A framework for prioritizing salt marsh restoration and conservation activities in Rhode Island

An addendum to the Rhode Island coastal wetland restoration strategy (Kutcher et al. 2018)
Prepared for the Rhode Island Department of Environmental Management

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1. Introduction

This salt marsh restoration and conservation prioritization framework (hereafter, Prioritization Framework) is a guidance document for the Rhode Island Salt Marsh Restoration, Assessment, and Monitoring Program (hereafter, RAMP). It is written as an addendum to the Rhode Island Coastal Wetland Restoration Strategy (hereafter, Restoration Strategy; Kutcher et al. 2018) to further guide the systematic prioritization of restoration and conservation actions for state agencies and their partners. It is recommended that this document is viewed and applied in the context of the Restoration Strategy, and is used in concert with other information relevant to marsh condition, functions, and values.

There is considerable public and political interest in salt marsh restoration and conservation in Rhode Island, but finite resources to carry out projects. In recent decades, federal, state, and municipal agencies have partnered together with NGO, academic, and private institutions to promote and conduct ecological interventions to conserve and restore salt marshes, with the goal of preserving and improving their ability to sustain the ecosystem functions and services they have historically provided. In the past, marsh restoration typically targeted anthropogenic impacts that were site-specific and thus were documented and addressed on a site-by-site basis. For example, hydrological restrictions such as dams or roads could be identified and removed or modified, or fill could be excavated. These were often ***stakeholder-driven*** projects, addressing the concerns of a party with interest in a specific marsh.

More recently, salt marsh assessment efforts, such as the RI Salt Marsh Assessment (Save The Bay, Ekberg et al. 2017), sentinel site monitoring (Narragansett Bay National Estuarine Research Reserve, Raposa et al. 2017a), MarshRAM (RI Natural History Survey, Kutcher 2019), and a host of individual research projects (e.g., Watson et al. 2017a), have provided a better understanding of wide-spread marsh impacts due to accelerating sea-level rise and its interaction with other stressors. Marsh degradation and loss due to sea level rise are occurring statewide at a rapid pace, which requires a broad-scale, coordinated response. The Restoration Strategy recommends a ***systematic***, state-led approach to restoration that focuses on preserving statewide and regional at-risk ecosystem functions and services across all salt marshes in the state. Due to the finite resources that can be allocated to salt marsh interventions, state managers and their restoration partners need to ***prioritize*** salt marsh restoration projects that have the greatest ecological, social, and economic benefits. Stakeholder-driven restoration projects can also benefit from being considered in a broader, systematic context. Managers need a consistent process to efficiently compare sites across a diverse set of attributes and conditions to ensure management decisions have a solid basis in the best available scientific information.

The Restoration Strategy outlines restoration practices and tools currently in use in Rhode Island, identifies salt-marsh critical ecosystem functions and services, recommends restoration prioritization criteria, and recommends the development of standardized methods and explicit programming to support salt marsh intervention projects. But while several intervention practices have been identified, tested, and implemented, restoration practitioners need further guidance on ***when and where to use which practices***. A three-tiered monitoring and assessment strategy and associated tools have recently been developed to provide standardized information about marsh condition at multiple scales (Raposa et al. 2016a). As a result, targeted information is increasingly more available to inform management decision-making.

This Prioritization Framework aims to provide guidance for decision-making related to salt marsh conservation, restoration, enhancement, and other ecological intervention practices. The Framework describes various decision-support tools, the products of which should be considered alongside other tools and information. No single tool is intended to be a stand-alone determinant of marsh restoration or migration facilitation priority for funding or other resources.

2. Salt Marsh Restoration and Migration Facilitation

2.1 Sea-level Rise and Restoration

Considering recent sea-level rise predictions, salt marshes in Rhode Island are in existential crisis. CRMC (2017) considers NOAA sea-level rise scenarios for developing coastal resilience policy, focusing on the upper probability values (+1 SD) of the *High*-scenario curve, which predict a 2.96-m gain above lower mean sea level by 2100 (available: https://coast.noaa.gov/digitalcoast/tools/curve.html). Under this *High* scenario, which equates to an increase of 35.7 mm/y averaged evenly across years, it is highly unlikely that natural marsh accretion will keep pace to sustain vegetated marsh area. Eco-geomorphic models have predicted that salt marshes with low sediment loading, such as those in Rhode Island (Carey et al. 2017), would destabilize at sea-level rise rates above ~5 or 6 mm/y (Kirwan et al. 2010; Morris et al. 2002, respectively). Even NOAA's *Low* sea-level rise scenario (upper probability values) predicts 0.65m by 2100 or 7.8 mm/y averaged evenly across years, exceeding that critical rate. In empirical trials using controlled field mesocosms, Watson et al. (2017b) found that in Rhode Island, the highest yearly biomass productivity was consistently associated with artificially-raised soil elevations, indicating that, at current rates of sea-level rise, inundation periods were already above-optimal for biomass production, resulting in widespread marsh instability. High-marsh accretion rates in Rhode Island remained nearly constant between 1983 and 2011 (2.4 to 2.7 mm/y), even as the rate of sea-level rise rose nearly 60% (2.6 mm/y from 1931 to 1983 versus 4.1 mm/y from 1983 to 2011, Bricker-Urso et al. 1989, Carey et al. 2017). And, over the last decade, net high-marsh elevation gain was estimated to be only 1.4 mm/y in unrestored marshes, lagging well behind sea-level rise, estimated at 5.3 mm/y (Raposa et al. 2017b), and indicating inundation stress and resulting underperformance of the accretion process. These findings suggest that although discrete, in-marsh interventions may provide short-term benefits in Rhode Island, they are unlikely to re-establish or stimulate accretion rates adequate to sustain long-term marsh health under predicted rates of sea-level rise.

In-marsh interventions may, however, act as interim measures to prolong marsh functions and values while longer-term interventions are planned and enacted. For example, tidal restorations have shown potential to restore some functionality and habitat value for fish and stimulate native plant growth (Roman et al. 2002, Roman 2012). Because sea-level rise is predicted to follow an exponential curve, rather than a linear trend, in-marsh interventions may provide important suitable habitat and functionality to salt marshes for the coming years during-which sea-level rise is lower than the linear average of the long-term predictions. For example, the upper probability ranges of NOAA's sea-level rise curves predict sea-level rise rates below 6 mm/y through ~2035 for the *High* curve and through ~2070 for the *Low* curve, suggesting that interventions promoting optimal vertical accretion (e.g., optimal elevations and inundation durations), including those that may require periodic maintenance, could sustain marshes to a point within those dates. This period, perhaps several decades, may be critical for sustaining populations of marsh-dependent species and other important functions during the time needed to enact longer-term solutions.

2.2 Marsh Migration Facilitation

Long-term marsh sustainability has always depended on the capacity for marsh platform elevations to remain stable in relation to the tide frame, either by vertical accretion or upslope landward migration (Redfield 1972, Roman et al. 2000). Because vertical accretion will not likely be sufficient to sustain long-term marsh stability in Rhode Island (Sec. 2.1), a management plan that includes landward migration may be the only viable long-term solution for salt marsh conservation in some locations (Donnelly and Bertness 2001, CRMC 2015, Watson et al. 2017b). To accommodate marsh migration at a meaningful scale, the state, municipalities, and their partners will need to conserve appropriate coastal properties on a statewide basis, which will require addressing a number of socio-economic, political, and logistical challenges.

Broadly, salt marsh managers will need to incorporate salt marsh conservation into state and municipal environmental and planning policies. In 2015, Rhode Island established the Executive Climate Change Coordinating Council (EC4) to address the challenges of climate change. The Council focuses on strategies to minimize societal harm from hazards associated with climate change, including coastal inundation. As thousands of homes, businesses, roads, farms, and utilities also lie in the zone of coastal climate impact, marsh managers will need to make a strong case around the socio-economic and environmental values of salt marsh conservation, among these other primary human concerns, to secure support for restoration efforts and protection. The public needs to be made aware of the societal benefits of salt marshes, such as protection of property from storms, support of commercially and recreationally important fish species, carbon storage, and filtration and uptake of pollution. Rhode Island's statewide climate resilience strategy, *Resilient Rhody* (http://climatechange.ri.gov, 2018), identifies the conservation of coastal wetlands as a key goal for climate resilience in Rhode Island, a tangible example of incorporating salt marsh conservation into climate response policy.

Coastal land is socially and economically valuable for private landowners and as taxable property for municipalities; this poses a unique challenge for marsh migration facilitation compared with in-marsh interventions, which typically occur on properties that are publicly owned or protected from development. Conservation of undeveloped coastal uplands for marsh migration is expensive, and there may be strong private, public, and political resistance to retreating from developed coastal properties versus armoring and building up their elevations as sea level rises. In this socio-economic context, marsh migration will not likely be embraced as a *target* of planned retreat; however, it could be incorporated as an *ancillary benefit* of a necessary process of carefully-planned retreat that considers the range of challenges and opportunities that will arise as coastal properties across the state are simultaneously confronted with regular coastal flooding.

In order for migration to be conceptualized and accepted in this context, the public and decision-makers will need to know where marsh migration will happen, how it will affect public and private lands, structures, and infrastructure, and what it will look like. Salt marshes migrate best across specific elevations, slopes, soils, and vegetation types, and lands may need to be physically modified to facilitate efficient and successful migration. Geospatial models have used elevation and estimations of sea-level rise and marsh accretion rates to predict marsh migration and new growth statewide (CRMC 2015); and recent studies have shed light on the influence of slope, soils, and existing vegetation on marsh migration (Stolt 2018; K. Raposa et al., in prep.). Salt marsh scientists and managers need to apply this knowledge using tools that can efficiently provide the necessary information to evaluate and prioritize salt marshes and adjacent coastal properties to determine where and how salt marsh migration will occur. They can then deliver this information to state planners to inform statewide policy. This Prioritization Framework lays out a systematic process for meeting those ends.

3. Prioritization Framework

3.1 The Salt Marsh Restoration, Assessment, and Monitoring Program (RAMP)

The Salt Marsh Restoration Monitoring and Assessment Program (RAMP) was conceived to coordinate statewide conservation of salt marshes using information gained through applied science, including ecological monitoring and assessment and sociological research. The significance and scale of the threats to salt marshes require a state-sanctioned coordinated response that engages a broad group of partners and stakeholders and employs a diversity of resources. The Restoration Strategy recommends for the RAMP to be housed across multiple state, federal, and other entities through strategic assignment of RAMP duties to pertinent staff. The RAMP has already been functioning through opportune multi-organization cooperation, particularly related to large-scale restoration projects and assessment efforts (see Appendix 1 for a brief description of primary RAMP partners). In some cases, cooperating entities have begun to specifically allocate a proportion of staff time to the RAMP in staff job descriptions, endorsing the RAMP without increasing or significantly changing staff responsibilities; in other cases, partners are engaged on a voluntary and ad hoc basis (e.g., providing technical or field support on a specific issues). As public interest continues to grow in the RAMP's work, the program could be further formalized by the state environmental agencies, and expanded to include other coastal and watershed conservation activities (e.g. eelgrass restoration, stream continuity). In the absence of a formal program, state partners will continue to work together to organize salt marsh conservation activities in Rhode Island and operationalize the guidance and recommendations in this Prioritization Framework.

3.2 Rhode Island Coastal Wetland Restoration Strategy

The Restoration Strategy (Kutcher et al. 2018) was developed through the participation of 24 stakeholders representing 15 federal, state, academic, private, and NGO agencies and organizations. The Restoration Strategy's vision is that Rhode Island's "coastal wetlands perpetually retain the critical functions and ecosystem services they have provided historically". The goals of the Restoration Strategy are to (1) minimize the loss of salt marsh area and (2) preserve critical marsh functions and services across the state. The Restoration Strategy further identifies objectives, including an objective to prioritize coastal wetlands for restoration and migration potential, and details the following eight criteria for statewide coastal wetland project prioritization.

1. Target restoration of high-priority ecosystem functions and services
    a. Protection of coastal property
    b. Pollution filtration and nutrient uptake
    c. Support marsh-dependent animal and plant species
    d. Support commercial and recreational fish and shellfish
2. Target marsh migration facilitation interventions
3. Target mitigation of stressors that diminish condition or increase vulnerability
4. Consider vulnerability to sea-level rise
5. Require project sustainability and resiliency
6. Consider project achievability and potential for adverse impacts
7. Evaluate costs vs. benefits
8. Consider social benefits

The Restoration Strategy additionally identifies 11 intervention practices and their typical applications, in relation to the human disturbances they are designed to remediate. The Strategy distinguishes between intervention practices that are aimed at mitigating causes of stress and those aimed at only addressing symptoms of stress, and endorses prioritization of practices aimed at mitigating causes (prioritization criterion 3 above). Although the Restoration Strategy outlines general guidance on when to use which practices, more specific and nuanced guidance is needed, informed by data on diverse attributes and conditions collected across salt marshes being considered for intervention. Tools have recently been developed to address this need directly.

4. Supporting Tools and their Applications

Decision-making for salt marsh conservation and restoration will benefit from existing and new decision processes, and information gathered with newly-available tools described in the recent Salt Marsh Monitoring and Assessment Strategy (Raposa et al. 2016a). The Monitoring and Assessment Strategy details a suite of monitoring and assessment methods that can support restoration assessment and prioritization. The information collected by these methods can be applied to secondary decision-support tools, such as the decision processes and matrix described below.

4.1 The Salt Marsh Rapid Assessment Method (MarshRAM)

The salt marsh rapid assessment method, MarshRAM, was specifically designed to support the prioritization of salt marsh restoration, conservation, and other management practices (Kutcher 2019). MarshRAM provides site-level information on salt marsh setting and type, habitat diversity, perceived functions and ecosystem services, bird use, surrounding landscape and buffer condition, human disturbances, invasive species, marsh platform integrity, and landward migration potential (Appendix 2). The MarshRAM's *Index of Marsh Integrity* (IMI) uses the relative cover of marsh community types to categorize salt marshes by integrity and vulnerability. Ten additional metrics rank the intensity of human disturbances at the site level and can generate an index to characterize cumulative disturbances (*Wetland Disturbance* Score). The *Ecosystem Functions and Services* metric aggregates the perceived importance of 12 commonly-cited functions and values of salt marshes. These indices and metrics provide managers with information on the setting, relative value, and condition of marshes, and can suggest what interventions may be most appropriate to address the disturbances and degradation at each marsh. MarshRAM data collected across multiple marshes can help managers to compare marshes to gain perspective on these attributes and rank them for condition, vulnerability, and intervention priority.

MarshRAM's three marsh migration metrics estimate (1) the physical, biological, and socioeconomic resistance to salt marsh migration of land within 60m of the marsh edge (*Migration Potential*), (2) the area (Ha) of land where that resistance is considered low (*Migration Area*), and (3) how that area of low-resistance land relates to the size of the current vegetated marsh surface (*Replacement Ratio*). *Replacement Ratio* offers site-specific information on marsh sustainability by predicting what proportion of the marsh will persist with minimal intervention, whereas *Migration Area* estimates the marsh's contribution to broader regional marsh sustainability under the scenario of accelerating sea-level rise. Both concepts are important to salt marsh conservation and allow managers to weigh the interactive prospects of migration and restoration at individual sites and across sites in a region.

MarshRAM has already been conducted at 31 salt marshes in Rhode Island (Appendix 3) and funding has been secured to conduct MarshRAM at an additional 20 sites. Using MarshRAM data sorted by IMI (primarily) and the other informative metrics (Figure 1, Table 1), restoration sites and projects can be selected from among these salt marshes to address specific restoration goals and priorities, such as sites providing priority functions and services, marshes with migration potential, and projects targeting stressors that diminish condition or increase vulnerability. And this growing, sorted list of marshes can act as a *reference gradient* for other prospective projects. Salt marshes not already assessed and listed, can be assessed with MarshRAM and compared with marshes already on the list (i.e., the reference gradient) to evaluate its integrity, disturbances, and attributes relative to other marshes in the state.

4.1.1 MarshRAM Application to Systematic Prioritization

MarshRAM can serve as a tool to inform ***systematic prioritization*** of salt marshes across Rhode Island. The Rhode Island Natural History Survey (RINHS) and the Narragansett Bay National Estuarine Research Reserve (NBNERR) have developed a prioritization-guidance matrix for systematic salt marsh conservation, based on MarshRAM (Table 2). It applies MarshRAM data to prioritize marshes by migration opportunity and restoration need. Specifically, the matrix (Table 2) applies data from Table 1 to produce a ***Priority List*** (Table 3) that ranks salt marshes by priority for migration facilitation and restoration, and shows the intensity of disturbances documented at each site. The matrix rankings are driven by MarshRAM metrics scores for platform integrity (IMI value), perceived aggregate *Ecosystem Functions and Services* (i.e., *Value*, decision points are detailed in Appendix 4), and migration potential (*Migration Area*, *Replacement Ratio*). The rankings consider the interaction between migration potential and restoration need, where restoration need is offset by higher migration potential (lower resistance). The matrix rank assignments are further detailed in Appendix 5. Guidance on restoration practices that may be applied to address the various human disturbances is offered in Appendix 6.

As more salt marshes are assessed using MarshRAM, or as marshes are restored or conserved, the matrix can be updated to include the full suite of current intervention candidates. Additionally, as new data become available, such as high-resolution migration data (Sec. 4.3), the best-available information could be incorporated into the matrix to refine the model and update the rankings. We recommend building out the number of salt marshes assessed using MarshRAM by conducting additional state-funded field work and by training stakeholders in MarshRAM assessment techniques.

This process and resulting *Priority List* (Table 3) provide ***guidance*** to help salt marsh managers select priority projects for limited available funding. The process aggregates and organizes numerous factors that contribute to the prioritization decision process, but is not intended to serve as a decision in itself. Other factors outside of data in the MarshRAM-based guidance will also need to be considered before any prioritization decisions are made; these may include information from other tools (below), ownership, location, size, project logistics, stakeholder interest, whether priority salt-marsh functions and values are addressed, and restoration cost versus benefit. Many of these are already incorporated in CRMC's Coastal and Estuarine Habitat Restoration Trust Fund Worksheet (Sec 4.2).

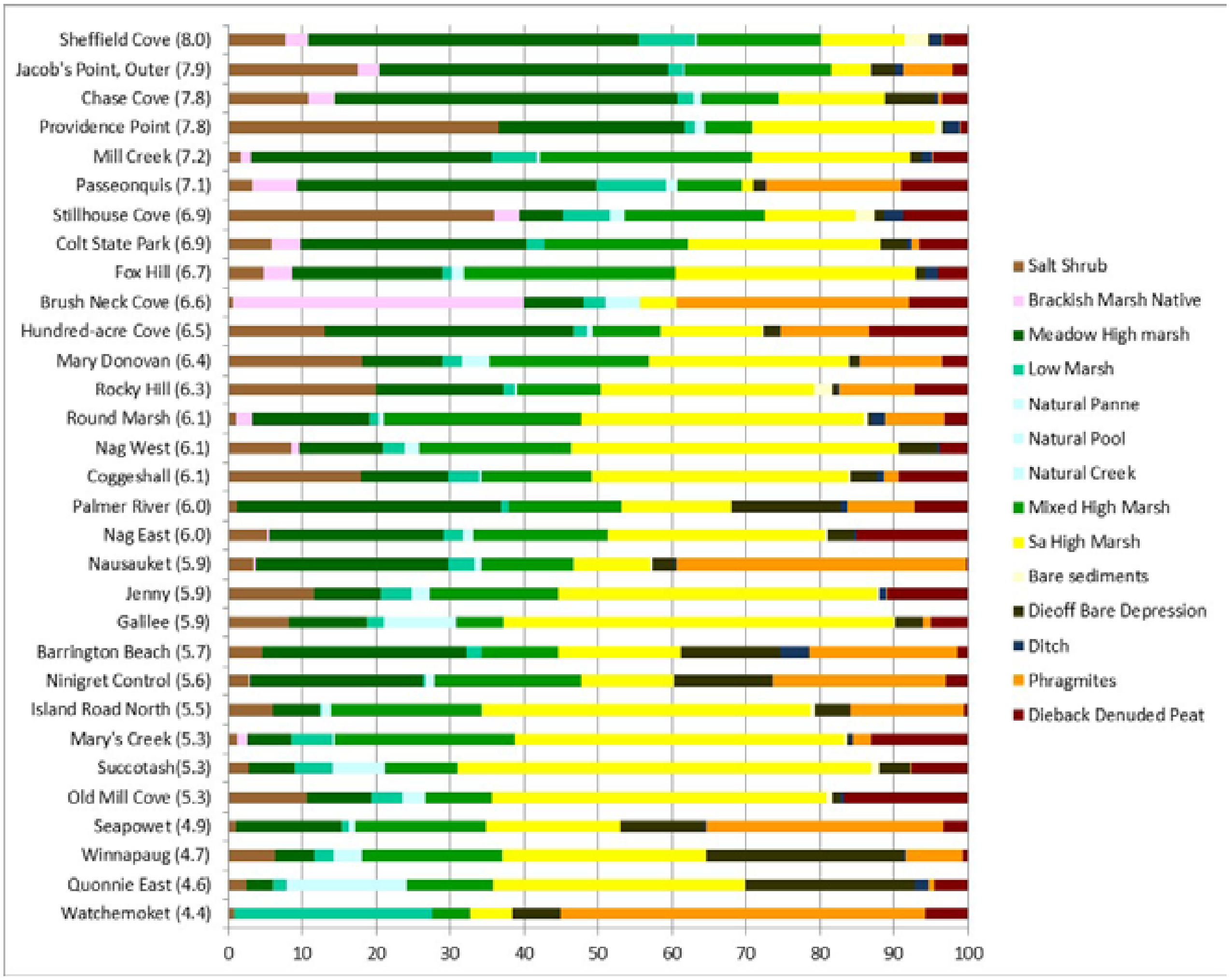

Figure 1. From Kutcher (2019). IMI scores (parenthetic) and relative proportions of IMI salt marsh cover types from 31 salt marshes in Rhode Island; salt marshes are listed in descending order of marsh integrity according to IMI scores.

Table 1. From Kutcher (2019). Matrix depicting IMI marsh degradation categories (IMI Bin) in relation to categories of MarshRAM functions and services, marsh migration potential, intensity of human disturbances, and mean elevation from Watson et al. (2017b); MD=most-degraded, ID=intermediately-degraded, LD=least-degraded; AA=above average, A=average, B=below average summed ranks of MarshRAM (A.7) *Ecosystem Functions and Services*; Migration Area=ha of adjacent land with moderately-high migration potential; Replacement Ratio=Migration Area ÷ area of site; disturbance categories: X=low-intensity, XX=moderate-intensity, XXX=high-intensity; green, yellow, and red shading represent, respectively, upper-quartile, moderate, and lower-quartile categories of marsh resiliency or value.

SITE CODE	Elevation	Disturbance	IMI Bin	Functions and Services	Migration Potential	Migration Area (ha)	Replacement Ratio	Buffer	Impoundment	Ditching	Nutrients	Fill	Erosion	Crabs	Die-off	Mowing	Phragmites
Sheffield Cove	ND	Low	LD	A	High	1.5	92%	X		XX		XX	XXX				X
Jacob's Point, Outer	High	High	LD	A	Low	0.5	6%	XX		XX	XX	XX	XX	XX	X		XX
Chase Cove	High	Mod	LD	A	High	4.1	80%		X	XX	X	X	XXX	XX	X		X
Providence Point	Med	Low	LD	B	High	2.5	53%			XX			X	X	X		X
Mill Creek	Med	Low	LD	B	Mod	1.4	29%			XX	X		XXX	XX			X
Passeonquis	High	Mod	LD	A	Low	2.3	75%	X		X	XXX		XXX	XX		X	XX
Stillhouse Cove	Med	High	LD	B	Low	0.0	0%	XXX		XX	XX	XX	XXX	X	XX	X	X
Colt State Park	High	High	LD	A	Mod	8.2	39%	X		XXX	XX	X	XXX	XXX	X	X	X
Fox Hill	Low	Low	ID	A	Mod	3.9	25%	X		X		X	XX	X	X		X
Brush Neck Cove	Low	Low	ID	A	Mod	3.2	114%				XXX		XX		X		XX
Hundred-acre Cove	Med	Mod	ID	AA	Mod	1.3	20%			X	XXX		XXX	XXX	X	X	X
Mary Donovan	Low	Mod	ID	A	Mod	5.4	15%	X		X	XXX	X	XX	XXX	X	X	X
Rocky Hill	Med	Mod	ID	AA	High	5.0	29%	XX	XX	X	XX	X	X	X	X	X	X
Round Marsh	Med	Mod	ID	A	High	11.7	37%	X	X	XX	XX	X	XX	X	X		X
Nag West	Med	Mod	ID	AA	Mod	2.9	22%			XX		X	XXX	XXX	X	X	X
Coggeshall	Med	Mod	ID	A	Mod	7.7	38%			XX	X		XXX	XXX	X		X
Palmer River	Med	Mod	ID	AA	High	5.2	27%			XX	XX		XXX	XXX	XX		X
Nag East	Med	Mod	ID	AA	Mod	3.9	18%	X		XX	X	X	XXX	XXX	X	X	X
Nausauket	ND	Low	ID	B	Low	1.0	13%	X		XX	XX			X	X		XX
Jenny	Med	Mod	ID	A	Mod	3.8	30%	X		XXX		X	XXX	XXX		X	X
Galilee	Med	Mod	ID	B	Low	1.4	13%	XX		X		XXX	XXX		X	X	X
Barrington Beach	High	Mod	ID	AA	Mod	1.1	18%	X	X	XX	XXX	XX		X	XX		XX
Ninigret Control	Low	Low	ID	A	Mod	0.0	0%				XX		XXX		XX		XX
Island Road North	Med	Mod	MD	B	Low	0.4	29%	XXX			XXX	XX	XX		X		XX
Mary's Creek	Med	High	MD	B	Low	0.0	0%	XXX		XX	XX	XXX	XXX	XXX	XX	X	X
Succotash	Low	High	MD	A	Mod	6.5	16%	XX	X	X	XX	XX	XX	XXX	X		X
Old Mill Cove	Low	High	MD	B	Mod	2.0	73%	X		X	XXX	XX	XXX	XXX	XX		X
Seapowet	Med	High	MD	AA	Mod	12.6	14%	XX	X	XX	XX		XXX	XXX	XX	X	XX
Winnapaug	Low	Low	MD	A	Mod	0.0	0%	X		X	XX	X	XX		XX		X
Quonnie East	Low	High	MD	AA	High	5.3	19%			XXX	XX	XX	XXX	XX	XX		X
Watchemoket	Low	High	MD	B	Low	0.8	136%	XX	X		XXX	XX	XX	XX			XXX

Table 2. Decision matrix designed to assign migration (M) and restoration (R) priority ranks to individual marshes based on estimated platform integrity (*Integrity*, using IMI value), the sum of *Ecosystem Functions and Services* ranks (as a proxy for *Value*), and *Migration Potential* according to MarshRAM index and metric scores. Assignment of ranks is detailed in Appendix 5.

		Migration Potential					
Integrity	*Value*	High		Moderate		Low	
High	High	M5	R2	M4	R3	M2	R4
High	Mod	M4	R1	M3	R2	M1	R3
High	Low	M3	R1	M2	R1	M1	R2
Mod	High	M5	R3	M4	R4	M2	R5
Mod	Mod	M4	R2	M3	R3	M1	R4
Mod	Low	M3	R1	M2	R2	M1	R3
Low	High	M5	R4	M4	R5	M2	R5
Low	Mod	M5	R3	M4	R4	M2	R5
Low	Low	M4	R2	M3	R3	M1	R4

M=Migration Priority
R=Restoration Priority
5=Highest Priority
4=Higher Priority
3=Mod Priority
2=Lower Priority
1=Lowest Priority

Migration Potential Definitions

High: High Replacement Ratio or High Migration Area

Moderate: Moderate Replacement Ratio and Moderate or Low Migration Area, or Moderate Migration Area and Moderate or Low Replacement Ratio

Low: Low Replacement Ratio and Low Migration Area

Migration Area:

Low ≤ 1Ha	Mod > 1 - 5Ha	High > 5Ha

Migration Ratio:

Low < 15%	Mod 15 - 50%	High > 50%

Table 3. Marsh restoration and migration priority ranks assigned to 31 salt marshes using data from MarshRAM assessments (Table 1) and the decision matrix presented in this report (Table 2). Higher ranks denote higher priority as outlined below the list. Marshes are sorted first by the sum of migration and restoration priorities, then by highest migration priority, then by highest integrity according to IMI scores. Disturbance intensities are described in Table 1, where more X's indicate higher intensity. Guidance on restoration practices to address the various disturbances is offered in Appendix 6.

	Priority											
Site	Migration Facilitation	Other Restoration	Buffer	Impoundment	Ditching	Nutrients	Fill	Erosion	Crabs	Die-off	Mowing	Phragmites
Seapowet	5	4	XX	X	XX	XX		XXX	XXX	XX	X	XX
Quonnie East	5	4			XXX	XX	XX	XXX	XX	XX		X
Palmer River	5	3			XX	XX		XXX	XXX	XX		X
Succotash	5	3	XX	X	X	XX	XX	XX	XXX	X		X
Hundred-acre Cove NE	4	4			X	XXX		XXX	XXX	X	X	X
Pettaquamscut	4	4	XX	XX	X	XX	X	X	X	X	X	X
Nag West	4	4			XX		X	XXX	XXX	X	X	X
Nag East	4	4	X		XX	X	X	XXX	XXX	X	X	X
Barrington Beach	4	4	X	X	XX	XXX	XX		X	XX		XX
Winnapaug	2	5	X		X	XX	X	XX		XX		X
Brush Neck Cove	4	2				XXX		XX		X		XX
Mary Donovan	4	2	X		X	XXX	X	XX	XXX	X	X	X
Round Marsh	4	2	X	X	XX	XX	X	XX	X	X		X
Coggeshall	4	2			XX	X		XXX	XXX	X		X
Old Mill Cove	4	2	X		X	XXX	XX	XXX	XXX	XX		X
Watchemoket	4	2	XX	X		XXX	XX	XX	XX			XXX
Fox Hill	3	3	X		X		X	XX	X	X		X
Jenny	3	3	X		XXX		X	XXX	XXX		X	X
Island Road North	3	3	XXX			XXX	XX	XX		X		XX
Sheffield Cove	4	1	X		XX		XX	XXX				X
Chase Cove	4	1		X	XX	X	X	XXX	XX	X		X
Passeonquis	4	1	X		X	XXX		XXX	XX		X	XX
Colt State Park	4	1	X		XXX	XX	X	XXX	XXX	X	X	X
Ninigret Control	1	4				XX		XXX		XX		XX
Mary's Creek	1	4	XXX		XX	XX	XXX	XXX	XXX	XX	X	X
Providence Point	3	1			XX			X	X	X		X
Galilee Outer	2	2	XX		X		XXX	XXX		X	X	X
Jacob's Point Outer	1	3	XX		XX	XX	XX	XX	XX	X		XX
Nausauket	1	3	X		XX	XX			X	X		XX
Mill Creek	2	1			XX	X		XXX	XX			X
Stillhouse Cove	1	2	XXX		XX	XX	XX	XXX	X	XX	X	X

5 = Highest Priority 4 = Higher Priority 3 = Moderate Priority 2 = Lower Priority 1 = Lowest Priority

4.2 Rhode Island Coastal and Estuarine Habitat Restoration Trust Fund Process

Rhode Island General Law 46-23.1-3 established the Rhode Island Coastal and Estuarine Habitat Restoration Trust Fund (hereafter CEHRTF). Under authority of the CRMC, the CEHRTF disburses grant money to fund coastal and estuarine restoration projects based on priority ranked according to criteria set forth in the law and reflected in the CEHRTF 2018/2019 Non-Planning Project Evaluation Worksheet (Appendix 7). Project evaluation is conducted by a state-appointed Technical Advisory Committee (TAC) comprised of estuarine scientists, managers, and stakeholders from federal, state, academic, and non-government organizations. The Restoration Strategy recommends using the CEHRTF Worksheet and TAC evaluation process as a central mechanism for stakeholder-driven prioritization. Although the Worksheet and TAC process were established specifically for evaluating and prioritizing projects for the

CEHRTF, they may be useful for other prioritization applications, such as evaluating salt marsh intervention projects selected for other funding sources.

To facilitate evaluation of salt marsh project proposals specifically, additional language could be added to the CEHRTF Evaluation Worksheet to align with the recommendations of the Restoration Strategy. One approach could be to add language (underlined gray italic text) to CEHRTF Worksheet text (gray italic text) to direct the reviewer to Restoration Strategy prioritization criteria not already addressed in the CEHRTF Worksheet, as follows.

Proposal Narrative
3. Activities: Proposed project activities are reasonable in scope and likely to result in significant long-term improvements to the habitat value of the project site. <u>Activities aimed at reducing or eliminating one or more causes of stress may be more sustainable than those aimed at addressing symptoms alone. See Table x for guidance on salt marsh restoration.</u>

9. Planning Consistency/Restoration Priority: The project is consistent with the goals of one or more local, state or regional planning initiatives. The project involves one or more state, regional or federal priority habitat needs or special considerations. <u>Salt Marsh Interventions should consider the eight prioritization criteria and four priority ecosystem functions and services described in the Coastal Wetlands Restoration Strategy (Kutcher et al. 2018).</u>

As part of a ***stakeholder-driven project evaluation*** process, MarshRAM data can help inform the following CEHRTF Project Evaluation Worksheet decision points (in gray italic font):

Proposal Narrative

1. Purpose: The proposed project seeks to restore ecological function to an area that has been degraded by human impacts.

> MarshRAM identifies the sources and intensity of human disturbances (impacts) to coastal wetlands in relation to reference salt marshes from across Rhode Island (Table 1), giving managers and reviewers broad perspective on the impacts and the restoration proposal.

2. Justification: Habitat degradation at the proposed project site is the result of anthropogenic impacts, and is significant enough to warrant investment in restoration efforts.

> MarshRAM's walking vegetation transects generate a quantitative Index of Marsh Integrity (IMI) that indicates marsh platform/habitat degradation in relation to the intensity of cumulative disturbances (impacts) and marsh platform elevation (Table 1), giving managers and reviewers insight into the causes of degradation and the significance of the degradation relative to other salt marshes in the state.

5. Adverse Impacts: An effort has been made to identify any potential adverse impacts resulting from project activities, and to minimize those impacts.

> MarshRAM estimates the importance of ecosystem functions and services held by each marsh and the observed waterbird use of the marsh, providing managers and reviewers with an indication of the functions and values that may be at risk from restoration activities.

8. Climate Change and Coastal Resiliency: The present and future impacts of climate change at the project site have been considered.

MarshRAM's IMI has been shown to indicate current condition and vulnerability to loss from sea-level rise (Kutcher 2019); and MarshRAM estimates marsh landward migration potential and the area of available migration corridor. MarshRAM data can be used by the applicant to demonstrate that climate change (specifically sea-level rise) has been considered.

10. Species of Concern: The project is likely to result in benefits to wildlife species listed as federally or state endangered, threatened, or species of concern within Rhode Island.

MarshRAM identifies known occurrences of species of concern (through GIS analysis of Heritage Species data) and documents observed waterbirds, including those listed as species of Greatest Conservation Need by the Rhode Island State Wildlife Action Plan (http://www.dem.ri.gov/programs/fish-wildlife/wildlifehuntered/swap15.php). This information will help reviewers to determine whether wildlife species may benefit from a proposed restoration action.

4.3 Sea Level Affecting Marsh Migration Model (SLAMM)

The Sea Level Affecting Marsh Migration Model (SLAMM) is a geospatial model specifically developed to predict salt marsh migration and resilience, and is therefore directly useful for salt marsh management and conservation. SLAMM uses LIDAR-based elevation data, estimates of salt marsh platform elevation change and sea-level rise, and other data to predict the loss and gain of vegetated coastal wetland area considering various scenarios of sea-level rise. Recent studies have suggested that salt marsh landward migration may be a critical factor in marsh sustainability (Donnelly and Bertness 2001, Watson et al. 2017b), and the Restoration Strategy recommends that SLAMM be used in the statewide prioritization of salt marsh restoration and conservation efforts. The first SLAMM conducted in Rhode Island was aimed at predicting the fate of coastal wetlands under projections of 1, 3, and 5 feet of sea-level rise, and identifying resulting marsh migration corridors (CRMC 2015). This SLAMM model has been applied in salt marsh management to identify and protect salt marsh migration corridors and identify salt marsh restoration and other coastal adaptation opportunities. SLAMM information is also being used as a factor to rank open space acquisition grants through state bond funds. Although the 2015 SLAMM provides useful information predicting salt marsh loss and migration, consensus among SLAMM project partners has been that the model may overestimate marsh gains due to deficiencies in the input data (CRMC 2015, C. Chaffee, personal communication).

The University of Rhode Island Environmental Data Center has recently been awarded funding to run an updated version of SLAMM that addresses the deficiencies of the earlier model and adds information that will better characterize the range of possibilities of future marsh migration. In addition to refining critical input data, such as marsh platform accretion and sea-level rise rates, the new effort will introduce parameters related to physical, biological, and socio-economic resistance to migration, such as cultural and natural land covers, and parcel ownership and conservation status. This improved model should be useful to evaluate the potential for salt marsh migration corridors in light of physical, economic, and social challenges and opportunities, which may be particularly applicable to systematic statewide prioritization efforts.

The updated SLAMM will help to inform the critical decision point weighing the potential, costs, and benefits of land acquisition or protection for marsh migration against other interventions, or abandoning particular marsh corridors in favor of more promising opportunities. The new SLAMM data will identify areas and parcels that are predicted to have elevation and land use conditions that may support ***new marsh growth*** in areas that are not already adjacent to existing salt marshes. These areas are not accounted for in MarshRAM and may be important to mitigate the estimated losses expected to accompany sea-level rise. Additionally, incorporating parcel-level information into SLAMM will help managers plan for coastal resilience including and beyond salt marsh conservation, particularly to support the acquisition or conservation of vulnerable or ecologically-valuable coastal properties.

4.4 Long-term Intensive Monitoring

Long-term monitoring is essential to understanding how marshes are responding to changing environmental conditions. Unlike rapid assessments, which typically use rapidly-collected observational data to compare the conditions among sites in a single time period, long-term monitoring typically uses intensive, quantitative data to assess changes in a single or set of representative sites over a period of time. Long-term monitoring is useful to correlate observed marsh changes with changes in other environmental factors, such as sea-level rise, direct disturbances, or surrounding development. Long-term monitoring in Rhode Island follows the National Estuarine Research Reserve System's (NERRS) System-Wide Monitoring Program (SWMP), which focuses on biological (i.e., vegetation, nekton, avian), inundation, and edaphic response to sea-level rise at a nationwide suite of "Sentinel" marshes across participating NERRS sites (Buskey et al. 2015). The Salt Marsh Monitoring and Assessment Strategy expands on two existing Sentinel sites on the Narragansett Bay NERR properties, to include an additional six to eight Sentinel sites across coastal Rhode Island (Raposa et al. 2016a).

Information from the original NBNERR Sentinel sites has already been instrumental in understanding the causes of salt marsh degradation in Rhode Island. Our understanding of platform response to relative sea-level rise (Raposa et al. 2017b); vegetation response to inundation stress (Raposa et al. 2017a); top-down interactions among fauna, sea-level-rise, and marsh platform integrity (Raposa et al. 2018); local salt marsh integrity in relation to marshes nationwide (Raposa et al. 2016b); invasive species drivers (Silliman and Bertness 2004); and other valuable information important to salt marsh conservation, has been informed by analysis of long-term Sentinel-site data. In particular, MarshRAM incorporates long-term monitoring data into several of its indices and metrics, including the IMI and metrics on impoundment, nutrient inputs, burrowing crabs, ponding and die-off, and invasive species. Long-term elevation data are also used as a critical component of the SLAMM model and are being used to calibrate marsh gain-loss across model scenarios. As information is continually collected at long-term monitoring sites, these prioritization tools may be updated or adjusted to reflect any new information gained on salt marsh response properties.

Finally, long-term monitoring sites can act as control sites for restoration projects. The BACI (Before, After, Control, Impact) study design (Stewart-Oaten et al. 1986), which compares changes at a restoration (i.e., Impact) site with changes observed in a similar unrestored (i.e., Control) site, is widely used in ecological restoration assessment. Because the Salt Marsh RAMP has worked to standardize the way data are collected among marsh conservation and research projects (Raposa et al. 2016a, Kutcher et al. 2018), data collection protocols at state and federally-funded salt marsh restoration projects in Rhode Island typically follow the Sentinel-site protocols; thus, data collected at the Sentinel sites can be used as control data for most restoration projects, alleviating data collection burdens for practitioners.

4.5 Other Tools

Other tools identified in the Restoration Strategy can be used to complement or supplement information available from SLAMM, MarshRAM, and long-term monitoring.

- Tide-frame data, characterizing the monthly tidal range, were collected at 31 marsh complexes and subembayments across Rhode Island in 2019. Once integrated with marsh elevation data, these tide-frame data could characterize the ***elevation capitol*** of individual marshes and serve as an indicator of vulnerability to sea-level rise. This indicator could complement IMI in certain decision points regarding restoration and migration prioritization.
- A high-resolution ***wetland functional assessment*** tool will soon be available through The U.S. Environmental Protection Agency (EPA) and the U.S. Army Corps of Engineers. This may be appropriate to use in addition to, or in place of, the courser Ecosystem Functions and Services metric integral in MarshRAM.
- Salt-marsh ***community classification data*** produced through remote sensing (i.e., Tier 1) could supplement community composition data collected on-site to generate the IMI. IMI is generated through relative abundance of community types estimated using walking transects; however, Kutcher (2019) found that IMI scores generated using NBNERR statewide salt-marsh community classification data based on 2012 imagery was correlated with transect-derived IMI scores. Newer remote IMI scores generated using NBNERR classification data from 2016 imagery could be used to assess wetland platform integrity at marshes where MarshRAM has not been conducted.
- ***Wildlife data*** from monitoring efforts, such as the Saltmarsh Habitat and Avian Research Program (SHARP, available: www.tidalmarshbirds.org), the newly-conducted Rhode Island Breeding Bird Atlas (available: www.ribirdatlas.com), RI DEM's wading bird, terrapin, or fish monitoring, the Rhode Island Winter Waterfowl Survey (McKinney et al. 2015), or other opportunistic wildlife data, could be used to further evaluate the ecosystem value of individual or collective salt marshes for conservation prioritization. MarshRAM already uses RINHS-RIGIS *Heritage Species* dataset and other wildlife data to inform the Ecosystem Functions and Services metric, which is applied to the prioritization-guidance matrix (Sec. 4.1). However, important information beyond conservation status, such as species abundance or richness, may be important to consider in prioritizing conservation interventions.
- ***Socioeconomic data*** can be collected through application of tools similar to EPA's Rapid Benefits Indicator (Mazzotta et al. 2019), recreational user counts, benefit transfer analyses (e.g., Vedogbeton and Johnston 2020) and more. While some of these data would need to be collected through intensive monitoring and research, other data, such as GIS population data, are already available for application. These data would provide deeper context to the valuation of ecosystems services and functions provided by the marshes. MarshRAM provides a rough estimate of some ecosystem services and functions, but value is difficult to attribute to those services without additional socioeconomic data collection for marshes relevant to Rhode Island (fringing and back barrier marshes). In particular the number of people who benefit from and the specific values of those services and functions would allow for a more informative prioritization.

5. Recommendations

The following are recommendations for establishing and implementing this framework for the prioritization of salt marsh restoration projects across Rhode Island:

1. Systematically prioritize salt marsh interventions using the tools and systematic prioritization processes discussed in this report Sec. 4.
    - Use MarshRAM data and prioritization process to systematically identify marshes in greatest need of migration facilitation or restoration.
    - Use SLAMM 2020 to identify parcels where marsh migration facilitation can be demonstrated and implemented, and where new salt marshes may develop.
    - Coordinate with EC4 and DEM Division of Planning and Development to identify priority lands for marsh migration.
    - Coordinate with CEHRTF TAC to select restoration projects for funding.
2. Initiate and manage regular systematic salt marsh interventions.
    - Set up reliable long-term funding sources (SNEP, CEHRTF, NRCS WREP)
    - Facilitate marsh migration (adaptations and migration parks) and proactively protect coastal lands identified by SLAMM as potential marsh migration corridors.
    - Implement priority state-run restorations once every one to two years.
    - Monitor interventions according to the RAMP protocols.
    - Apply adaptive management.
3. Continue to pursue stakeholder-driven restorations.
    - Use the CEHRTF process and worksheet to review and prioritize project for funding.
        i) Modify CEHRTF worksheet for salt marsh projects, specifically.
        ii) Apply MarshRAM data and prioritization outcomes to the evaluation process, as available.
    - Insinuate RI salt marsh restoration priority criteria into other funding programs.
    - Use the state program to seek funding sources and organize communities/outreach etc.

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Appendix 1: Primary Salt Marsh Restoration, Monitoring, and Assessment Program (RAMP) Partners

This is by no means an exhaustive list of organizations involved in salt marsh assessment and restoration in Rhode Island. Rather, it is a brief summary of the primary partner organizations currently contributing to the Salt Marsh RAMP effort. It is the hope of Salt Marsh RAMP proponents that the list of key partners will expand and involvement of each partner will increase over time.

State Partners

The Narragansett Bay National Estuarine Research Reserve (NBNERR)--NBNERR has been involved in salt marsh monitoring, restoration, and adaptive management since its inception in 1998 and is well-suited to play a central role in salt marsh prioritization and intervention management. The NERRS staff framework is specifically designed to support ecological research and stewardship, and NBNERR staff have accrued decades of experience in salt marsh restoration planning and monitoring. The NBNERR manager serves on several committees important for coordination of environmental monitoring, assessment, and planning, including the Environmental Monitoring Collaborative, and the Narragansett Bay Estuary Program, facilitating coordination among important salt marsh conservation partners, stakeholders and potential funders. The Research Coordinator advises and manages monitoring and assessment procedures for salt marsh restoration projects across the state, and the Stewardship Coordinator position typically focuses on ecological mapping, restoration, and land acquisition (https://coast.noaa.gov/nerrs/), which could provide direct capacity for restoration management, including systematic prioritization. The NBNERR also staffs coastal training and education programs well-suited to deliver relevant technical information and assistance to professionals and the public. Each of these positions could support salt marsh conservation capacity in the state. The Reserve is hosted by and maintains office space within the RI Department of Environmental Management, which will facilitate coordination between the two organizations.

RI Department of Environmental Management (RIDEM)—RI DEM has an important role to play in a coordinated state salt marsh program through its multiple offices and divisions. The DEM Office of Mosquito of Abatement has been working closely with Save The Bay for years to implement in-marsh interventions to reduce excessive surface ponding and mosquito breeding. The DEM Office of Water Resources has provided funding for salt marsh assessment and restoration program development in partnership with the RI Natural History Survey. The DEM Division of Fish and Wildlife has been an important partner in implementing restoration and marsh migration projects on state-owned properties, with appropriate consideration for public access and use. The DEM Office of Planning and Development is a key partner in identifying, prioritizing and funding land acquisition projects as well as providing technical design support for projects on DEM-owned properties, and input through its Public Access Committee. As mentioned above, DEM is also host agency to the Narragansett Bay National Estuarine Research Reserve, providing important fiscal management, personnel and facilities support to the program.

Rhode Island Coastal Resources Management Council (CRMC)--CRMC is the central state agency presiding over coastal wetland regulation. Coastal wetlands within 200 feet of coastal features fall under CRMC jurisdiction, requiring state assent for alterations and certain activities on both public and private lands. Consistent with its jurisdiction, CRMC has taken a central role in salt marsh management, including conservation planning and restoration, and has recently led the development of the Rhode Island Coastal Wetland Restoration Strategy (Kutcher et al. 2018).

Funding sources and partnership structures vary among salt marsh restoration projects. As the permitting agency for coastal wetlands, CRMC has been involved in salt marsh restoration projects since the concept was first implemented by Save The Bay in the mid 1990s. More recently, CRMC has managed two large-scale marsh-platform elevation projects on state-owned salt marshes that were showing signs of degradation due to inundation stress. These projects were federally funded with considerable match from local municipalities and non-profit organizations. They have been implemented and managed by CRMC in close partnership with local municipalities, state and federal agencies, and non-government organizations. It is anticipated that CRMC will continue to support and coordinate with Save The Bay on its numerous coastal habitat restoration and enhancement efforts--including marsh restorations—throughout Rhode Island.

University of Rhode Island (URI)—URI, primarily through its Natural Resources Science department (NRS) and Environmental Data Center (EDC), provides important research and geospatial data and analyses that inform salt marsh restoration and management efforts. State-sponsored salt marsh projects have often provided graduate research opportunities for URI students.

Federal Partners

NOAA Restoration Center (NOAA RC)—The NOAA Restoration Center has been an important federal partner in RI salt marsh restoration efforts. With a regional office in Narragansett, RI, the NOAA RC has served on the state's Coastal and Estuarine Habitat Restoration Trust Fund Technical Advisory Committee, and provided funding and technical assistance for on-the-ground projects. Most recently, the NOAA RC provided competitive restoration funding for a marsh elevation enhancement project in Quonochontaug Pond, and assisted with project implementation through a cooperative agreement with CRMC.

US Fish and Wildlife Service (USFWS) – The USFWS has long been a key partner in marsh assessment and restoration efforts in Rhode Island. They have implemented and evaluated innovative restoration techniques on National Wildlife Refuges, and established long-term monitoring sites within Refuge lands that have served as control sites for multiple monitoring efforts, and contributed important data to statewide efforts to understand marsh condition and vulnerability. The USFWS has provided funding and technical assistance through multiple programs, especially in consideration of species-specific impacts, and serves as an important connection to regional and national efforts.

US Environmental Protection Agency (US EPA) – US EPA ecologists and social scientists provide ad hoc technical and field support to conservation and restoration of coastal wetlands, communities, and watersheds. US EPA also coordinates the Southeast New England Program (SNEP) which consists of coastal areas in Massachusetts and Rhode Island including Cape Cod, Narragansett Bay and Buzzards Bay. SNEP is an interagency group which includes government and non-government organizations currently working collaboratively and innovatively to maintain and improve water quality and habitat conditions within Southern New England coastal watersheds. SNEP funding opportunities are competitive, but could provide future funding for salt marsh prioritization research and decision-making tools.

Non-governmental Partners

Several non-governmental partners have been involved in salt marsh restoration and play key roles in restoration prioritization. These partners often have long-standing relationships with local communities and are uniquely positioned to conduct outreach because their function is non-regulatory.

Save The Bay, Narragansett Bay, (STB)—Save The Bay has been a leader in salt marsh restoration planning and management in Rhode Island since the 1990s. STB has developed salt marsh prioritization tools, identified priority restoration sites, coordinated with salt marsh property owners, including municipalities, land trusts, and the state, to secure restoration funding, planned and managed several on-site restoration projects, initiated and implemented salt marsh migration facilitation at several locations, and worked with state and federal partners to apply adaptive management to salt marsh restoration projects and science. It is anticipated that STB will continue to be a leading partner of the state in all phases of salt marsh restoration planning and implementation moving forward.

The Narragansett Bay Estuary Program (NBEP)--The NBEP has recently committed to taking a convening and organizing role in the Salt Marsh RAMP. The NBEP has staff and operational capacity to convene meetings; organize directives; manage, spatially rectify, store, and display data; and catalogue scientific reports pertaining to salt marsh restoration, monitoring, and assessment. The NBEP has the scientific and technical expertise to apply data management and GIS tools to help convey scientific information to decision-makers and the public. The NBEP is also a bi-state, watershed-based program, and can help to facilitate information exchange with programs in Massachusetts. In this capacity, the NBEP will act as a critical partner in the RAMP. The NBEP's offices are located within RIDEM in Providence, facilitating collaboration with RIDEM and NBNERR.

The Nature Conservancy of Rhode Island (TNC)—TNC has been active in coastal restoration and has committed to manage long-term monitoring of the Andy's Way salt marsh on Block Island. TNC has recently managed a living shoreline / marsh creation project in East Providence, and has staff capacity and expertise to contribute to statewide prioritization of marsh restoration.

The Rhode Island Natural History Survey (RINHS)—The RINHS has a mission to gather and disseminate information on Rhode Island's animals and plants, geology, and ecosystems, to support the use of scientific information in the management of natural resources, and to facilitate the work of the people, agencies, and organizations interested in the ecology of Rhode Island. RINHS has been a key partner in statewide salt marsh assessment and monitoring efforts, supporting a full-time wetland scientist position through a cooperative agreement with RIDEM as part of RIDEM's EPA-funded wetland program development activities.

Audubon Society of RI (ASRI)— The mission of the Audubon Society of Rhode Island is to protect birds, other wildlife and their habitats through conservation, education and advocacy, for the benefit of people and all other life. ASRI plays a significant role as owner and steward of many of the state's salt marshes, has participated in salt marsh prioritization planning efforts, and provides fiscal and administrative support for the Narragansett Bay National Estuarine Research Reserve, through a contract with RIDEM.

Appendix 2

MarshRAM Field Datasheet

MarshRAM V.2 Investigators__________________________ Site Code__________ Date________
Longitude (DD) ____________________ Latitude (DD) ______________________

A. Marsh Characteristics; apply to the *current* state of the marsh. Not Scored.

1) Assessment Unit Area*_________ha; select one class:

- ÿ <0.5 hectares
- ÿ 0.5 to 2.0 hectares
- ÿ 2.0 to 5.0 hectares
- ÿ 5.0 to 10 hectares
- ÿ 10 to 20 hectares
- ÿ 20 to 30 hectares
- ÿ 30- 40 hectares
- ÿ > 40 hectares

2) Position in Watershed

- ÿ Upper Bay
- ÿ Mid Bay
- ÿ Lower Bay
- ÿ South Coast
- ÿ Block Island
- ÿ Mt. Hope Bay
- ÿ Sakonnet River

3) Marsh Setting and Type

Geomorphic Setting; select primary one or two

- ÿ Open Coast
- ÿ Open Embayment
- ÿ Finger
- ÿ Riverine
- ÿ Back Barrier Marsh
- ÿ Back Barrier Lagoon

Geoform; select one

- ÿ Platform
- ÿ Fringe

Adjacent upland; select primary one or two

- ÿ Bluff
- ÿ Plain
- ÿ Barrier spit or beach
- ÿ Rock
- ÿ Hardened shoreline

Tidal water salinity; select one

- ÿ Fresh............. <0.5 ppt
- ÿ Oligohaline.... 0.5 to <5 ppt
- ÿ Mesohaline... 5 to <18 ppt
- ÿ Polyhaline...... >18 ppt

Freshwater input; select primary one or two

- ÿ River or stream
- ÿ Sheet flow
- ÿ Precipitation only
- ÿ Groundwater

4) Exposure to Tides

*Exposed Marsh Edge**; estimate exposed edge as a proportion of total unit circumference

- ÿ < 5% no or very low exposure
- ÿ 5 – 25 % low exposure
- ÿ 26 – 50 % moderate exposure
- ÿ > 50 % high exposure

*Effective Fetch of Tidal Water**

- ÿ < 0.5 km
- ÿ 0.5 - 1 km
- ÿ 1 - 2 km
- ÿ 2-3 km
- ÿ > 3 km

Tidal Range

- ÿ < 0.4 m
- ÿ 0.4 – 1 m
- ÿ 1 - 1.5 m
- ÿ >1.5 m
- ÿ Unknown

5) Natural Habitat Diversity; indicate presence of all significant natural habitat types by checking all present

- ÿ Salt Shrubs
- ÿ Brackish Marsh
- ÿ High Marsh Platform
- ÿ Pools
- ÿ Established Pannes
- ÿ Tall Sa Low Marsh
- ÿ Creeks
- ÿ Ponds
- ÿ Overwash Fan

6) Connected Natural Habitats; check all natural habitats that occur within 150 m of the unit.

- ÿ Forested or shrub wetland
- ÿ Freshwater marsh or pond
- ÿ Brackish marsh or pond
- ÿ Other salt marsh
- ÿ Sand or cobble beach
- ÿ Coastal dunes or overwash
- ÿ Intertidal flats
- ÿ Eelgrass or other SAV
- ÿ Upland forest
- ÿ Upland shrubland
- ÿ Upland grassland
- ÿ Other________________________

7) Count of Waterbirds Present: Wading Birds ________ Shorebirds ________ Waterfowl ________
Swallows_______ Raptors ________ Gulls ________ Sparrows__________

*If the vegetated marsh area is larger than any open water feature encompassed by the unit, then the water is considered part of the unit. If open water feature is larger, it is considered the tidal water.

B. Ecosystem Functions and Services; estimate importance of all evident or known according to ranks provided:

- ___ Storm protection of property
- ___ Floodflow alteration
- ___ Part of a habitat complex or corridor
- ___ Sediment / toxin retention
- ___ Nutrient uptake
- ___ Carbon storage
- ___ T/E species habitat
- ___ Fish and shellfish habitat
- ___ Wildlife habitat
- ___ Hunting or fishing platform
- ___ Other recreation
- ___ Educational or historic significance

0...Not evidently provided
1...Minor or potential importance
2...Evident or known importance
3...Special importance

Sum of ranks = [ ] Explain special importance ________________________________

C. Surrounding Land Use

Adjacent Land Use Intensity weighted average within 150-m buffer.
Estimate proportion of each class to the ***nearest tenth*** and multiply (max = 10)

	Proportion	Score	Weighted Value
Very Low	______	× 10 =	______
Low	______	× 7 =	______
Moderately High	______	× 4 =	______
High	______	× 0 =	______

Sum weighted values for score = ______

Very Low.......Natural areas, natural open water
Low................Recovering natural lands, passive recreation, low trails, mooring fields
Mod High......Residential, pasture/hay, mowed areas, raised roads, marina docks
High................Urban, impervious land cover, new construction, row crops, turf crops, mining operations, paved roads > 2-lane, dense marina docks

Surrounding Land Uses: Check all that apply

- ÿ Commercial or industrial development
- ÿ Unsewered Residential development
- ÿ Sewered Residential development
- ÿ New construction
- ÿ Landfill or waste disposal
- ÿ Raised road beds
- ÿ Foot paths / trails
- ÿ Row crops, turf, or nursery plants
- ÿ Poultry or livestock operations
- ÿ Orchards, hay fields, or pasture
- ÿ Piers, docks, or boat ramps
- ÿ Golf courses / recreational turf
- ÿ Sand and gravel operations
- ÿ Railroad bed
- ÿ Power lines
- ÿ Other____________________

D. Wetland Disturbances. Average metrics D.1 to D.10

1) Buffer Encroachment.

Estimate % cultural cover on adjacent land within 30-m buffer.

- ÿ <5% (10)
- ÿ 6 to 25% (8)
- ÿ 26-50% (6)
- ÿ 51-75% (3)
- ÿ >75% (1)

Primary Associated Stressor; check one or two:

- ÿ Road
- ÿ Railway
- ÿ Fill
- ÿ Raised Trail
- ÿ Power Lines
- ÿ Cleared/mowed Land
- ÿ Buildings
- ÿ Paved Lot
- ÿ Dirt Lot
- ÿ Dam/dike
- ÿ Other__________________

Primary Source of Stress; indicate as current (C) or historic (H):

__ Private / Residential
__ Commercial
__ Agricultural
__ Public transportation
__ Public utilities
__ Public recreation
__ Undetermined

2) Impoundment and Tidal Restriction.

Change in depth or hydroperiod. Select one. If less than half of the marsh is impounded or restricted, average score with 10.

- ÿ None observed (10)
- ÿ Restriction observed but no change in vegetation or elevation evident (7)
- ÿ Restriction observed with change in vegetation evident (4)
- ÿ Restriction observed with subsidence, ponding, or die-off evident (1)

- ÿ Less than half the marsh is affected, average with 10 = _____

Evidence: check all that apply

- ÿ Physical barrier across seaward edge of wetland
- ÿ Dam or restricting culvert downstream of wetland
- ÿ Ponding or subsidence evident
- ÿ Widening of wetland upstream of barrier
- ÿ Change in vegetation across barrier
- ÿ Dead or dying vegetation

Primary Associated Stressor; check one:

- ÿ Road
- ÿ Railway
- ÿ Weir / Dam
- ÿ Raised Trail
- ÿ Development Fill
- ÿ Other __________

Primary Source of Stress; indicate as current (C) or historic (H):

__ Private / Residential
__ Commercial
__ Agricultural
__ Public transportation
__ Public utilities
__ Public recreation
__ Undetermined

3) Ditching and draining density.

Estimate the density of ditching and draining. For difficult determinations, use key.

Select one

- ÿ None observed (10)
- ÿ Low (7)
- ÿ Moderate (4)
- ÿ High (1)

Key: density classes of ditches

Low:	< 100 m/Ha
Moderate:	100-300 m/Ha
High:	> 300 m/Ha

4) Anthropogenic nutrient inputs.

Select the evidence of sources and impact.

- ÿ No evidence (10)
- ÿ Sources observed only (7)
- ÿ Sources observed and some impacts evident (4)
- ÿ Sources and multiple or strong impacts clearly evident (1)

Evidence: check all that apply
- ÿ Known high-nutrient tidal or fresh waters
- ÿ Runoff sources evident
- ÿ Point sources evident
- ÿ Sewage smell
- ÿ Pervasive sulfide smell
- ÿ Excessive algae in surface waters
- ÿ Unusually tall Sa (≥ 1.5 m)
- ÿ Dense and tall Phragmites (≥ 3m) abutting sources
- ÿ Obvious plumes or suspended solids

Primary Associated Stressor; Check one or two:
- ÿ High-nutrient tidal water
- ÿ High-nutrient up-stream water
- ÿ Stormwater discharge
- ÿ Sheet runoff
- ÿ Unsewered residential
- ÿ Point effluent discharge
- ÿ Organic / yard waste
- ÿ Other point ______________
- ÿ Multiple / non-point

Primary Source of Stress; indicate as current (C) or historic (H):
- __ Private / Residential
- __ Commercial
- __ Agricultural
- __ Public transportation
- __ Public utilities
- __ Public recreation
- __ Multiple / non-point
- __ Undetermined

5) Filling and dumping within wetland. Select <u>one</u> or two from below. If fill is hardened to the edge subtract 1.

Fill includes typical construction fill, yard waste, and trash.

- ÿ No fill observed (10)
- ÿ Scattered trash in the marsh, aesthetic impacts only (9)
- ÿ Fill covers <10% of the unit area or perimeter (7)
- ÿ Fill covers 10-60% of the unit area or perimeter (4)
- ÿ Fill covers >60% of the unit area or perimeter (1)
- ÿ Fill has hardened edge (subtract 1 from above)

Evidence: check all that apply
- ÿ Unnaturally abrupt change in ground level
- ÿ Abrupt change in soil texture or content
- ÿ Unnaturally straight or abrupt wetland edge
- ÿ Unnatural items on or within the sediments

Primary Associated Stressor; Check one:
- ÿ Road
- ÿ Raised Trail
- ÿ Railway
- ÿ Organic / yard waste
- ÿ Fill
- ÿ Other
- ÿ Dam
- ÿ Dike
- ÿ Trash

Primary Source of Stress; indicate as current (C) or historic (H):
- __ Private / Residential
- __ Commercial
- __ Agricultural
- __ Public transportation
- __ Public utilities
- __ Public recreation
- __ Undetermined

6) Edge erosion. Select the appropriate category. Edge includes seaward edge and major creeks.

Intensity of edge erosion

- ÿ Minimal erosion observed (10)
- ÿ Low (7): <10% of the seaward edge is eroded
- ÿ Moderate (4): 10-60% of the seaward edge is eroded
- ÿ High (1): >60% of the seaward edge is eroded

Evidence: check all that apply
- ÿ Vertical marsh edge from platform
- ÿ Undercut edge
- ÿ Disintegrating unvegetated edge
- ÿ Oversized crab burrows

7) Crab burrow intensity. Select the appropriate category. Marsh edge includes major creeks.

- ÿ None (10): Burrows are limited to the peat edge with dense vegetation
- ÿ Low (7): <10% of the marsh edge is densely burrowed and partly or fully denuded
- ÿ Moderate (4): 10-60% of the marsh edge is densely burrowed and denuded
- ÿ High (1): >60% of the marsh edge is densely burrowed and denuded

Evidence: check all observed
- ÿ Dense crab burrows
- ÿ Eroding or oversized crab burrows
- ÿ Abundant fiddler crabs
- ÿ Purple marsh crabs
- ÿ Clipped vegetation
- ÿ Denuded areas of peat

8) Ponding and Dieoff Depressions. Estimate the incidence of shallow ponding, dieoff, or sparsely vegetated soft peat on the high marsh platform.

- ÿ None observed (10)
- ÿ Low: <10% cover (7)
- ÿ Moderate: 10-60% cover (4)
- ÿ High: >60% cover (1)

Evidence: check all observed on the marsh platform
- ÿ Shallow ponding
- ÿ Shallow unvegetated depressions
- ÿ Sparsely vegetated soft peat

9) Vegetation cutting / removal / soil disturbance. Select intensity of vegetation or soil disturbance.

- ÿ None Observed (10)
- ÿ Low: <10% (7)
- ÿ Moderate: 10-60% (4)
- ÿ High: > 60% (1)

Evidence: check all that apply
- ÿ Cut stems or stumps
- ÿ Immature vegetation strata
- ÿ Missing vegetation strata
- ÿ Mowed areas
- ÿ Browsing or grazing
- ÿ Tire ruts
- ÿ Cattle hoof prints / trampling
- ÿ Human footprints / trampling
- ÿ Excavation evident

Primary Associated Stressor; Check one:
- ÿ Power lines
- ÿ Grazing
- ÿ Crops
- ÿ Lawn maintenance
- ÿ Development clearing
- ÿ View-shed clearing
- ÿ Trails / non-raised roads
- ÿ Shore access
- ÿ Other_____________

Primary Source of Stress; indicate as current (C) or historic (H):
- __ Private / Residential
- __ Commercial
- __ Agricultural
- __ Public transportation
- __ Public utilities
- __ Public recreation
- __ Undetermined

Primary Abutting Stressors; Check one or two:
- ÿ Road
- ÿ Railway
- ÿ Raised Trail
- ÿ Footpath
- ÿ Dam / Dike
- ÿ Organic / yard waste
- ÿ Other Fill
- ÿ Mowed Lawn
- ÿ Crops
- ÿ Pasture
- ÿ Drainage ditch / tile
- ÿ Stormwater input
- ÿ Clearing
- ÿ Multiple
- ÿ Residential Development
- ÿ Other

10) Phragmites within wetland. Select <u>one</u> class for total coverage.

- ÿ None noted (10)
- ÿ Low: <10% cover (7)
- ÿ Moderate: 10-60% cover (4)
- ÿ High: >60% cover (1)

Primary Source of Stress; indicate as current (C) or historic (H):
- __ Private / Residential
- __ Commercial
- __ Agricultural
- __ Undetermined
- __ Public transportation
- __ Public utilities
- __ Public recreation

Sum of D1 to D10 Scores = _________ ÷ 10 = [ ] D. Wetland Disturbance Score

E. Marsh Community Composition and **Index of Marsh Integrity.** Walking straight and evenly along each of 8 transects, tally every step traversing the listed community types.

Zone	T1		T2	
Salt Shrub				
Brackish Marsh Native				
Phragmites				
Meadow High Marsh				
Mixed High Marsh				
Sa High Marsh				
Dieoff Bare Depression				
Low Marsh				
Dieback Denuded Peat				
Natural Panne				
Natural Pool				
Natural Creek				
Ditch				
Bare Sediments				
	Sum:		Sum:	
Sparrow Tally				

Zone	T3		T4	
Salt Shrub				
Brackish Marsh Native				
Phragmites				
Meadow High Marsh				
Mixed High Marsh				
Sa High Marsh				
Dieoff Bare Depression				
Low Marsh				
Dieback Denuded Peat				
Natural Panne				
Natural Pool				
Natural Creek				
Ditch				
Bare Sediments				
	Sum:		Sum:	
Sparrow Tally				

MarshRAM V.2 Investigators________________________ Site Code___________ Date________

Zone	T5		T6	
Salt Shrub				
Brackish Marsh Native				
Phragmites				
Meadow High Marsh				
Mixed High Marsh				
Sa High Marsh				
Dieoff Bare Depression				
Low Marsh				
Dieback Denuded Peat				
Natural Panne				
Natural Pool				
Natural Creek				
Ditch				
Bare Sediments				
	Sum:		Sum:	
Sparrow Tally				

Zone	T7		T8	
Salt Shrub				
Brackish Marsh Native				
Phragmites				
Meadow High Marsh				
Mixed High Marsh				
Sa High Marsh				
Dieoff Bare Depression				
Low Marsh				
Dieback Denuded Peat				
Natural Panne				
Natural Pool				
Natural Creek				
Ditch				
Bare Sediments				
	Sum:		Sum:	
Sparrow Tally				

MarshRAM V.2 Investigators____ Site Code_____________ Date_________

	CCI	Total Tally	CCI X TT	% Cover*
Salt Shrub	9			
Brackish Marsh Native	10			
Phragmites	3			
Meadow High Marsh	10			
Mixed High Marsh	7			
Sa High Marsh	5			
Dieoff Bare Depression	1			
Low Marsh	8			
Dieback Denuded Peat	0			
Natural Panne	8			
Natural Pool	6			
Natural Creek	8			
Ditch	2			
Bare Sediments	4			
	Sums:			

E. Index of Marsh Integrity

$$= \frac{\text{Sum (CCI X TT)}}{\text{Sum (Total Tally)}}$$

=

Marsh Community Composition:

$$\text{*For each cover type, \% Cover} = \frac{\text{Total Tally}}{\text{Sum (Total Tally)}}$$

B. Ecosystem Functions and Services (Sum)

C. Surrounding Land Use Score (max 10)

D. Wetland Disturbance Score (max 10)

E. Index of Marsh Integrity (max 10)

Investigator______________________________ Site ________________________ Date______________

F. Migration Potential

Estimate the proportion, to the nearest tenth, of surrounding land within 60m falling into each class, and multiply.
Total sum of proportions must = 1.0 and sum of weighted values must = 0.0 to 10.0.

Landward* Surface Waters

No Potential:

____Ocean
____Estuary
____ Lake/pond
____Other
Sum = ____ x 0 = __0_

*separated from marsh by upland

Elevated Land >1.5m above MHW

No Potential:

____Bedrock
____Hardened shoreline
____Developed land
____Landfill
____Other_________________
Sum = ____ x 0 = __0_

Low Potential:

____Elevated erodible Land
Sum = ____ x 2 = ____

Low-lying Land <1.5m above MHW

No Potential:

_____Ocean Beach / Dune
_____Estuarine Beach
Sum = ____ x 0 = __0_

Low Potential:

____Paved street or lot
____ Residential development (structures present)
____ Industrial / commercial development (structures present)
____Other____________________
Sum Low = ____ x 2 = ____

Moderate Potential:

____ Active farmland
____Golf course
____Sand and gravel operation
____Undeveloped land behind a raised shoreline feature
____Phragmites marsh
____Freshwater deep wetland
____Other_____________________
Sum Moderate = ____ x 5 = ____

Moderately High Potential:

____Forested or shrub wetland
____Forested or shrub upland
____Mowed land, no structures
____Pasture
____Other__________________
Sum Mod High = ____ x 8 = ____

High Potential:

____Emergent FW wetland
____Upland field / meadow
____Abandoned farmland
____Other___________________
Sum High = ____ x 10 = ____

Sum weighted values for **Migration Potential score:** [ ]

a. Area of Marsh = ________
b. Area of surrounding land to 60m = _______
c. Proportion of Moderately High + High class = _______

d. **Migration Area =** (b × c) **=** [ ]

e. **Replacement Ratio =** (d ÷ a) **=** [ ]

Appendix 3

Rhode Island salt marshes assessed using MarshRAM

Barrington Beach, Barrington

Brush Neck Cove, Warwick

Chase Cove, Warren

Coggeshall, Prudence Island

Colt State Park, Bristol

Fox Hill, Jamestown

Galilee Outer, Narragansett

Hundred Acre Cove MU1, Barrington

Island Road North, Narragansett

Jacobs Point Outer, Warren

Nag East, Prudence Island

Nag West, Prudence Island

Mary Donovan, Tiverton

Mary’s Creek, Warwick

Mill Creek, Wickford

Nausauket, Warwick

Ninigret Control, Charlestown

Old Mill Cove, Warwick

Palmer River, Barrington

Rocky Hill, Warwick

Round, Jamestown

Passeonquis, Warwick

Providence Point, Prudence Island

Quonnie East, South Kingstown

Seapowet, Tiverton

Smith Cove, Barrington

Stillhouse Cove, Cranston

Succotash, South Kingstown

Watchemoket, East Providence

Winnapaug, Westerly

Appendix 4. Definitions and decision processes for ranking *Ecosystem Functions and Services* in MarshRAM

Rank definitions

The MarshRAM *Ecosystem Functions and Services* section uses a four-rank system. The ranking system focuses on the three lower ranks (0, 1, and 2), with *special importance* (3) being reserved for truly unique or critically-important examples of the function or service. An experienced salt marsh scientist (the investigator) uses all available information and best professional judgement to assign one rank to each function and service for each marsh. These **general scoring ranks** for all categories are defined as follows:

Not evidently provided (0): There is no evidence or knowledge of the salt marsh providing the function or service.

Minor or potential importance (1): There is evidence or knowledge of the marsh having a minor or potential contribution to providing the function or service.

Evident or known importance (2): There is clear evidence or knowledge of the marsh providing or largely contributing to the function or service.

Special importance (3): Used sparingly; the evident or known function or service provided by the marsh is uniquely, unusually, or critically important to people or wildlife.

Decision processes and breakpoints

Each of the following **ecosystem functions and services** were ranked according to the above definitions using a combination of geospatial analysis, field investigation, and investigator knowledge for each salt marsh. The sum of the ranks was used as a metric of aggregate "value" for categorizing salt marshes statewide as above average (AA; upper quartile), average (A; interquartile), or below average (B; lower quartile). The category was applied to the prioritization matrix in the Prioritization Framework (Table 2). Unique decision processes and breakpoints used to determine the rank of each function and service are provided below. Examples are provided when extra context seems useful.

1. <u>Storm protection of developed property</u>

Premise: The salt marsh platform and vegetation elevation and roughness provide resistance to the laminar flow of water, interrupting the momentum of tidal surges and causing wave energy to dissipate before reaching adjacent developed properties.

Evidence: The salt marsh lies between tidal waters and low-lying developed property (less than 3m above the marsh surface) vulnerable to damage by tidal flooding or wave action from tides, storm events or boat wakes. The marsh provides the service if it would prevent or mitigate such damage.

Not evidently provided (0): Common; there is no vulnerable developed property landward of the marsh.

Minor or potential importance (1): There is some evidence or knowledge that the marsh geomorphology or vegetation could lessen the impacts of flooding or wave action on some vulnerable developed property, but it is not clear that the marsh would be effective.

- Examples: The marsh lies between tidal water and low-lying developed property, but:
    - The marsh is narrow (<5m) and unlikely to offer much protection

- o The developed property is somewhat elevated and it's unclear that the property is in danger

Evident or known importance (2): There is clear evidence or knowledge that the marsh is providing protection to vulnerable developed properties.

Special importance (3): Unlikely; protection of developed property from tides or waves clearly provided by the marsh is critically important to many people.

- Example: The marsh clearly protects a municipal water source from exposure or damage from tides or waves.

2. Floodflow alteration:

Premise: Salt marshes can provide or contribute to water-storage capacity that mitigates downstream flooding from upstream floodwaters. Because gross flood storage along any stretch of river is typically cumulative, each marsh's contribution may be important.

Evidence: The marsh lies upstream from low-lying developed land that is vulnerable to flooding from upstream waters.

Not evidently provided (0): Common; the marsh does not sit upstream of developed property vulnerable to upstream flooding.

Minor or potential importance (1): Unusual; it is unclear that the marsh provides storage of upstream flooding on vulnerable downstream developed property, or the storage it provides is negligible compared to the volume of flood water.

Example: It is unclear whether the downstream developed property is vulnerable to flooding.

Evident or known importance (2): The marsh is situated to provide flood storage upstream of vulnerable developed property.

- Ø Decision Point: Most marshes situated anywhere upstream of vulnerable developed property should be assigned this rank (2), as all marsh area contributes to cumulative flood storage.

Special importance (3): Unlikely; protection of developed property from upstream flooding clearly provided by the marsh is critically important to many people.

- Example: The marsh clearly and largely contributes to the protection of important public infrastructure from upstream flooding.

3. Part of a habitat complex or corridor

Premise: Salt marshes may contribute to larger tracts of wildland, including wildlife corridors, which are important to support biodiversity.

Evidence: Investigation of aerial imagery or site visit reveals that the salt marsh is contiguous with other substantial wildlands that together provide a larger continuous wildlife area.

Not evidently provided (0): The marsh is not contiguous with any other wildlands (uplands/wetlands).

Minor or potential importance (1): The marsh is adjacent to a parcel of wildland that is not substantial or important in the landscape context.

- Example: The marsh is adjacent to small undeveloped woodlands in a developed matrix that may provide additional collective habitat for certain species:

Evident or known importance (2): The marsh is contiguous with larger wildlands or is connected by a wildlife corridor to substantial wildlands.

Special importance (3): The marsh is part of a larger protected wildlife sanctuary or corridor, or is contiguous with wildlands that are critical to species of special concern.

- Example: Pettaquamscut Marsh is part of a continuous wild riparian system that supports diamond back terrapins, a species of state concern.

4. <u>Sediment / toxin retention</u>

Premise: Salt marshes can trap sediments and toxins from storm water runoff that would otherwise be carried into surface waters.

Evidence: The salt marsh is situated between a source of sediments or toxins (such as a farm, highway, quarry, scrapyard) and a vulnerable receiving surface water. Toxins may be pesticides, salts from road salt, or other toxics carried by storm water or adsorbed to sediments carried by storm water.

Not evidently provided (0): The marsh is not situated between a significant source of sediments or toxins and a receiving surface water body.

Minor or potential importance (1): The marsh is adjacent to a source of toxins or sediments but the input is small, or it is unclear or unlikely that input of the toxins / sediments is present or substantial.

- Example: The marsh is adjacent to a small road that is likely sanded and salted during the winter.

Evident or known importance (2): The marsh is adjacent to a substantial source of sediments or toxins that are clearly running off into the marsh.

Special importance (3): Unusual; the marsh clearly traps sediments or toxins that pose a human health threat or a direct threat to species of concern.

5. <u>Nutrient uptake</u>

Premise: Salt marshes can intercept anthropogenic nutrients from overland runoff and groundwater from reaching a receiving surface water.

Evidence: The salt marsh is situated between a source of nutrients (such as a farm, manicured lawn, unsewered residential development) and a vulnerable receiving surface water. Nutrients may be from fertilizers, human or pet waste, compost, yard debris, or other sources.

Not evidently provided (0): The marsh is not set between a source of anthropogenic nutrients and a receiving water.

Minor or potential importance (1): The marsh is adjacent to a source of nutrients but the input is small, or it is unclear or unlikely that input of the nutrients is present or substantial.

- Example: The marsh is adjacent to a sewered residential area where yard waste and lawn fertilizers are likely causing some nutrient inputs.

Evident or known importance (2): The marsh is adjacent to a substantial source of nutrients that are clearly running off into the marsh.

Special importance (3): Unusual; the marsh clearly traps nutrients that pose a human health threat or a direct threat to species of concern.

6. <u>Carbon storage</u>

Premise: Salt marshes can collect and store carbon through plant growth and creation of organic peat soils; this process reduces carbon in the atmosphere.

Evidence: The salt marsh has plants or a peat substrate.

Not evidently provided (0): Unlikely; use with discretion.

Minor or potential importance (1): The marsh stores little carbon and is actively losing carbon to the atmosphere through decomposition of existing peat.

Evident or known importance (2): The marsh is mostly vegetated or has a sound peat substrate.

- Ø Decision Point: Marshes are defined by having plants or peat substrates; therefore, all marshes store at least some carbon, contributing to the collective carbon storage of marshes, worldwide. All marshes were therefore assigned this rank (2) unless they were clearly rapidly losing vegetation and peat to erosion and decomposition, in which case a marsh was assigned a rank of 1.

Special importance (3): Unlikely; use with discretion.

7. <u>Threatened / endangered species habitat:</u>

Premise: Salt marshes can provide important or critical habitat for listed threatened or endangered species.

Evidence: The salt marsh or its immediate buffer (within 30m) supports a known occurrence of a plant or animal species that is threatened or endangered according to official federal or state lists. Evidence is gathered through investigation of geospatial data (Rhode Island Natural Heritage Database), field observation, or another trustworthy source.

Not evidently provided (0): The marsh is not known or likely to support a threatened or endangered species.

Minor or potential importance (1): Unusual; the marsh has potential to support obligate species of special concern or has historically supported species of special concern.

- Example: The marsh is large enough and has ample *Spartina* high marsh and buffer to support state-threatened salt marsh sparrows (*Ammospiza* spp.), but there are no records of their presence and none were observed during the assessment.

Evident or known importance (2): The marsh is known to support one or more species of high conservation concern (threatened / endangered).

Special importance (3): Unusual; the marsh is one of few in the state to support a threatened or endangered species.

- Example: The marsh is in one of two marsh complexes statewide known to support diamond-back terrapins.

8. Fish and shellfish habitat

Premise: Salt marshes provide important or critical habitat for fish and shellfish, including economically valuable species.

Evidence: The salt marsh has intertidal vegetation, creeks, ponds, or mud flats that support fish and shellfish.

Not evidently provided (0): Unlikely; the marsh is highly degraded and situated in an area unlikely to support any fish or shellfish.

Minor or potential importance (1): Unusual, the marsh is degraded to a point that it provides little valuable habitat for fish or shellfish.

- Example: A fringing marsh almost entirely dominated by *Phragmites australis* with no geomorphic features that typically support fish and shellfish.

Evident or known importance (2): The marsh is mostly vegetated with native plants or has creeks, ponds, pools, mudflats, or other features known to support fish or shellfish.

- Ø Decision Point: Nearly all marshes provide habitat for fish or shellfish, contributing to the collective, broader ecological function of marshes. All marshes were therefore assigned this rank (2) unless the above-listed features were clearly absent, in which case a marsh would be assigned a rank of one (1).

Special importance (3): Unusual; the marsh provides uniquely-important habitat for fish or shellfish.

- Example: The salt marsh is part of a fish or shellfish habitat restoration area, such as an active oyster restoration project.

9. Wildlife habitat

Premise: Salt marshes provide important or critical habitat for wildlife beyond fish and shellfish, including birds, mammals, reptiles, and insects.

Evidence: Wildlife are directly observed using the marsh during the assessment, or the salt marsh is known or suspected to support wildlife due to its size, location, adjacency to wildlands, or some other indication of wildlife value.

Not evidently provided (0): Unlikely; the marsh is highly degraded and situated in an area unlikely to support any wildlife.

Minor or potential importance (1): The marsh is suspected to provide some wildlife habitat or provides a small amount of known habitat (e.g., the marsh is small relative to most marshes).

- Example: A small marsh surrounded by a suburban landscape.

Evident or known importance (2): The marsh clearly provides substantial wildlife habitat.

Special importance (3): Unusual; the marsh clearly provides an unusually large amount of wildlife habitat or provides substantial wildlife habitat within a special habitat conservation area or to species of some conservation concern.

- Example: The marsh is part of an active wildlife refuge.

10. Hunting or fishing platform

Premise: Salt marshes can provide a platform for hunting or fishing.

Evidence: The salt marsh is accessible and used by hunters or fishermen as evidenced by prior knowledge, direct observation, the presence of hunting blinds, discarded gun shells, fishing litter, worn paths, etc.

Not evidently provided (0): The marsh is not easily accessible to hunters or fishermen and there are no signs of use, or hunting and fishing are not permitted on the marsh.

Minor or potential importance (1): The marsh is accessible and occasionally or potentially used by hunters or fishermen.

Evident or known importance (2): The marsh is accessible and clearly used by hunters or fishermen.

Special importance (3): Unlikely; the marsh is clearly an unusually important hunting or fishing platform for many users.

11. Other recreation

Premise: Salt marshes can provide a platform for passive recreation such as bird-watching, sight-seeing, kayaking, or paddle boarding.

Evidence: The salt marsh is accessible and used by people for recreation as evidenced by prior knowledge, direct observation, worn paths, etc.

Not evidently provided (0): The marsh is not easily accessible to recreating and there are no signs of use.

Minor or potential importance (1): The marsh is accessible and potentially used for recreation.

Evident or known importance (2): The marsh is accessible and clearly used for recreation.

Special importance (3): Unlikely; the marsh is clearly an unusually important recreation platform for many users.

12. Educational or historical significance

Premise: Salt marshes are culturally important assets that can have historical or educational significance.

Evidence: The salt marsh known to have cultural significance or is known to be a current or ongoing platform for education.

Not evidently provided (0): The marsh has no cultural or educational significance beyond its typical intrinsic values.

Minor or potential importance (1): The marsh is historically or culturally significant to a small group or is occasionally used for education.

Evident or known importance (2): The marsh has unique historical or cultural significance or is commonly used for education.

Special importance (3): Unusual; the marsh has unique and broadly-recognized historical or cultural value or is used for wide-reaching education.

Appendix 5: Justifications for priority rankings in the Rhode Island salt marsh prioritization matrix (Table 2)

The following factors were used to populate the prioritization matrix (Table 2 in the Prioritization Framework). To assign the ranks, the matrix was initially populated with all Migration (M) and Restoration (R) ranks set at 3 (neutral). For each factor, the rank was raised or lowered by one point according to the below rules, except for Factor 3 B, for which the Migration (M) rank was lowered by two points.

Factor 1: Integrity according to IMI (reflects inundation stress + direct disturbance stress)

A. **Low-integrity** marshes were assigned **higher migration facilitation priority** because they are most stressed and vulnerable.
B. **High-integrity** marshes were assigned **lower restoration priority** because they are already healthy and should mainly be monitored for change.
C. **Low-integrity** marshes were assigned **higher restoration priority** because they are most stressed and vulnerable.

Factor 2: Value (aggregate Ecosystem Functions and Services categories from MarshRAM)

A. **High-value** marshes were assigned **higher migration facilitation priority** because they are more valuable to people and wildlife.
B. **Low-value** marshes were assigned **lower migration facilitation priority** because they are less valuable to people and wildlife.
C. **High-value** marshes were assigned **higher restoration priority** because they are more valuable to people and wildlife.
D. **Low-value** marshes were assigned **lower restoration priority** because they are less valuable to people and wildlife.

Factor 3: Migration Potential (relative size of high-potential adjacent migration area)

A. **High-migration-potential** marshes were assigned **higher migration facilitation priority** because it represents a practical and long-term intervention opportunity and will benefit cumulative marsh area regionally.
B. **Low-migration-potential** marshes were assigned **lower migration facilitation priority** because migration facilitation is less practical at these marshes.
C. **High-migration-potential** marshes were assigned **lower restoration priority** because migration facilitation may be more practical or effective to sustain or improve conditions at these marshes.
D. **Low-migration-potential** marshes were assigned **higher restoration priority** because in-marsh restoration may be the only viable option to sustain them.

Appendix 6: Guidance for restoration actions to target human disturbances

All below recommendations are based on the intensity scores as defined and documented in the *Wetland Disturbances* section of MarshRAM (Appendix 2) for each site, and as reported in Tables 1 and 3 of the Framework. These recommendations are for *consideration* of the practices; several factors may affect the viability or appropriateness of the practices for any given site.

Buffer management (BM) should be considered as a potential restoration practice when >25% of the marsh buffer zone to 30m is dominated by developed land (denoted as XXX or XX in Tables 1 and 3), and as an ancillary practice when 6 to 25% of the marsh buffer zone to 30m is dominated by developed land (denoted as X in Tables 1 and 3).

Drainage enhancement (DE) should be considered as a potential restoration practice when >10% of the marsh platform is covered by bare die-off depressions (denoted as XXX or XX in Tables 1 and 3), and as an ancillary practice when <10% of the marsh platform is covered by bare die-off depressions (denoted as X in Tables 1 and 3).

Edge stabilization (ES) should be considered as a potential restoration practice when >10% of the marsh edge is eroded (denoted as XXX or XX in Tables 1 and 3), and as an ancillary practice when <10% of the edge is eroded (moderate or high erosion, denoted as X in Tables 1 and 3).

Elevation enhancement (EE) may be considered as a potential restoration practice when >10% of the marsh platform is covered by bare die-off depressions (denoted as XXX or XX in Tables 1 and 3). This practice is currently considered experimental, poses a risk of unintended harm, and requires a source of clean, sandy (preferably) sediments from a nearby dredging operation or quarry.

Fill removal (FR) should be considered as a potential restoration practice when >10% of the marsh area or perimeter is covered with fill (denoted as XXX or XX in Tables 1 and 3), and as an ancillary practice when <10% of the marsh area or perimeter is covered with fill (denoted as X in Tables 1 and 3).

Invasive species management (ISM) should be considered as a potential restoration practice when >10% of the marsh platform is covered by *Phragmites australis* (denoted as XXX or XX in Tables 1 and 3), and as an ancillary practice when <10% of the marsh platform is covered by *Phragmites australis* (denoted as X in Tables 1 and 3).

Nutrient management (NM) should be considered as a potential restoration practice when sources and impacts of nutrient inputs are clearly evident (denoted as XXX or XX in Tables 1 and 3), and as an ancillary practice when only sources are evident (denoted as X in Tables 1 and 3). Nutrient sampling is recommended when there is any doubt about nutrient inputs.

Pool and creek restoration (PCR) may be considered as a potential restoration practice when the intensity of ditching is observed to be moderate or higher (>100m/Ha, denoted as XXX or XX in Tables 1 and 3), or as a way to increase habitat diversity in a hydrologically-modified or filled marsh. PCR can range from introduction of small pools to ditch filling and entire marsh-drainage reconfiguration, which poses a risk of unintended harm. Large-scale PCR has not been demonstrated on in Rhode Island, although small pools dug on the marsh platform have been shown to support diverse nekton. Digging new pools should be avoided in marshes showing signs of drowning (e.g., >10% die-off bare depressions), as it could trigger *pond runaway* (Mariotti et al. 2020).

Tidal flow (TF) restoration should be considered as a potential restoration practice when a tidal restriction is observed to cause changes in vegetation, elevation, proportion of open water, or marsh function (denoted as XXX or XX in Tables 1 and 3), and as an ancillary practice when a restriction is observed that restricts tidal flow but no other marsh changes are observed (denoted as X in Tables 1 and 3).

Appendix 7

RICRMC Coastal and Estuarine Habitat Restoration Trust Fund

2018/2019 Non-Planning Project Evaluation Worksheet

RICRMC Coastal and Estuarine Habitat Restoration Trust Fund
2018/2019 Non-Planning Project Evaluation Worksheet

Project Proposal Title : ____

Project Proposal Total Percentage Score : __________ **Planning Project?** Y / N

Reviewer: Score each statement 0-3 (0=disagree, 1=somewhat agree, 2=agree, 3=strongly agree)

Proposal Narrative

1. *Purpose*: The proposed project seeks to restore ecological function to an area that has been degraded by human impacts. Project goals are specific, measurable, achievable, results-oriented and time-sensitive. (score value multiplied by 2) ____ x 2 = ____

2. *Justification*: Habitat degradation at the proposed project site is the result of anthropogenic impacts, and is significant enough to warrant investment in restoration efforts. (score value multiplied by 2) ____ x 2 = ____

3. *Activities*: Proposed project activities are reasonable in scope and likely to result in significant long-term improvements to the habitat value of the project site. (score value multiplied by 2) ____ x 2 = ____

4. *Schedule and Work Plan*: The proposed schedule and work plan are reasonable. The proposed project will be completed within 2 years of the award date. _____

5. *Adverse Impacts*: An effort has been made to identify any potential adverse impacts resulting from project activities, and to minimize those impacts. _____

6. *Public Support/EducationalBenefits*: An effort has been made to gain support for the proposed project from the surrounding community including adjacent landowners and other stakeholders. Public outreach and education efforts (e.g. interpretive signage, workshops) have been planned and/or implemented. _____

7. *Economic Benefits*: It has been demonstrated that the proposed project will result in significant economic benefits to the surrounding community and/or the state. _____

8. *Climate Change and Coastal Resiliency*: The present and future impacts of climate change at the project site have been considered. The project will improve the targeted habitat's resilience to climate change. _____

9. *Planning Consistency/Restoration Priority*: The project is consistent with the goals of one or more local, state or regional planning initiatives. The project involves one or more state, regional or federal priority habitat needs or special considerations. _____

10. *Species of Concern*: The project is likely to result in benefits to wildlife species listed as federally or state endangered, threatened, or species of concern within Rhode Island. _____

11. *Permitting:* Necessary federal, state and/or local permits have been identified, and are likely to be granted. _____

12. *Capacity of Lead Organization*: The lead and/or partner organization(s) have demonstrated their capacity to successfully complete the proposed project. The lead and/or partner organization(s) have successfully completed previous habitat restoration projects similar to the type proposed. _____

Section Total (out of possible 45 points) = ______

Sustainability

1. *Lifespan:* The estimated lifespan of planned restoration activities is at least 15 years. ____

2. *Maintenance:* All short-term and long-term operation and maintenance requirements have been identified. Responsibility has been assigned for all future O & M activities. Funding and/or in-kind contributions have been secured for all future O & M activities. ____

3. *External Factors:* An effort has been made to identify external factors that could reduce the likelihood of achieving project goals. Steps have been planned / taken to address these factors. Additional measures, such as the acquisition of conservation easements have been taken to ensure the long-term success of the project. ____

4. *Climate Change and Sea Level Rise:* An attempt has been made to predict and address the likely effects of climate change and future sea level rise on the proposed project. If applicable, predicted future sea level rise has been incorporated into the project design. ____

Section Total (out of possible 12 points) = _____

Evaluating Project Success

1. *Performance Measures*: Specific performance measures have been identified and will be used to determine the success of the project. ____

2. *Monitoring Plan:* A detailed monitoring plan has been included with the proposal that includes both pre- and post-project monitoring activities. The parameters to be monitored are directly related to the project goals set forth in the proposal. ____

3. Responsibility for all monitoring activities has been assigned. Funding and/or in-kind contributions for monitoring activities have been identified and/or secured. ____

Section Total (out of possible 9 points) = _____

Project Budget

1. All likely project expenses have been identified and sufficient detail included in the project budget and budget narrative. The proposed budget is realistic, given project needs and timeframe. ____

2. Matching funds and/or in-kind contributions have been secured. (no match=0, up to 25%=1, 26-50%=2, 50% or more=3) ____

Section Total (out of possible 6 points) = _____

Total Score (all sections) _____

Divide score by **72** to get percentage score _______**%**