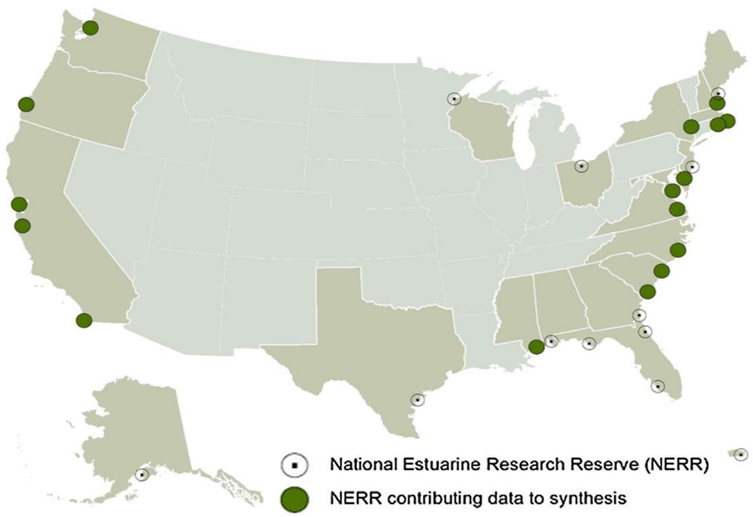
Rising to the challenge: Will tidal marshes survive rising seas?

Presented by: Jordan Mora, Waquoit Bay National Estuarine Research Reserve, Waquoit MA

Tidal marshes provide many benefits to nearby communities. They protect people and property against storm surges and flooding, improve water quality, and create habitat for commercially important fish and wildlife. Historically, marshes have remained in balance with rising sea levels through the accumulation of organic matter and sediments. However, the effectiveness of these two mechanisms depends on the local tidal range and sediment supply, which vary greatly across geographic regions. With sea levels projected to increase much faster with human-induced climate change, the fate of many marshes is now uncertain.



The Waquoit Bay National Estuarine Research Reserve (NERR) collaborated with 15 other NERRs to investigate regional differences in marsh resilience. The study is based on an innovative approach that evaluates five categories of resilience: marsh elevation; change in elevation; sediment supply; tidal range; and rate of sea level rise (see Figure 1). We refer to the set of metrics as **MARS indices**, assessing the tidal **Mar**sh **R**esilience to **S**ea-level rise.

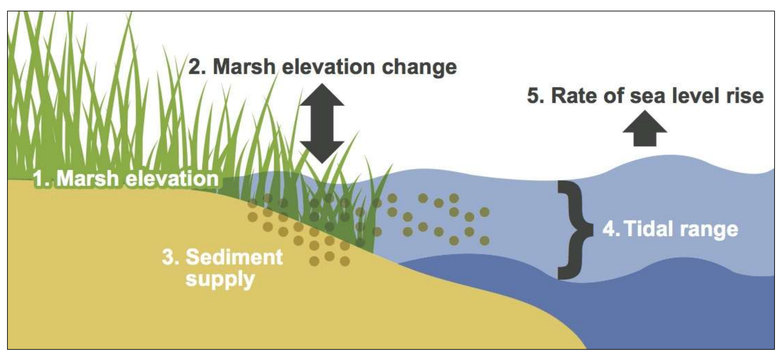
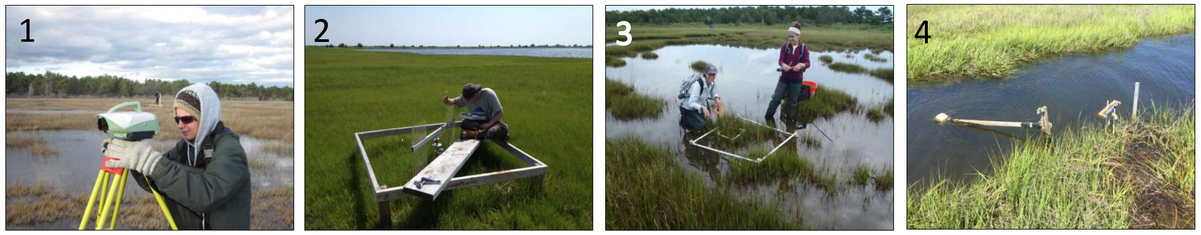


Figure 1: Diagram of the 5 major components in the MARS indices.



Sage Lot Pond (SLP) biomonitoring at the Waquoit Bay NERR: Elevation control marks, installed in 2011, were monitored for vertical movement with digital rod and level survey for two years (photo 1). Annual elevation measurements began in 2013 using a surface elevation table (photo 2). Annual tidal marsh vegetation monitoring (120 permanent, square-meter plots) started in August 2011 (photo 3). Real-time Kinematic GPS was used to obtain the elevation of each vegetation plot. Consistent, local water level recording started in 2013 (photo 4).

Table 1: Marsh resilience categories , metrics used , and data needs for each metric.

Category	Metric	Data needs
Marsh elevation distributions	Percent of marsh below mean high water	Frequency distribution of marsh elevation
		Estimate of mean high water
	Percent of marsh in lowest third of plant distribution	Frequency distribution of marsh elevation
	Skewness	Frequency distribution of marsh elevation
Marsh elevation change	Elevation change rate (mm/yr)	Time-series data from surface elevation tables
Sediment/accretion	Short-term accretion rate (mm/yr)	Time-series data from marker horizons
	Long-term accretion rate (mm/yr)	Soil cores for radiometric dating
	Turbidity (NTU)	Mean turbidity from water quality sondes
Tidal range	Tidal range (m)	Mean daily tidal range from water level loggers
Sea level rise	Long-term rate of SLR (mm/yr)	Long-term data from water station (e.g., NWLON)
	Short-term variability in water levels (mm)	Inter-annual data from water level station

Table 2: Color-coded results for metric categories and overall MARS index scores at 16 study sites.

	US State	Marsh Name and National Estuarine Research Reserve	CATEGORIES OF MARSH RESILIENCE TO SEA LEVEL RISE: Marsh Elevation	Elevation Change	Sediment Supply	Tidal Range	Sea Level Rise	Overall Resilience
EAST COAST	NH	Great Bay Discovery Center, Great Bay						
	MA	Sage Lot Pond, Waquoit Bay						
	RI	Nag West, Narragansett Bay						
	NY	Outer Tivoli North, Hudson River						
	DE	St. Jones Reserve, Delaware						
	MD	Jug Bay, Chesapeake Bay						
	VA	Goodwin Island Reserve, Chesapeake Bay						
	NC	Masonboro Island, North Carolina						
	SC	Crabhaul Creek, North Inlet-Winyah Bay						
	SC	Big Bay Creek, ACE Basin						
	MS	Grand Bay, Grand Bay						
WEST COAST	WA	Sullivan Minor, Padilla Bay						
	OR	Hidden Creek, South Slough						
	CA	China Camp State Park, San Francisco Bay						
	CA	Upper Slough Marshes, Elkhorn Slough						
	CA	Oneonta Slough, Tijuana River						

RESILIENCE TO SEA LEVEL RISE: Low — High

The low resilience score at SLP is a product of two main limiting factors: a low sediment supply from the incoming tide and a relatively small tidal range (1-3 ft). At SLP the impacts of sea level rise are proportionally greater than at a site with a larger tidal range (e.g., 6-9 ft). For example, the metric *percent of marsh below mean high water* was >60% at SLP, versus <40% at the mid-Atlantic sites, indicating that recent sea level rise has increased flooding extent and duration more at the SLP marsh.

HOW DOES YOUR MARSH COMPARE?

Comparing marsh resiliency based on the MARS indices can improve management efficacy and help shape policy across local, regional, and national scales. For example, marshes that have an overall low resilience score may be better slated for facilitation of migration rather than expensive restoration actions such as sediment augmentation. Apply the MARS index assessment to determine the best management approach for protecting tidal marshes in your area.
www.nerra.org/marsh

Reference:

Raposa, K.B., K. Wasson, E. Smith, J.A. Crooks, P. Delgado, S.H. Fernald, M.C. Ferner, A. Helms, L.A. Hice, J.W. Mora, B. Puckett, D. Sanger, S. Shull, L. Spurrier, R. Stevens, and S. Lerberg. 2016. Assessing tidal marsh resilience to sea-level rise at broad geographic scales with multi-metric indices. *Biological Conservation*. http://dx.doi.org/10.1016/j.bicon.2016.10.015

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