Salt Marsh Response & Resilience to Changing Conditions: Prospects for Management
Thursday, April 26, 2018 | 9:30 a.m. - 4:30 p.m.
Sheraton Portsmouth Harborside Hotel, Portsmouth, NH

SPEAKER ABSTRACTS

Salt marsh sustainability in New England: progress and remaining challenges

Dr. Cathleen Wigand, US EPA, NHEERL, ORD, Atlantic Ecology Division

Natural resource managers, conservationists, and scientists described marsh loss and degradation in many New England coastal systems at the 2014 "Effects of Sea Level Rise on Rhode Island's Salt Marshes" workshop, organized by the Narragansett Bay NERR, Save The Bay, RI CRMC, and US EPA. Workshop participants described how marsh loss and changes in vegetation and accretion patterns correlated with sea level rise and anthropogenic stressors. They agreed that partnerships throughout the New England region were needed to facilitate a better understanding of coastal marsh vulnerability, resilience, and sustainability. Development of climate adaptation and restoration methods to build coastal resilience were discussed, and an adaptive management framework incorporating reference systems was identified for implementation. I discuss the progress made in assessing, monitoring, and restoring coastal marshes in New England. I highlight the direction of the science including research addressing the underlying processes and dynamic feedbacks to sustain coastal marshes and communities. This progress has influenced the evolution of the adaptive management framework, with new emphasis on incorporating a social-ecological systems approach when defining restoration goals and selecting adaptation methods. Remaining challenges for social and ecosystem scientists are development of predictive, dynamic models to forecast coastal marsh resilience to sea level rise, storm surges, and multiple stressors, and the incorporation of socio-economic parameters into models and indicators of coastal resilience. Using ongoing restoration efforts, I describe the process for successfully building partnerships and selecting climate adaptation actions.

Coastal wetland loss in Rhode Island: 1850s-present

Dr. Elizabeth Watson, Drexel University and the Academy of Natural Sciences

Worldwide, coastal wetlands are recognized as transition zones that are critical for buffering the coast from the effects of climate change, and they are also one of the habitats most vulnerable to the effects of accelerated sea level rise. Recent research has shown that coastal wetlands in the U.S. Northeast are disappearing at an alarming rate. These wetlands largely are not being lost to coastal development, but to fragmentation and drowning. This presentation will discuss processes and rates of coastal marsh drowning in Rhode Island over the past four decades, within the context of late 19th and 20th century changes analyzed using historic maps, and present evidence that sea level rise is chiefly to blame. These results highlight the inability of current remote sensing monitoring programs (C-CAP and NWI) to identify coastal wetland drowning. Furthermore, these results demonstrate the need for an improved coastal remote sensing monitoring program as well as publicly-available on-the-ground monitoring data to guide and inform coastal climate adaptation projects.

Marsh impairment and future considerations: a Massachusetts overview

Marc Carullo, Massachusetts Office of Coastal Zone Management

Massachusetts' approximately 1,500 miles of shoreline includes over 18,000 hectares of tidal wetlands, including both micro- and mesotidal conditions and two biogeographic provinces (Virginian and Arcadian). Evidence suggests that while losses from filling have stabilized since the implementation of the Massachusetts Wetland Protection Act, significant future challenges and threats remain. Research and anecdotal evidence from the Great Marsh (northeastern MA) and Cape Cod suggests that drivers of marsh stress have caused excessive ponding, severe edge erosion, high marsh vegetation dieback, and overall marsh loss or impairment in a number of salt marsh complexes. Marsh areas perched high in the local tidal frame have experienced excessive ponding, possibly caused by a combination of legacy ditching effects, including subsidence and hydrologic impairment, and sea level rise. Edge erosion and creek widening, possibly driven by one or more stressors such as sea level rise, nutrient loading, and crab herbivory and burrowing, have significantly reduced the areal extent of marshes in numerous microtidal estuaries in Buzzards Bay and Vineyard/Nantucket Sound. Anecdotal evidence of increased erosion of fringing marsh suggests potential sea level rise and storm impacts. Tracts of salt marsh in the Great Marsh, Barnstable Great Marsh (Cape Cod), and elsewhere along the coast suggest that some areas may be more resilient than others, but the tipping points of marshes are largely unknown. Various research, monitoring, and inventory projects being conducted by federal agencies, academic and NGO institutions, and the state have raised the stakes for resource managers to develop sound tools, frameworks, and policies for increasing marsh resilience in the Commonwealth. CZM and partners are coming together to develop a blueprint for marsh resilience that aims to provide tools, strategies, and guidance on managing marshes at this critical juncture and beyond.

Maine: state of the State's salt marshes

Dr. Susan Adamowicz, US Fish and Wildlife Service, Rachel Carson National Wildlife Refuge

While known for its rocky shoreline, Maine also hosts thousands of acres of tidal marsh. Much of that acreage is held in Scarborough Marsh itself, though a slightly larger number of acres is held by the Rachel Carson National Wildlife Refuge in its 11 divisions across 50 miles of coastline. With tides ranging from 9 to over 20 feet in height, the state's salt marshes experience a meso- to macro-tide range. Salinities range from euryhaline to oligohaline. Though there are a few large salt marsh systems (Scarborough, Webhannet, Brave Boat Harbor), many of the sites are relatively small fringing marshes. Maine's salt marshes are definitely experiencing change/stress on multiple fronts. Fiddler crabs (*Uca spp.*) were first documented southern Maine in 2016. Though there have not been documented cases of *Sesarma*, *Carcinus maenas* may be having a significant effect on marsh edge stability. Certainly we have lost the sloping zone of *Spartina alterniflora* along many channels and now have unstable straight-sided banks, or collapsing banks with crevasses on the marsh platform. Large sediment deposits noted in New Hampshire in 2018 also occurred in southern Maine. We also await assessment of sediment deposition from Winter Storm Reily and the Nor'easter that followed a week later. With contributions from many state colleagues, we hope to present a brief synopsis of our marshes "by the numbers."

Prospects and uncertainties for tidal marshes in New Hampshire

Dr. David Burdick, Jackson Estuarine Laboratory, University of New Hampshire
(Moore, G., Peter, C., & Payne, A., Jackson Estuarine Laboratory, University of New Hampshire; Ballestero, T., Environmental Research Group, Department of Civil and Environmental Engineering, University of New Hampshire; Vincent, R., MIT Sea Grant College Program)

In New Hampshire as the rest of New England, tidal marshes are responding to climate change. Warmer climate allows northern limits of plants like *Iva frutescens* and *Hibiscus moscheutos* to extend northward. The rate of marsh building is chasing increased sea levels, but some marshes cannot keep up, leading to dramatic changes. Some of these high marshes are transitioning gradually to low marsh, but others exhibit hummock formation and dieback before cordgrass can colonize. Low marsh can drown as well, with significant and rapid loss of elevation (marsh collapse) seen in particularly vulnerable marshes. Although NH has been a leader in restoring tidal flow, a recent examination of culverts installed to restore tidal hydrology shows partial restrictions often remain and these may put upstream marshes in jeopardy. Loss of historic drainage paths combined with rising sea levels may lead to vegetation loss following tidal restoration. Since marshes require regular tidal flooding and ample sediment supply to build in elevation, the longer we wait to restore the tides to restricted marshes, the less likely marshes will be able to recover. Replacement of drowned marsh via migration onto uplands is a great concept, but marshes have built into large flat meadows over millennia, shores are generally much steeper, especially in NH and many shorelines have been (or will be) walled off with barriers. To hedge against widespread marsh loss in the region, it would be prudent to consider new and combined approaches, including artificial sediment nourishment and re-engineering new and existing shoreline barriers into living shorelines with new marshes that grade gently into uplands.

Long Island Sound tidal marshes in the Anthropocene
Dr. R. Scott Warren, Connecticut College Temple Professor Emeritus of Botany
(Shimon Anisfeld, Yale University, New Haven, CT)

For the last 350 years, Long Island Sound tidal marshes have been on the receiving end of multiple human activities that have affected both community structure and a range of ecological functions. There were direct losses from fill and dredge, and more subtle impacts from tidal restrictions due to transportation corridors and tidal gates. Extensive ditching for mosquito control in the 1930s continues to alter vegetation patterns and ecological functions. Nutrient loading may be accelerating low marsh loss and is unquestionably degrading estuarine water quality. Accelerating relative sea level rise (RSLR) is potentially the most problematic anthropogenic factor affecting tidal marsh systems throughout the Sound. The high marsh community is likely to be the most threatened by RSLR. High marsh accretion rates along the Sound have generally increased over the last century, though not enough to keep up with RSLR, leading to a regional elevation deficit and increased hydroperiods. However, some sites with greater sediment availability have fared better, with accretion rates exceeding 4 mm/yr. *S. patens*-dominated sites sitting higher in the tide range have thus far remained relatively stable in their vegetation cover; systems with less elevation capital, however, show a decline in high marsh graminoids and an increase in forbs, stunted *Spartina alterniflora*, bare peat, and open water, all reflecting increasing hydroperiods. Loss of high marsh habitat both through erosion and conversion to low marsh will lead to the loss of ecological function and presents a significant management challenge for individuals and institutions with stewardship responsibilities for the Sound's tidal wetlands.

No management is active management: a regional evaluation of salt marsh conservation and restoration opportunities in a changing climate
Rachel Stevens, Great Bay National Estuarine Research Reserve and NH Fish and Game Department

Traditional conservation and restoration strategies need to evolve to account for changing sea levels in the face of climate change. To assess what future conditions might look like, the Sea Level Affecting Marshes Model was run for coastal New Hampshire under multiple time and sea level rise scenarios. From this, supplemental "decision support" mapping layers were developed to help identify the most strategic restoration opportunities that will likely be sustained for the longest duration and maximize coastal resilience. An assessment of current salt marsh condition and adaptation potential, identifying areas of resilient salt marsh and pathways for migration, allows us to consider the relative benefit of restoration verses land protection when trying to maximize coastal resilience in the face of unprecedented change. A synthesis of statewide results and highlights at the community level will be presented.

A soils/landscape perspective to salt marsh migration
Dr. Mark H. Stolt, Laboratory of Pedology and Soil-Environmental Science, University of Rhode Island

Migration of New England's coastal marshes is a function of a range of factors and influences. In this study, we examined soil properties of five salt marsh settings in southern New England: back barrier, tidal river, tidal creek, cove, and open water. Our overall goal was to develop an understanding of the spatial relationships among soil properties relative to marsh setting and geographic location on the marsh. Within this context, we recorded the thickness of organic soil materials (peat) across the marsh and used these data to estimate the slope of the landscape over which the marsh was migrating as a result of sea level rise (SLR). Over 50 marshes were sampled and described along transects at a minimum of three transect points (directly adjacent to tidal water, within the marsh interior, and at the marsh-upland interface). We found that peat thickness, soil halinity, and the presence of porewater sulfide were the most important soil variables for understanding the distribution of soils across the marsh landscape. Tidal rivers had the thickest peat (average thickness >150 cm), followed by marshes in tidal creeks (130 cm), coves (120 cm), open water (60 cm), and back barriers (32 cm). In general, peat thickness decreased from the marsh area adjacent to the open water to the marsh/upland interface for the tidal river, tidal creek, and cove marshes. At the barrier marshes, peat thickness was similar regardless of the location of the marsh. Peat thickness data suggest that marshes have migrated over landscapes with slopes of 0 to 3.8% (mean =1.5%). We also used a restored marsh to examine marsh migration relative to rapid SLR. In this case, we measured the length that the marsh vegetation had advanced as the result of an increase in tidal flow into the restored marsh. Over 14 years the marsh vegetation advanced more than 60 feet from the original marsh boundary. This advance occurred on slopes as great as 2.9%.

Upland vegetation removal as a potential strategy for facilitating salt marsh migration
Dr. Kenneth B. Raposa, Narragansett Bay National Estuarine Research Reserve
(Robin LJ Weber & Daisy Durant, Narragansett Bay National Estuarine Research Reserve)

Research has linked sea level rise and crab impacts to the degradation of southern New England salt marshes. In response, adaptation projects aimed at building resilience are now underway in many marshes, but these projects are not expected to be applied extensively across the region due to financial and logistical limitations. As an alternative, researchers and managers are also focusing on ways to aid salt marsh migration to ensure continued marsh persistence. In the absence of built structures, marshes will ideally migrate landward with rising sea levels, but new research shows that some types of buffer vegetation (e.g., native forest and *Phragmites australis*) can inhibit migration of marsh species. We are therefore conducting a field experiment to determine if the removal of three distinct types of upland buffer vegetation will facilitate landward marsh migration. Our project is a before-after-control-impact experiment on Prudence Island, RI that includes the removal of ~0.2 ha tracts each of upland shrubland, red-maple forest, and *P. australis*. We will document ecological and physical changes in vegetation removal and control areas with annual monitoring of marsh plant distribution and abundance; marsh elevation; light levels; porewater chemistry; water table depth; and edaphic conditions. We are also monitoring bird use to investigate possible trade-offs in habitat value when removing existing coastal habitats to make way for marshes. This ongoing project is designed to inform future management decisions regarding the potential for, and facilitation of, salt marsh migration in response to sea level rise.

Increasing salt marsh surface elevations as an adaptation strategy- will it work in New England?
Caitlin Chaffee, RI Coastal Resources Management Council

Increasing marsh surface elevations through the application of sediment has proven a successful method for improving marsh resilience in locations such as Louisiana, however the applicability and effectiveness of the technique in the New England region has remained uncertain. The practice had been largely untested in New England as of 2016, when three thin-layer sediment deposition projects were implemented in Rhode Island. Monitoring is now underway at these sites to evaluate the effectiveness of this technique in building marsh resilience to sea level rise. Information will be presented on the Ninigret marsh enhancement project in Charlestown, RI, including design and permitting considerations, monitoring plan design, initial results and lessons learned. The project will be discussed within the broader context of marsh resilience planning and management in Rhode Island—a multi-tiered effort involving several partner organizations.

Ditch remediation pilot studies in National Wildlife Refuges of the Northeast

Dr. David Burdick, Jackson Estuarine Laboratory, University of New Hampshire
(Susan Adamowicz, Rachel Carson NWR, USFWS; Gregg Moore, Chris Peter, & Devin Batchelder, Jackson Estuarine Laboratory, University of New Hampshire; Geoff Wilson, Northeast Wetland Restoration)

We have begun to pilot new approaches to reducing the presence and effects of past ditching. Ditches drain the marsh, as intended, but also result in substantial subsidence and carbon loss, which was unintended. In New England, ditching ranges from light to severe with ditches every 10 linear meters. Our measurements suggest that dense ditching can reduce marsh elevation by 15 cm. By also destroying marsh capital, dense ditching makes these marshes more vulnerable to conversion or loss with sea level rise. Complete restoration to pre-settlement times is unlikely to be achieved – locating and re-excavating original tidal creeks would be difficult. Early attempts to reduce marsh drainage involved "ditch plugging" and led to excessive impounding and vegetation loss behind the plugs. Another approach to reduce negative impacts from ditching is called "ditch remediation." This technique involves harvesting the "salt hay" from the marsh platform, tamping it into pre-identified ditches, and securing with biodegradable twine. We began piloting this effort at Rachel Carson NWR and Parker River NWR in 2010 and show some early results. In 2014 at Parker River NWR, the treatment was applied to every other ditch for two successive years at six sites. Monitoring has shown steady declines in ditch depth, leading to recolonization by *Spartina alterniflora* after two years in some of the shallower ditches. Long-term monitoring will be required to determine if sediment accumulations reduce excessive drainage and allow rebuilding of elevation capital of the marsh bordering these artificial drainage paths. We also show pilot use of coir logs at Wertheim National Wildlife Refuge (NY) where there is not enough suitable vegetation.

Marsh response to shallow drainage or runnels

Wenley Ferguson, Save The Bay
(Watson, E., Drexel University)

Coastal wetlands in southern New England are not keeping pace with sea level rise and are experiencing an increase in interior ponding and die off areas and transitioning from vegetated to bare or open water areas. Installation of shallow channels, or runnels, is an adaptive management technique that is being used in New England marshes including Rhode Island, New Hampshire, and the Massachusetts section of the Narragansett Bay watershed. Runnels connect marsh dieback and shallow impounded water areas to existing tidal channels or ditches. By facilitating drainage, formerly impounded water areas can revegetate with early colonizing species such as *Salicornia* and eventually *Spartina alterniflora* and high marsh species dependent upon the marsh elevation. These hydrologic alterations can increase exchange of tidal waters and drainage of groundwater. Runnels can be relatively simple to install with low ground pressure equipment or by hand. Due to their shallow dimensions, runnels need to be maintained to prevent clogging from vegetation or sediment. In this presentation, data will be presented including the effect on the vegetation community, groundwater table and porewater salinities. Additionally, lessons learned from where this marsh adaptation technique has been implemented will be shared.

Long-term tidal wetland changes at Barn Island, Stonington, CT

Ron Rozsa, plant community ecologist

Many wetland scientists point to sea level rise as a primary driver of biophysical changes in tidal wetlands. A careful examination of changes over eight decades reveals that the Barn Island wetlands are responding to the drastic alteration of tidal hydrology by the construction of mosquito ditches. Ditching depresses the height of high water to the extent that the once wide and continuous levees shrink over eight decades. This causes a shift of the dominant levee grass from *Spartina patens* to *Juncus gerardii*. In 1947 Dr. Frank Egler describes a dieback of the *Juncus* belt along the upland border and this dieback returns in 1963, 1983 and 2008. In 1976 and 2017, the *Juncus* belt has been replaced by forbs

everywhere except for the one small natural marsh with levee and basin topography. Here the *Juncus* belt remains intact and therefore the dieback is the result of the altered hydrology from ditching and the tidal range fluctuations of the lunar nodal cycle. In 1976, the plant communities at several locations are mapped. Discovered in 2016 are Dr. Niering's field notes describing four new transects on the Palmer Neck section. These transects were resurveyed in 2017 and 1976-2017 data set allow for a detailed description of vegetation change in the last 40 years. Not all changes are slow as evident at and adjacent to the 2008 dieback at Brucker Marsh. In several locations, the marsh is reverting to the equilibrium levee and basin topography.

Overview of salt marsh losses on Cape Cod, with special emphasis on crab-driven vegetation losses and consequences
Dr. Stephen Smith, National Park Service, Cape Cod National Seashore

Research over the last 10+ years has revealed that salt marsh plants on Cape Cod are being consumed and eventually killed from intense, continuous grazing by a species of nocturnal, herbivorous crab—*Sesarma reticulatum Say* (Purple Marsh Crab). Losses within the low-marsh zone, dominated by smooth cordgrass (*Spartina alterniflora*), have been particularly severe, however, vegetation losses have also occurred in the high marsh, which is comprised of mainly saltmeadow cordgrass (*Spartina patens*). In contrast to the low marsh, high marsh losses consistently occur along the seaward-most edge of this zone, suggesting a link with flooding frequency and, therefore, sea level rise. Plants growing there also seem to have a much-reduced capacity to recover from *Sesarma* grazing. Throughout marshes, the creation of open dieback areas also seems to have facilitated invasions of mud fiddler crabs (*Uca pugnax*). Manipulative field experiments indicate that these crabs may be attracted to open, unvegetated habitats with softer substrates. This is important since these crabs contribute to elevated suspended sediment loads in the water column through bioturbation (burrowing and feeding) and this leads to erosion and elevation lowering. The loss of vegetation through *S. reticulatum* herbivory has resulted in a cascading series of events, with substantial consequences for vegetation recovery and overall marsh resilience.

Multimetric indices for integrated assessments of salt marsh integrity
Dr. Hilary A. Neckles, USGS Patuxent Wildlife Research Center

Tools for assessing and communicating salt marsh condition are essential to guide decisions aimed at maintaining, enhancing, or restoring ecosystem integrity and services. Ecosystem monitoring is recognized as a critical component of environmental decision-making, and integration of monitoring data into a multimetric index (MMI) offers a way to detect changes in ecosystem condition and report on overall system health. Ultimately, the usefulness of the index depends both on how well it reflects conservation goals and its sensitivity to change. The U.S. Department of the Interior protects extensive salt marsh acreage within northeastern National Wildlife Refuges and National Parks, and MMIs have been developed for salt marsh assessments to meet specific conservation mandates. The National Wildlife Refuge MMI is based on a structured decision-making framework to optimize management decisions. Monitoring variables were selected to target management objectives, and linear value modeling was used to aggregate multiple attributes into a single performance score representing total management benefit. The National Park MMI was generated using an algorithmic approach for selecting the combination of metrics most strongly correlated with human disturbance. In each case, the MMI provides an efficient, transparent approach to incorporate monitoring data into conservation practice.

Drone applications for estuarine monitoring and assessment
Bob Hartzel, CLM, CPESC, Principal, Comprehensive Environmental Inc.

The use of unmanned aerial systems (UAS, also known as drones) in environmental science and engineering is expanding rapidly as the accuracy of these tools increases and costs go down. In just a few hours, drones can provide high-resolution imagery for estuarine areas that would take days or weeks to assess on foot. This presentation will provide an overview of how drones can be put to work for estuarine investigations, including: Ecological assessments and mapping (salt marsh vegetation communities, seagrass beds, invasive species, etc.); Infrastructure inspections, including stormwater infrastructure and culverts; Shoreline/coastal erosion assessments and mapping; Shoreline structure inventories (docks/piers, Chapter 91 inventories, etc.); Topographic survey to support BMP designs; and High-resolution imagery (photo-mosaic and video) to document baseline conditions for climate resilience planning.

Appropriate use of numerical models for simulating salt marsh geomorphic evolution
Dr. Neil K. Ganju, U.S. Geological Survey, Woods Hole Coastal and Marine Science Center

Salt marshes respond to numerous forces, including sea level rise, sediment transport, and biogeochemical feedbacks. Identifying future states of salt marshes is a priority for coastal managers, and numerical models are used to predict future distribution under sea level rise scenarios. However, numerical model development for salt marshes has evolved rapidly, and in many cases these models neglect sediment transport processes, robust quantification of uncertainty, and proper skill assessment. In contrast, nearshore and estuarine physical scientists have developed numerical models to predict estuarine geomorphic response to sea level rise, tidal processes, and sediment transport, with limited success, despite adhering to comparatively rigorous assessment. The shortcomings, sources of uncertainty, and assessment standards of geomorphic models are well documented within the estuarine modeling community; however, the uncertainty surrounding salt marsh biogeomorphic processes likely results in relatively greater uncertainty. Nonetheless, we recognize the value of deterministic numerical models. They can be used to explore complex feedbacks between hydrodynamics, waves, sediment transport, and vegetation to develop a mechanistic understanding of what determines salt marsh geomorphic evolution. For example, we can investigate the fate of laterally eroded marsh sediments and examine the implications for landward migration of the seaward edge. With this application we aim to develop an increased understanding of coastal resilience through targeted scenarios (e.g., do living shorelines hamper sediment transport from the mudflat to the marsh levee and decrease vertical accretion?)