linearly at 25cm. We estimate that typical tidal currents in the marsh are about 2 cm/s, the corresponding Reynolds number is about 50 implying weakly turbulent flow regimes, therefore we can use the well known empirical formula for a cylinder in order to calculate the drag. The actual vertical drag profile behaves differently than the commonly used bulk formula involving bottom drag coefficient and depth of the flow. With a relatively small range of tides 60cm in Sage Lot Marsh two comparable phases of the flow can be identified: turbulent during high water and nearly laminar when the grass is barely submerged. The turbulence levels, sediment carrying capacity, and sedimentation rates are vastly different during these phases.

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CREE MONITORING OF JAMES BAY EELGRASS

Eelgrass in James Bay, Québec has declined since the 1980s, and standard eelgrass monitoring methods are inadequate for assessing the remote and extensive eastern coast of James Bay. In collaboration with the indigenous Cree of northern Québec, Dr. Fred Short and researchers at UNH are developing a protocol for monitoring eelgrass health. Observations are based on Cree knowledge and done using video-monitoring, plant sampling, and *in situ* data logging. Metrics of eelgrass health and habitat conditions are recorded from videos and are used to create a plant health index and a guide for continued Cree monitoring of eelgrass.

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USING UAS AND PHOTOGRAMMETRY TO EXPLORE THE GEOLOGY THAT INFLUENCED WINSLOW HOMER IN PROUTS NECK, MAINE

The resolution of current low-cost publicly available landscape imagery is too coarse for fine digitization work. 'Ground-truthing' can provide fine detail data, but it is expensive to obtain and spatially limiting. To bridge this gap, high resolution images produced by unmanned aircraft systems (UASs) and photogrammetry algorithms were used to look at the geology of Prouts Neck, Scarborough, Maine. Prouts Neck, and its geology, are in-part famous due to the artistry of Winslow Homer. This project was developed as a form of public outreach for the area. At present it creates an interesting intersection between the hard science of geology, the developments of UASs and photogrammetry, the opportunity for community education, and a look at the history and art of the area. To create the final products, a poster and brochure, photos were captured using a DJI Phantom™ UAS outfitted with a 20 mega-pixel camera. The photos were then merged into a three dimensional surface using AgiSoft™ photogrammetry software, exported and geo-rectified. Using this product, the geologic features of interest: dikes, lateral fractures, and quartz veins, were digitized in the GIS software GlobalMapper™. Outcomes of this project include public awareness regarding the geology of the area, an outstanding test case and product for digitization work, and some interesting realizations about the interactions between the Norembega Fault Zone and the local right-lateral shearing of Prouts Neck. One outcome this peculiar interplay is a clockwise rotation of orthogonal quartz veins.

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SEAGRASS MAPPING AND THREAT ANALYSES: CHALLENGES, SOLUTIONS AND NEW DEVELOPMENTS
Seagrasses are being threatened worldwide by different factors and there's an urgent need to better understand these threats and their potential impacts. Conventional methods of mapping seagrass distribution and assessing threats face many challenges in scale, input data, robustness, and effective communication of results. Here I present challenges, solutions and new developments in mapping and data analysis using research inspired by Dr. Fred Short in North America, Pacific Northwest, James Bay and Great Bay. In addition, I will present some areas for future collaboration among seagrass researchers.

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PRELIMINARY ASSESSMENT OF EELGRASS (*ZOSTERA MARINA*) BEDS DISCOVERS TWO INTRODUCED SPECIES NEW TO THE NORTHWEST ATLANTIC PLUS NORTHWARD RANGE EXTENSIONS
Eelgrass (*Zostera marina*) forms extensive intertidal and nearshore subtidal meadows all along the coast of Maine, though the extent of the beds does not remain the same through time. Mapping efforts in Casco Bay, Maine, in 2001-2002 showed reductions in meadow size and density during the following decade, a change calling for updated assessment with biological sampling. During summer 2018, three meadows were selected in the Bay, surveyed and sampled with a platform equipped with a 0.05m^2 Ponar grab, a YSI Exo sonde, and a video camera. Numerous colonies of the cribrimorph bryozoan *Cribrilina* (*Juxtacribrilina*) *mutabilis*, originally described from Hokkaido, Japan, were collected. Colonies encrusted eelgrass, rockweed (*Ascophyllum nodosum*), and laminarian drift algae. *Cribrilina mutabilis* appears to have high potential for introduction based on environmental measures. The aoridean amphipod *Grandidierella japonica*, originally described from Japan as well, also occurred in Casco Bay eelgrass. Both bryozoan and amphipod species are new records for the Northwest Atlantic, the Northeast Atlantic their closest published occurrence. Northward range extensions were evident, including the aoridean amphipod *Microdeutopus anomalus*, last recorded from southern New England. These discoveries indicate macroinvertebrate community composition associated with eelgrass meadows is dynamic and signal change driven by introductions and warming seawaters.

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ASSESSING PERFORMANCE AND GREENHOUSE GAS EMISSIONS FROM A PASSIVE NITROGEN-REMOVING SEPTIC SYSTEM SOIL TREATMENT AREA
Conventional septic systems are used to treat domestic wastewater by nearly a quarter of U.S. households and can be significant contributors of nitrogen (N) pollution to ground and coastal waters. They consist of a septic tank which disperses partially-treated wastewater to a soil treatment area (STA) where final treatment takes place. We are investigating the effectiveness of a novel, layered, cellulose-amended STA designed to passively remove N from wastewater by optimizing conditions for sequential nitrification and denitrification. The top layer of the STA consists of sand, to promote nitrification, and the lower layer contains a mixture of sand and sawdust. The sawdust serves as a carbon source for microbial biomass and as an electron donor to support denitrification. For the past year we have monitored a layered STA built next to a control STA that receives the same wastewater input but lacks sawdust in the lower layer. Preliminary results show that the layered STA removes 98-65% of total N inputs, compared to 88-11% removal in the control STA. We have also measured greenhouse gas (GHG) emissions (CO_2, CH_4, and N_2O) from four depths and the surface of the layered and control STA to determine where GHGs are being produced and consumed, and how emissions are related to N removal.

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DUELING DECAPODS: OBSERVING AGGRESSION LEVELS IN ONE-ON-ONE INTERACTIONS BETWEEN THE EUROPEAN GREEN CRAB *CARCINUS MAENUS* AND THE ASIAN SHORE CRAB *HEMIGRAPSUS SANGUINEUS* IN THE GULF OF MAINE

European green crabs *Carcinus maenus* have invaded the shores of the Gulf of Maine since the early 1800's, devastating native crab populations in the sandy shores and rocky intertidal zones. In the early 2000's the Asian Shore Crab *Hemigrapsus sanguineus* was introduced to the Gulf of Maine, and has since dominated rocky intertidal zones, overtaking the green crab populations in those areas. A study performed at the Cat Cove Marine Lab at Salem State University looked into the level of aggressive behavior between these crab species. An individual of each species was introduced into a round glass arena (1.65 L in volume, 16.5 cm in diameter), lined with a thin layer of sand to replicate a sandy shore, and shucked blue mussel, *Mytilus edulus*, placed in the center to attract the crabs. The crab-on-crab interactions were videotaped for 6 minute intervals, then statistically analyzed using numbers assigned to specific aggressive traits in each minute segment. The data showed that the European green crab was 11.56 times more dominant than the than the Asian shore crab in all of the trials combined. This information can be utilized to understand the behavior of the two invasive species and why Asian Shore Crabs are out-competing the European Green Crab populations in rocky shorelines.

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LEARNING FROM DISPUTES OVER SCIENCE: INITIAL LESSONS TO IMPROVE SCIENCE AND ENGAGEMENT

Disputes over the management of estuarine and nearshore resources appear to favor traditional hard-bargaining approaches that create missed opportunities and the perpetuation of distrust across groups, along with unsustainable, negative impacts on natural resources. In this research, we explore the role of public engagement, negotiation, and dispute resolution in coastal socio-environmental systems, specifically in the context of disputes over science. Drawing on two case studies along the New England coast, we present initial findings seeking to explore perceptions of science used in management and to better understand the role that cross-sectoral engagement opportunities (e.g. workshops, cooperative research, etc.) play in these disputes. Based on participant observation and analysis of semi-structured interviews with researchers, managers, and the regulated community within each case, we explore the role of credibility, legitimacy, and salience (Cash et al, 2003) in the use of science and discuss other patterns emerging from the data. Ultimately, this research seeks to contribute to a better understanding of how efforts to engage across sectors may impact science-intensive disputes over coastal and ocean management and - where appropriate - provide recommendations to adjust approaches to seek to create more durable solutions to move forward through disputes in these systems. We also draw lessons for consideration in how researchers and managers are trained, particularly in preparation for entry into work on potentially controversial topics.

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POTENTIAL OF RIBBED MUSSELS TO ENHANCE GROWTH AND NITROGEN-REMOVAL SERVICES IN RESTORED SALT MARSHES

Salt marshes are decreasing worldwide due to anthropogenic nitrogen pollution. Restoration projects have been performed to address marsh loss, yet it remains unclear how well these restored marshes will grow, expand, and function in nitrogen-enriched waters. Here we explored how a facultative mutualism between the Atlantic ribbed mussels (*Geukensia demissa*) and cordgrass (*Spartina alterniflora*) may enhance marsh

growth and nitrogen cycling. We created experimental plots in Jamaica Bay, NY, that contained live mussels, mussel shells, or no mussels (control). After 11 weeks, we measured sediment and plant characteristics. We also collected sediment cores for use in continuous-flow through incubations with control and ^{15}- NO_3 enriched treatments. Denitrification in marsh plots with live mussels was significantly greater compared to the other two treatment plots. Live mussels likely enhanced denitrification because their biodeposits led to an increase in organic matter in the sediment, which may have created more anaerobic conditions for denitrification and the added biodeposits may have fueled energy to denitrifying sediment bacteria. Mussel treatments did not impact cordgrass growth, possibly due to the short-time frame of our study or abundance of nitrogen in our study system. Our data suggests that ribbed mussels may be a valuable addition for salt marsh restoration projects in eutrophic ecosystems because of their contribution to nitrogen removal. Future work should focus on long-term monitoring of the effects of ribbed mussels on nitrogen removal and cordgrass biomass to determine how the mutualism impacts restoration success as sites age.