GAINING GROUND: DEFINING PRIORITY RESEARCH FOR RESILIENT SALT MARSHES
March 2022

Summary

The Salt Marsh Working Group (SMWG) has identified three intersecting salt marsh research priorities (Figure 1) to support collaboration and research that promotes resilient salt marsh habitat now and into the future. The SMWG is a network of state, federal, nonprofit, and university researchers, and coastal resource managers from Massachusetts, Maine, New Hampshire, and Rhode Island. Primary goals of the SMWG include identifying research gaps and priorities to support collaboration on critical research and ultimately increase the overall resilience of salt marshes. The purpose of this summary document is to communicate SMWG research priorities, developed over a year-long, consensus-based process, and to inspire coordinated, transdisciplinary discussion and action around the complex and intersecting challenges of salt marsh management and resilience.

FIGURE 1. THE SALT MARSH WORKING GROUP HAS DEFINED THREE INTERSECTING PRIORITY RESEARCH NEEDS TO ADVANCE REGIONAL SALT MARSH RESILIENCE

Background & Need

Salt marshes are a vital and valuable natural resource. They provide critical nursery, breeding, and foraging habitat for multiple species and are one of the most productive ecosystems on earth (Taylor et al. 2021). In addition, salt marshes provide multiple socioeconomic benefits including recreational and cultural uses, improved water quality, carbon sequestration, fisheries and aquaculture, and protection for the built environment (Drake et al. 2015, Rendón et al. 2019). Occupying the space between the ocean and land, they serve as a buffer, filtering contaminants from runoff, absorbing flood water, and preventing structural damage by reducing wave energy and erosion (Costanza et al. 2008, Leonardi et al. 2018, Rezaie et al. 2020).

Climate change poses a serious threat to salt marshes, resulting in potential cascading impacts to ecosystem functions and the associated loss of critical ecosystem services (Colombano et al. 2021, Craft et al. 2008, Morris et al. 2002). Sea level is rising, and will continue to rise, in addition to predicted increases in air and water temperature, precipitation, and other changes (EOEEA 2018, Sweet et al. 2022). There is widespread concern and urgency across disciplines to understand marsh processes in the context of a changing climate, identify vulnerabilities, prioritize restoration actions, develop predictions and projections of future impacts, and support resiliency of this critical habitat now, while there is still time to effectively act.

Marshes are complex systems; local environmental conditions, landscape position, and tidal range play a role in formation and function through time as do anthropogenic stressors and modifications (Fagherazzi

et al. 2013, Redfield 1972, Ziegler et al. 2021). The availability of mineral sediments and accumulation of organic matter is a key factor for salt marsh elevation building and persistence (Cahoon et al. 2021, FitzGerald et al. 2020, Weston 2014). If sea level rises beyond the capacity for a salt marsh to maintain or gain elevation through natural processes, the equilibrium of the system will reach a tipping point, hastening degradation and resulting in eventual conversion from a vegetated marsh system to mudflat (Fitzgerald and Hughes 2019, Ganju et al. 2020). While some marshes may migrate inland in response to sea level rise, in many coastal areas built structures, forested land, invasive species (e.g., *Phragmites australis*), and steep topography can create barriers that prevent or slow this process (Fagherazzi et al. 2019, Field et al. 2016, Smith 2013). Legacy activities for the purposes of mosquito control, farming of salt hay, and infrastructure (tidal restrictions) can exacerbate the impact of rising sea level by altering natural hydrology, contributing to lowering of marsh platform elevation (subsidence), and increasing water retention on the marsh surface (Adamowicz et al. 2020, Elsey-Quirk and Adamowicz 2015, Burdick et al. 2020, Kennish 2001, Vincent et al. 2013). Marsh areas upstream of a structure that is restricting tidal flow can become less saline, supporting the invasion of the common reed *P. australis*, and with less opportunity to receive sediments from tidal inundation, may be lower in elevation and thus more vulnerable as sea levels rise (Bowron et al. 2009, Burdick et al. 1997, Saltonstall et al. 2005). Excess nutrient inputs to marshes may also accelerate losses through vegetation changes and degradation of the marsh platform (Deegan et al. 2012, Krause et al. 2020).

Salt Marsh Working Group

Given the complexity of marsh systems, and the significant threat of climate change, a collaborative, transdisciplinary approach is needed to address data gaps, improve understanding of current and future drivers of change, and inform effective management strategies (Waltham et al. 2021. Wigand et al. 2017). In recognition of this need, the Salt Marsh Working Group (SMWG) was formed in 2018 by the Massachusetts Office of Coastal Zone Management and the University of Massachusetts Amherst Gloucester Marine Station. What began as a grassroots effort with a few key members has grown to comprise a network of over 80 researchers and coastal managers from state, federal, nonprofit and university entities across Massachusetts, Maine, New Hampshire, and Rhode Island. The SMWG meets quarterly to advance the following collective goals:

1. Facilitate a coordinated forum between scientists and managers to offer open communication across organizations and regions
2. Share best practices to assess and monitor salt marshes and restoration efforts
3. Identify research gaps and priorities
4. Design collaborative approaches to support critical research that increases the resilience of salt marsh systems

The SMWG is one of five working groups of the Massachusetts Ecosystem Climate Adaptation Network (Mass ECAN). Mass ECAN is a community of practice for climate adaptation practitioners and researchers interested in ecosystem resilience and natural resource conservation in Massachusetts. See Appendix 1 for a list of SMWG participants at the time of this publication.

Process to Identify Research Priorities

Throughout 2021, the SMWG completed a process to identify salt marsh data gaps and research needs. First, through a series of polling exercises, the SMWG selected five priority research areas:

- Sea Level Rise: Impacts to physical structure, ecosystem shifts, functional changes, modeling, management, adaptation
- Hydrology: Historical impacts, tidal restrictions, panne and pool expansion, ditching, restoration, modeling
- Marsh Migration: Processes, modeling, land management, facilitation, conservation
- Sediment Supply: Sediment availability, elevation processes, horizontal/vertical accretion and loss, dredging
- Nutrients: Impacts, associated stressors (e.g., land use), management

Second, subgroups were formed for each of the priority research areas comprised of volunteers from the broader SMWG (45 subgroup participants total; 7-10 per subgroup), creating teams with a broad range of expertise and perspectives (note subgroup participants in Appendix 1). Using an agreed-upon, standardized process, subgroups identified near-term (within the next five years) research needs for their respective priority research areas. Upon completion, the five subgroup leads were convened to discuss overlap and connections among their respective goals. Ultimately, through this collaborative effort, three high level salt marsh research priorities were identified to comprehensively reflect subgroup-identified needs across the five areas.

Priority Research Needs Identified to Advance Salt Marsh Resilience

The three intersecting salt marsh research priorities are not listed in order of importance as they are intended to support and build upon each other (Figure 1). Specific research and data needs to address subgroup-identified gaps are listed for each priority.

1. IMPROVE UNDERSTANDING OF ECOLOGICAL AND PHYSICAL PROCESSES WITHIN SALT MARSH SYSTEMS, ESTABLISH BASELINES: This priority emphasizes the need for research and data to better understand salt marsh ecosystems in the present day, and how past alterations, including anthropogenic stressors, influence current functioning and condition. This need also addresses a priority to establish baseline conditions in marshes, the application of standardized methods, and synthesis of existing datasets to increase research communication and efficient coordination.

RESEARCH AND DATA NEEDS
- Research to understand temporal and spatial variability in natural sediment supply and the factors that control this variability (e.g., geomorphic, geologic, and oceanic)
- Accurate Digital Terrain Models (DTMs) for salt marshes
- A centralized catalog of geospatial and other data products
- Inventories of local nitrogen inputs to salt marshes
- A comprehensive assessment of salt marsh changes over the past century, including analysis of historic marsh migration rates
- Models and/or data on regional/local sediment availability, supply, and distribution for New England marshes
- Better understanding of relationships between bordering habitat type and marsh migration rates
- Development of standard methods to broadly assess marsh condition
- Synthesis of existing datasets on a local and regional scale to identify gaps, support decision making, and inform effective management measures and actions

2. IDENTIFY VULNERABLE MARSHES; COLLECT OR DEVELOP DATA TO TRACK ECOSYSTEM CHANGES AND SUPPORT PREDICTIVE MODELS: This priority reflects the need to understand how marshes will respond to changes in the future (or how they have responded in the recent past). Given the serious challenge of climate change and sea level rise, examining which factors increase the vulnerability and/or resiliency of marshes and generating data to support models and metrics of future change is critical.

RESEARCH AND DATA NEEDS

- Identification of factors correlated with salt marsh resiliency or vulnerability (e.g., landscape position, tidal range/elevation capital, sediment supply, unvegetated to vegetated ratios, anthropogenic stressors, primary productivity, below-ground biomass, geography)
- Improved predictive models of marsh migration and changes to marsh platform elevation and habitat; spatially explicit datasets for sensitive parameters and model validation
- Understanding effects on processes and functions such as carbon sequestration and biomass accumulation; analyses of the impacts of ecosystem changes to microbes, algae, invertebrates, fish, birds, and food webs
- Modeling to support predictions of changing hydrology and sediment supply with rising sea levels
- Analyses to understand the compound effects of sea level rise, groundwater rise, and precipitation on marsh migration potential
- Development of standard methods to identify vulnerable and resilient marshes
- Coordinated monitoring programs to track changes over the long term

3. INFORM RESTORATION AND ADAPTATION ACTIONS TO SUSTAIN SALT MARSHES AND THEIR ASSOCIATED FUNCTIONS AND SERVICES: This priority addresses the need to generate, review, and synthesize data to support best practices and effective restoration and adaptation actions. While this is a standalone priority, research completed as part of the previous two priorities will also generate results to support this need. Supporting marsh resilience is a foundational SMWG goal. Research needs under this priority are centered on both novel and traditional restoration techniques.

RESEARCH AND DATA NEEDS

- Research to understand the effectiveness of restoration and adaptation approaches to support salt marsh resilience and ecosystem function, including but not limited to sediment-based strategies and restoration of natural hydrology
- Assessment of what level of research and monitoring effort is required to effectively track results of restoration and adaptation strategies, inform adaptive management, support permitting, and develop best practices
- Better understanding of site level factor variability (existing soil chemistry, presence of anthropogenic alterations, physical factors, etc.) and how these intersect with restoration and adaptation outcomes
- Need for comprehensive ecosystem services valuation to provide context for potential losses
- Analysis of socio-economic drivers as a basis for marsh migration area preservation
- Evaluation of trade-offs between potential actions and strategies versus a "do nothing" approach given site specific factors

Next Steps

The Salt Marsh Working Group is building regional collaborative capacity. It is our shared belief that collaboration is necessary to protect and restore salt marshes and the vital services they provide now and into the future. Our vision is to advance a solid grounding of science to support priority actions that result in collective, positive impact. We intend to pursue these goals through the following actions:

- Communicate priority research needs through dedicated meetings and conversations with stakeholders, public presentations, and publications
- Develop a five-year strategic research agenda centered on the above priorities to coordinate research and fundraising
- Evaluate action on our research priorities annually and examine emerging priorities and factors of salt marsh resiliency
- Identify barriers to research and application of resilience strategies and provide opportunity to address these barriers through information exchange and discussion
- Continue to serve as a network and resource for practitioners, with regular meetings and opportunities to present research, vet ideas, and broaden membership across disciplines
- Inform, learn from, and collaborate with other efforts occurring in the region

The purpose of this document is to both communicate the SMWG research priorities and to inspire coordinated, transdisciplinary discussion and action around the complex and intersecting challenges of salt marsh management and resilience. Together we will leverage the growing expertise of the SMWG to not only advance critical research but also to facilitate partnerships that explore and support innovative research and management approaches and funding strategies.

Closing

When the very first survey questions were posed to the SMWG shortly after formation in 2018, unanimously, "resilience" was the top goal that respondents wished to achieve in their near-term work on salt marshes. We hope that this document will inspire members of the SMWG and others who focus on salt marshes to pursue actions to support this critical ecosystem for generations to come. Over 50 years ago John and Mildred Teal expressed in Life and Death of the Salt Marsh "*We have only begun to understand the interrelationship of the animals and plants that make the salt marshes and associated estuaries one of the most productive on earth*." (Teal and Teal 1976). While knowledge of marshes has grown by leaps and bounds since then, there is still much work to do and emerging threats to address. We look forward to tracking progress made by all the dedicated scientists, managers, and practitioners that contributed to this document and have made salt marshes an integral part of their life and work.

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Appendix 1

Salt Marsh Working Group Participant List*

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*Defined as attending meetings during Oct 2021-Feb 2022 and/or participated in the development of the research needs
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