How to Sustain New England's Tidal Marshes in the Face of Sea Level Rise?

A Case Study of Action-oriented Knowledge Sharing among Scientists, Managers, and Stakeholders

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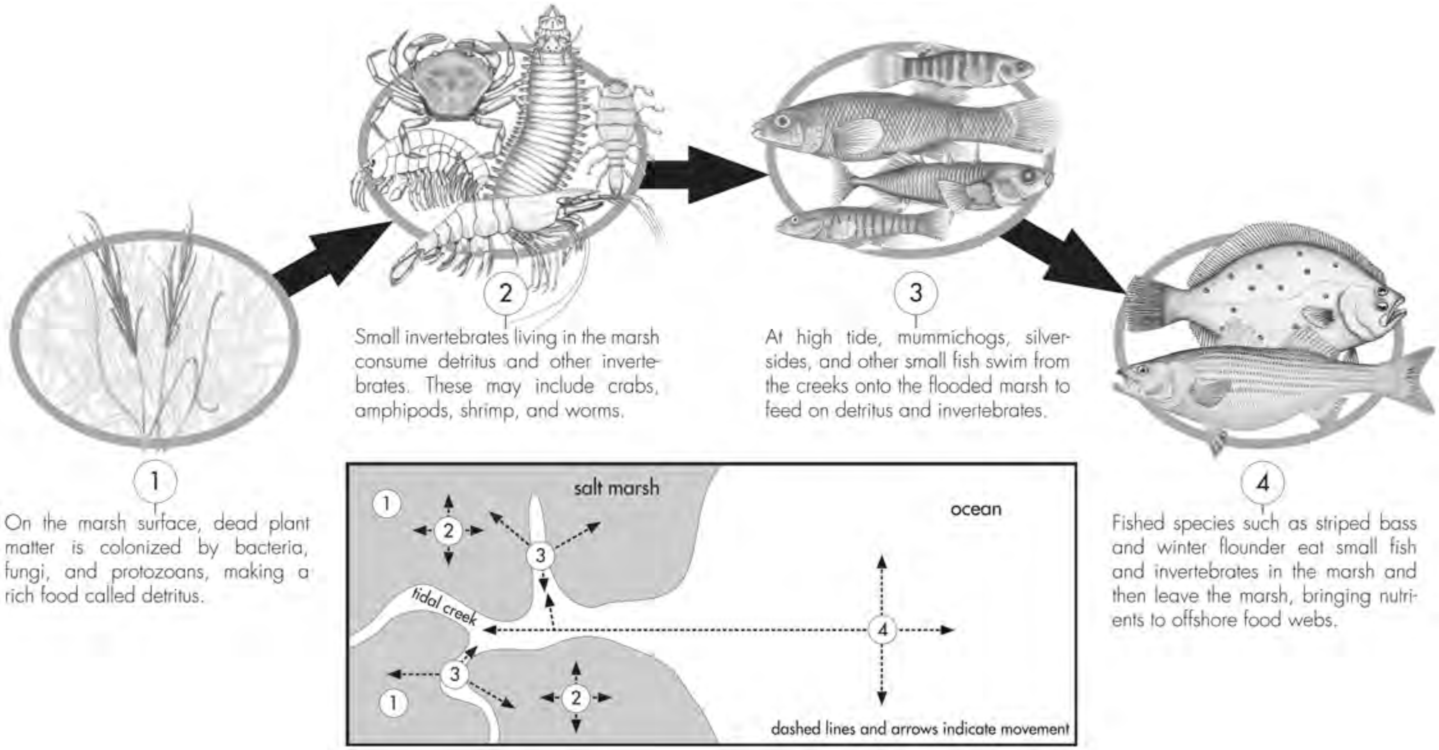
1
On the marsh surface, dead plant matter is colonized by bacteria, fungi, and protozoans, making a rich food called detritus.
2
Small invertebrates living in the marsh consume detritus and other invertebrates. These may include crabs, amphipods, shrimp, and worms.
3
At high tide, mummichogs, silversides, and other small fish swim from the creeks onto the flooded marsh to feed on detritus and invertebrates.
4
Fished species such as striped bass and winter flounder eat small fish and invertebrates in the marsh and then leave the marsh, bringing nutrients to offshore food webs.
salt marsh
ocean
tidal creek
dashed lines and arrows indicate movement


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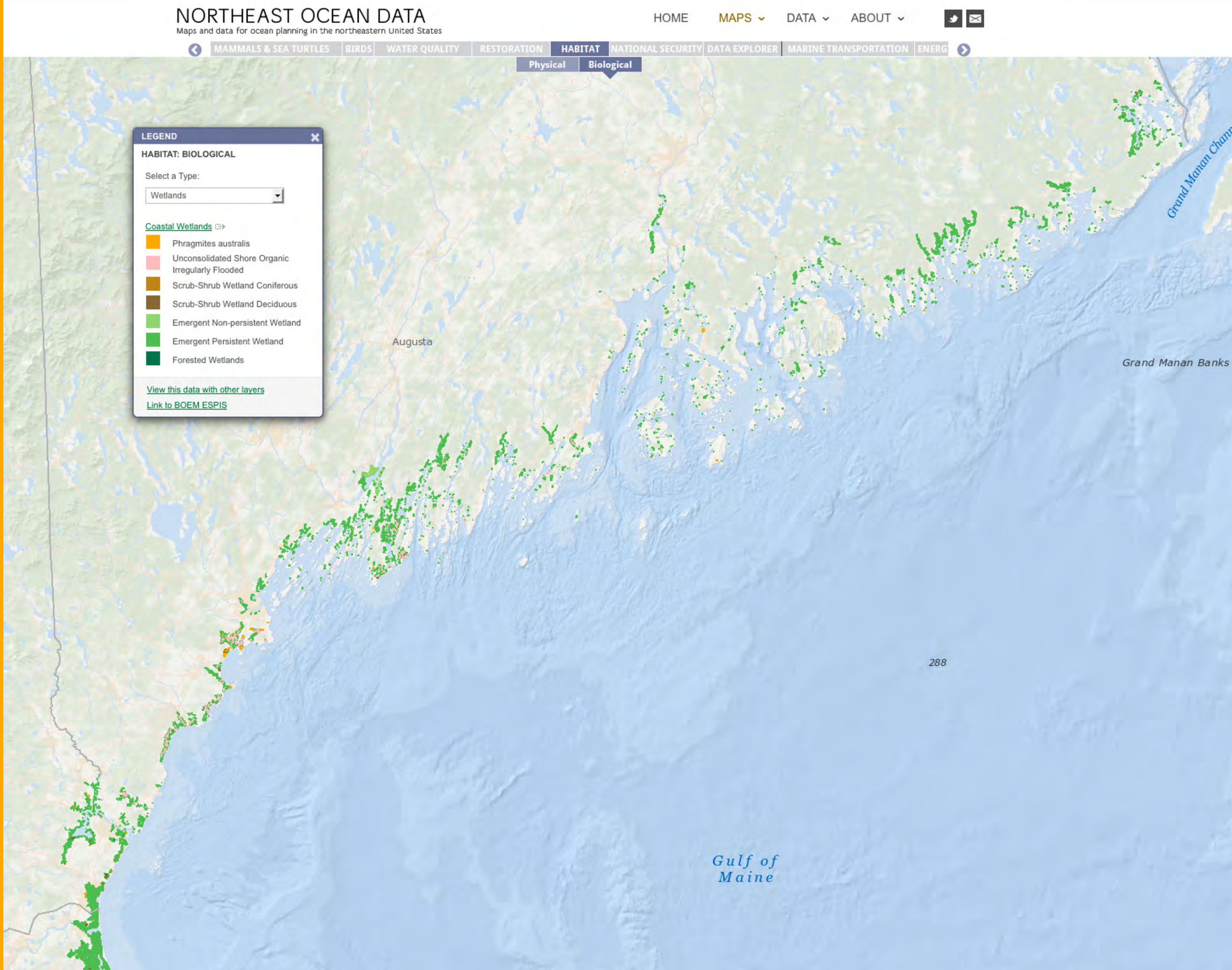

NORTHEAST OCEAN DATA
Maps and data for ocean planning in the northeastern United States
HOME
MAPS
DATA
ABOUT
MAMMALS & SEA TURTLES
BIRDS
WATER QUALITY
RESTORATION
HABITAT
NATIONAL SECURITY
DATA EXPLORER
MARINE TRANSPORTATION
ENERG
Physical
Biological
LEGEND
HABITAT: BIOLOGICAL
Select a Type:
Wetlands
Coastal Wetlands
Phragmites australis
Unconsolidated Shore Organic Irregularly Flooded
Scrub-Shrub Wetland Coniferous
Scrub-Shrub Wetland Deciduous
Emergent Non-persistent Wetland
Emergent Persistent Wetland
Forested Wetlands
View this data with other layers
Link to BOEM ESPIS
Augusta
Grand Manan Banks
288
Gulf of Maine

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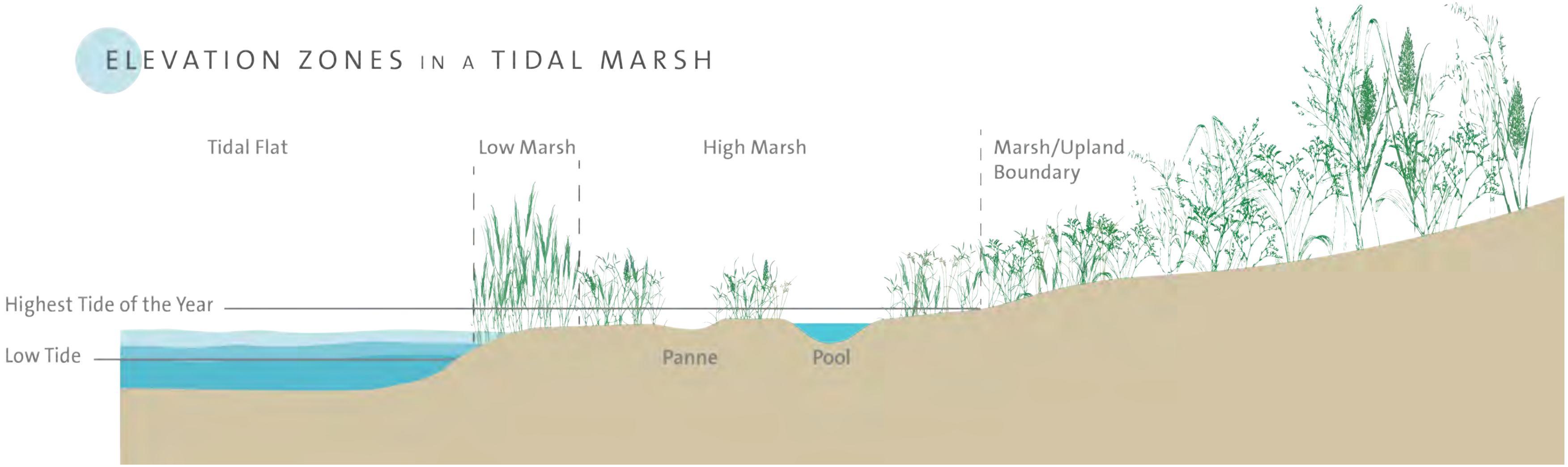

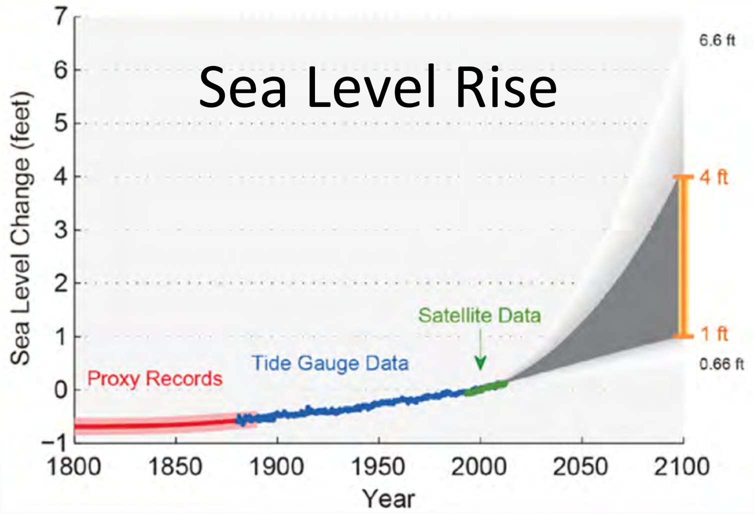

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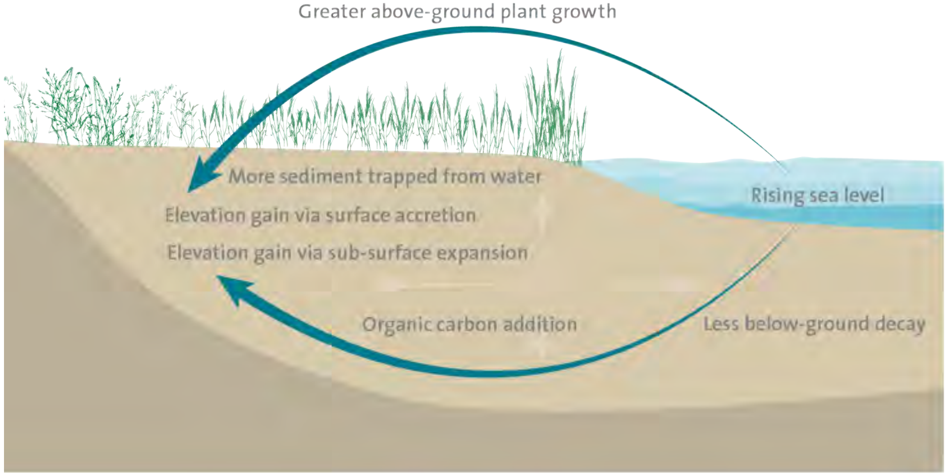
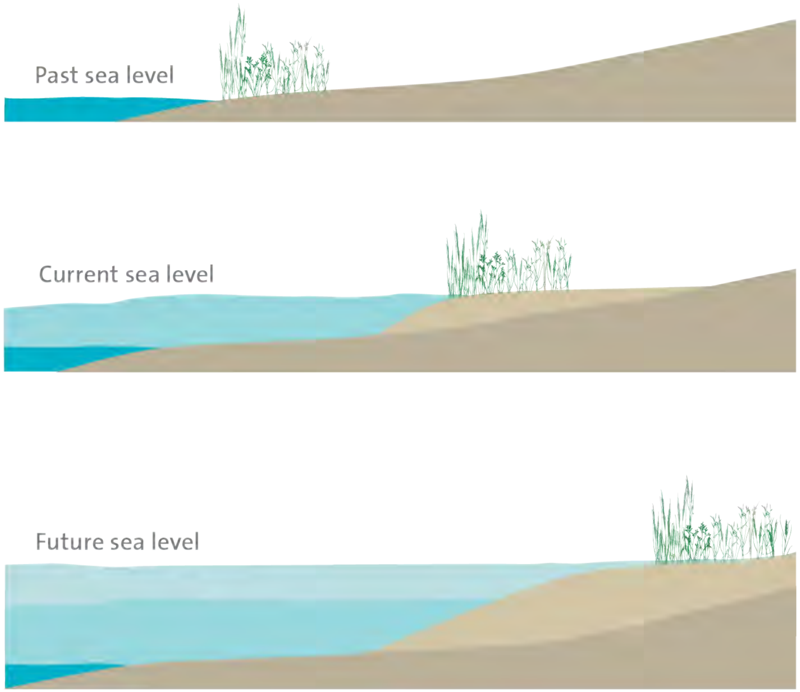
Two Ways for Marshes to Survive—for a Time

Tidal marshes in the Northeast have evolved and persisted in the face of rising seas for thousands of years. Natural feedback loops among biology, geology, and hydrodynamics in marshes enable them to survive when the rate of sea level rise is low to moderate. Two types of changes make this posssible.

INCREASE IN MARSH SURFACE ELEVATION

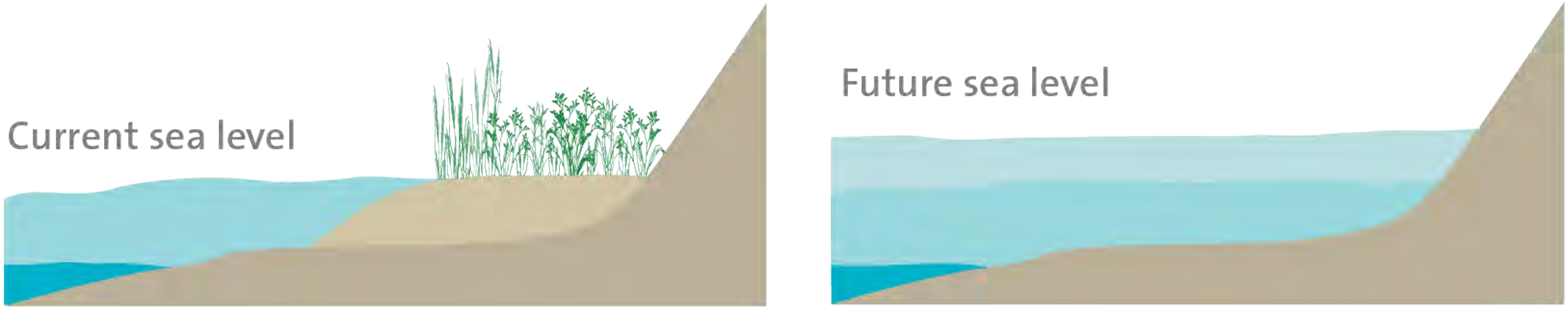


MIGRATION TO HIGHER GROUND

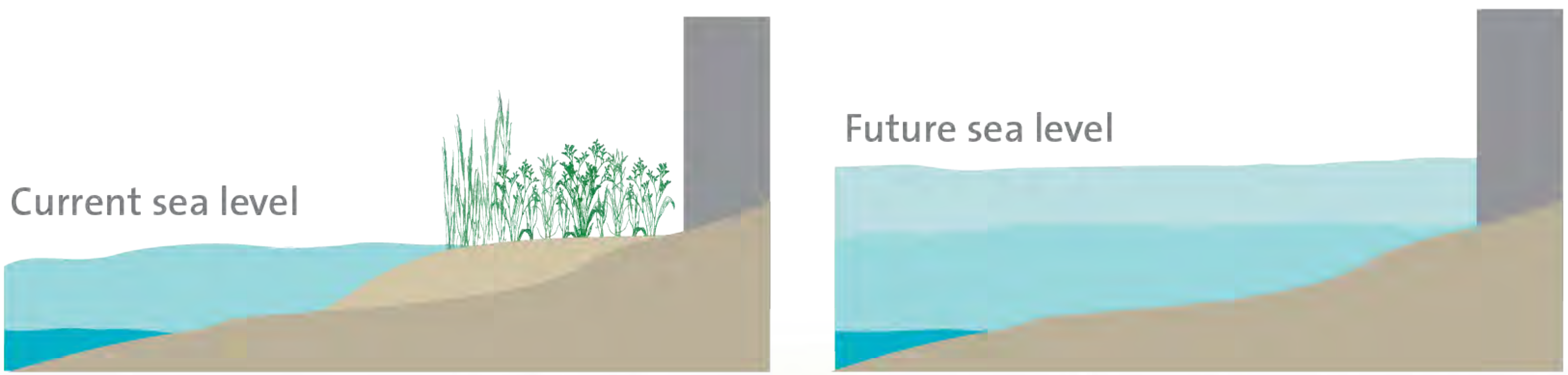


BARRIERS TO MARSH MIGRATION

Steep terrain impairs or prevents marsh migration



Land development blocks marsh migration



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PROJECTED SEA LEVEL RISE PRESENTS UNPRECEDENTED CHALLENGES TO THE SURVIVAL OF TIDAL MARSHES.

- Sea level is rising so quickly that it could outpace the natural processes that normally enable marshes to keep from drowning.
- Roadways, seawalls, and other features of land development will block some marshes from shifting landward.

A Priority Issue for Scientists and Managers

The Northeast Regional Ocean Council (NROC) is a state and federal partnership that facilitates the New England states, federal agencies, regional organizations, and other interested regional groups in addressing ocean and coastal issues that benefit from a regional response.

NROC
Northeast Regional
Ocean Council

NROC's partners identified **tidal marsh migration** as a priority issue because of marshes' ecological significance, valuable ecosystem services, and vulnerability to climate change.

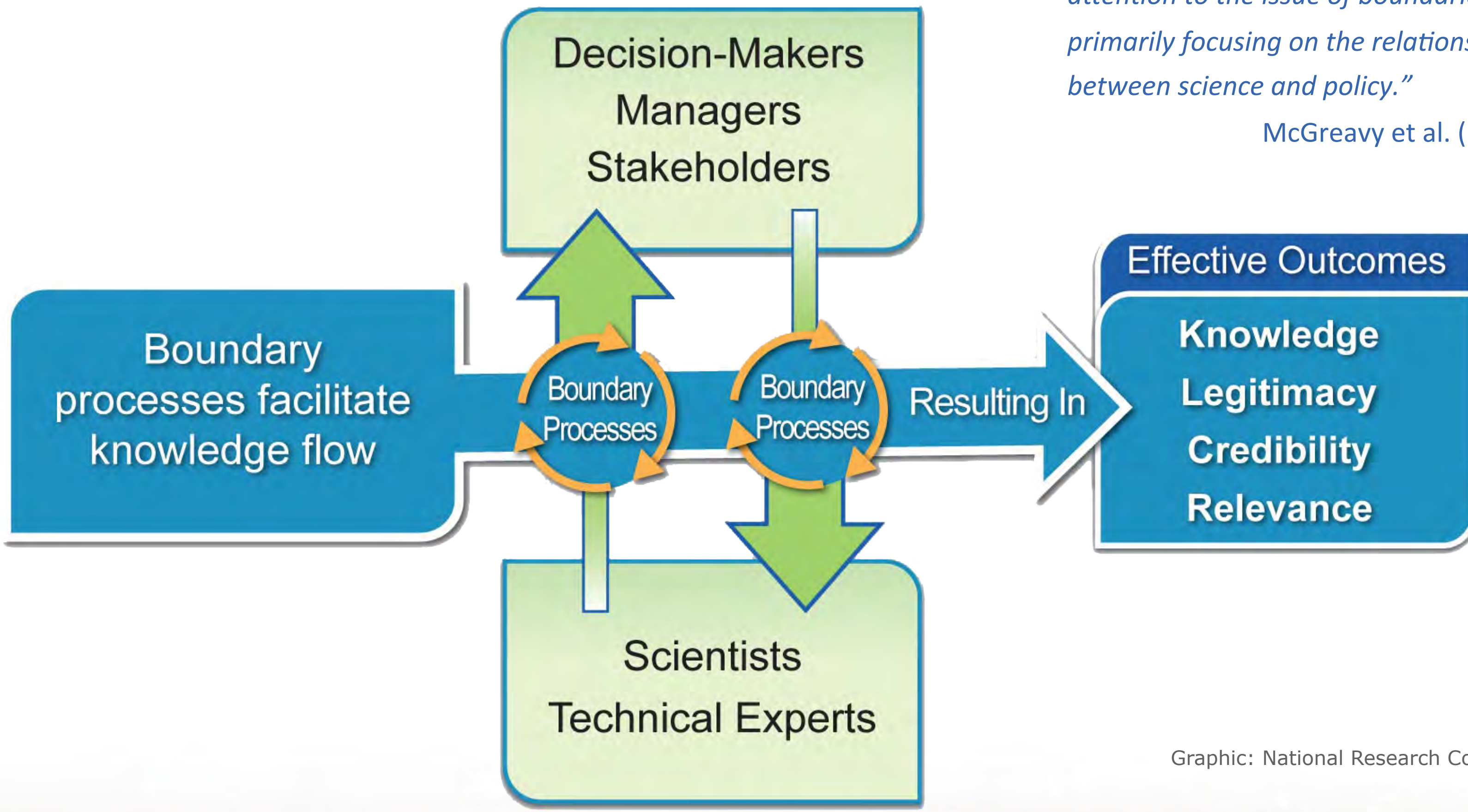
The Need for Action: Collaboration among Scientists and Managers

- Rapidly advancing basic and applied science
- Significant ecological and socioeconomic consequences
- Management and policy efforts already happening (local, state, regional)

Working Across the Boundary

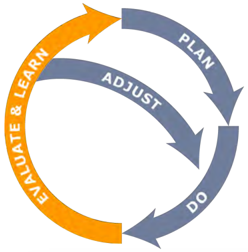
"Research in the field of sustainability science has committed significant attention to the issue of boundaries, primarily focusing on the relationship between science and policy."

McGreavy et al. (2013)

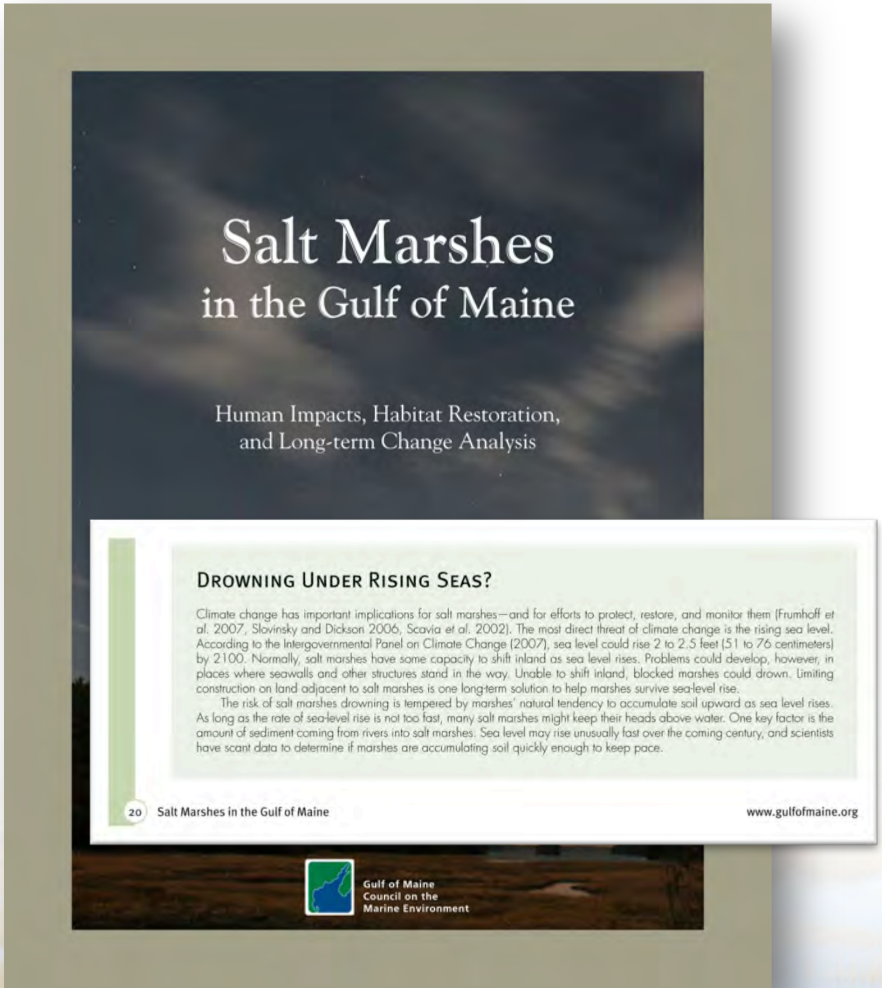


Graphic: National Research Council

A **boundary organization** facilitates collaboration and information flow between the research and public policy communities. **Role of a boundary organization:** (1) Translation and creation of "boundary objects," (2) Participation and co-production, (3) Dual accountability (Parker and Crona 2012)



Building on Our Previous Boundary Work



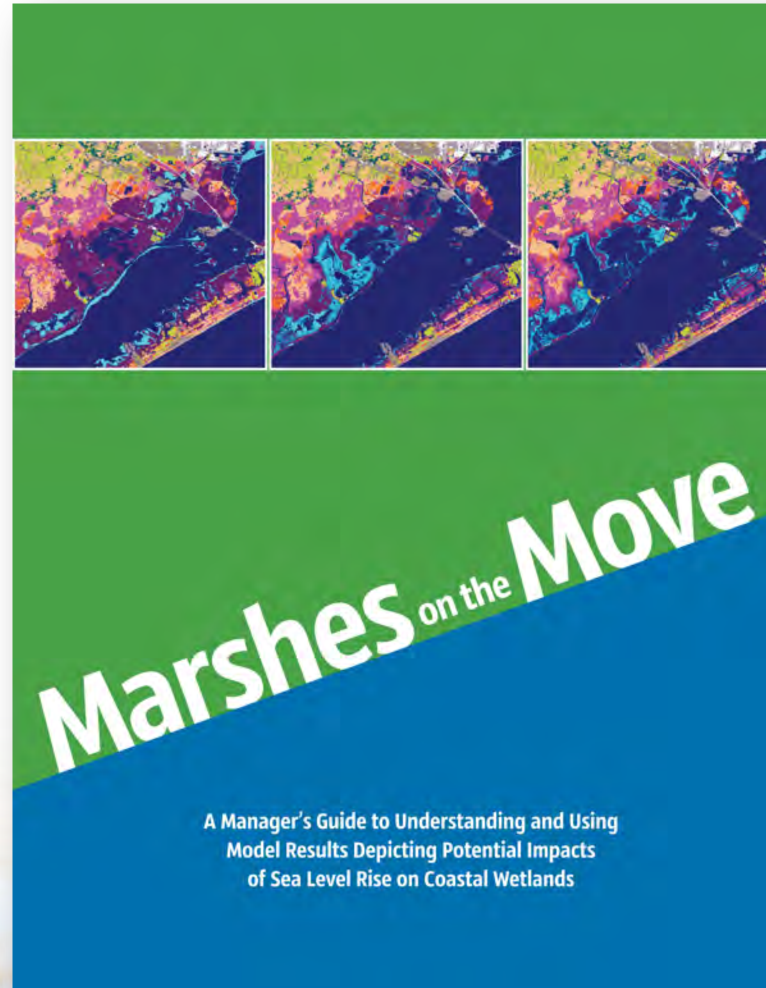
DROWNING UNDER RISING SEAS?

Climate change has important implications for salt marshes—and for efforts to protect, restore, and monitor them (Frumhoff et al. 2007, Slovinsky and Dickson 2006, Scavia et al. 2002). The most direct threat of climate change is the rising sea level. According to the Intergovernmental Panel on Climate Change (2007), sea level could rise 2 to 2.5 feet (51 to 76 centimeters) by 2100. Normally, salt marshes have some capacity to shift inland as sea level rises. Problems could develop, however, in places where seawalls and other structures stand in the way. Unable to shift inland, blocked marshes could drown. Limiting construction on land adjacent to salt marshes is one long-term solution to help marshes survive sea-level rise.

The risk of salt marshes drowning is tempered by marshes' natural tendency to accumulate soil upward as sea level rises. As long as the rate of sea-level rise is not too fast, many salt marshes might keep their heads above water. One key factor is the amount of sediment coming from rivers into salt marshes. Sea level may rise unusually fast over the coming century, and scientists have scant data to determine if marshes are accumulating soil quickly enough to keep pace.

20 Salt Marshes in the Gulf of Maine www.gulfofmaine.org

2008



2011

Many Partners

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Peter Taylor	Lead
Molly Brown	Geographer / Communicator
Ginny Howe	Illustrator / Graphic Designer
Keil Schmid	Coastal Geoscientist / Modeler
Sally Ann Sims	Coastal Ecologist / Technical Writer

NROC Northeast Regional Ocean Council

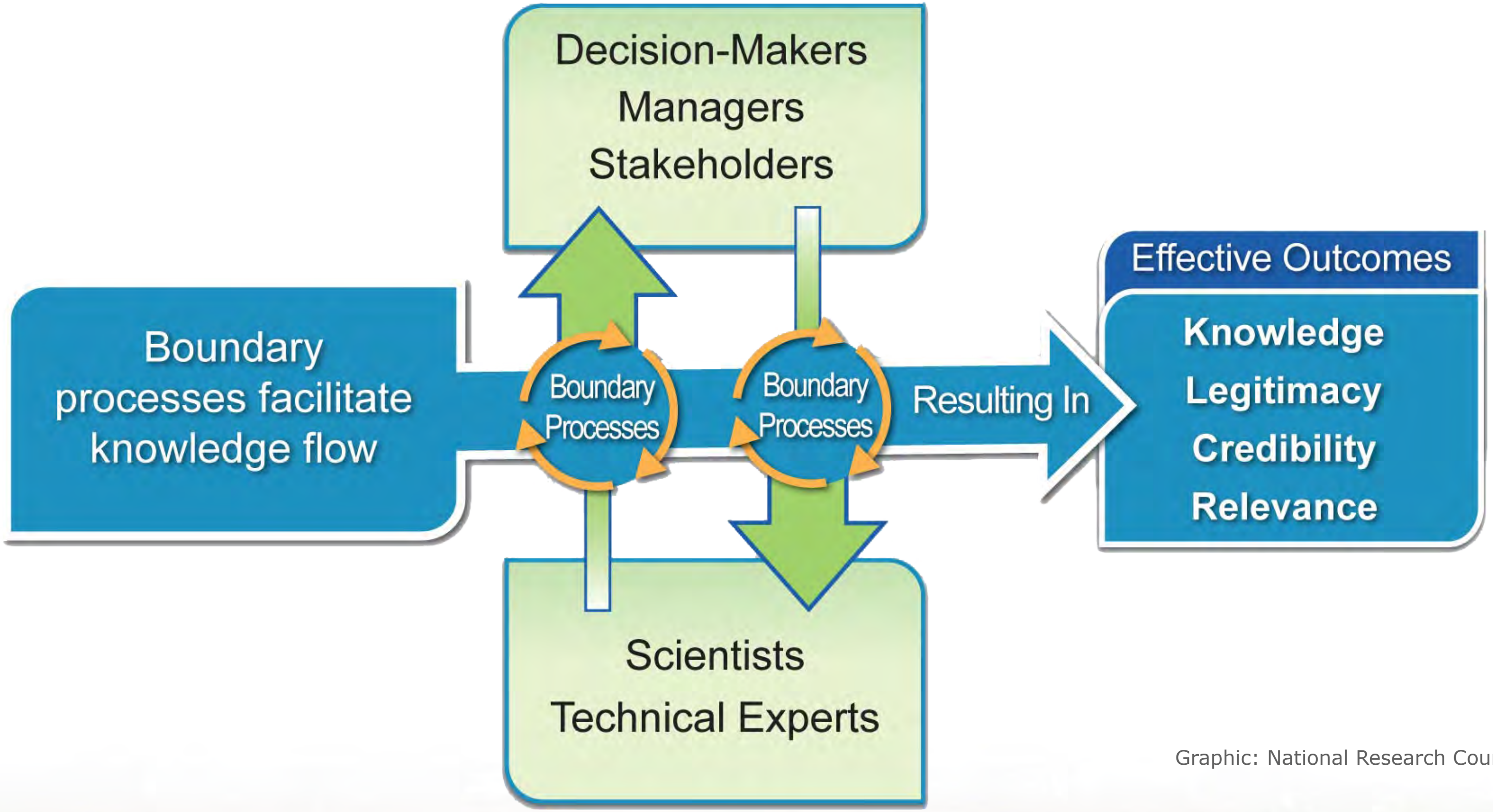
Ocean and Coastal Ecosystem Health Committee

Project Lead: Regina Lyons, EPA

Project Steering Committee

States:	Federal:
Connecticut	EPA
Rhode Island	National Park Service
Massachusetts	USFWS
New Hampshire	USGS
Maine	
New York	

Working Across the Boundary



Graphic: National Research Council

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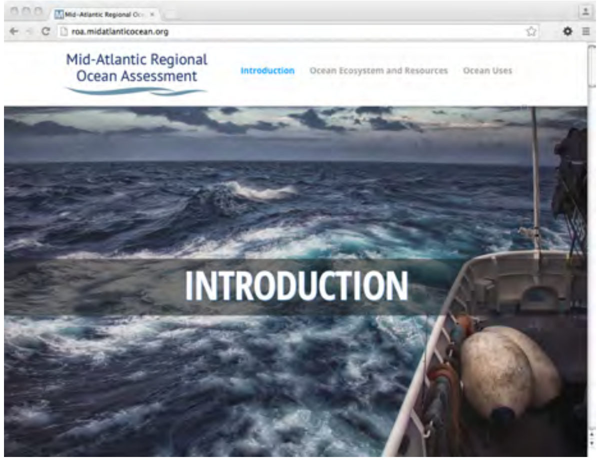
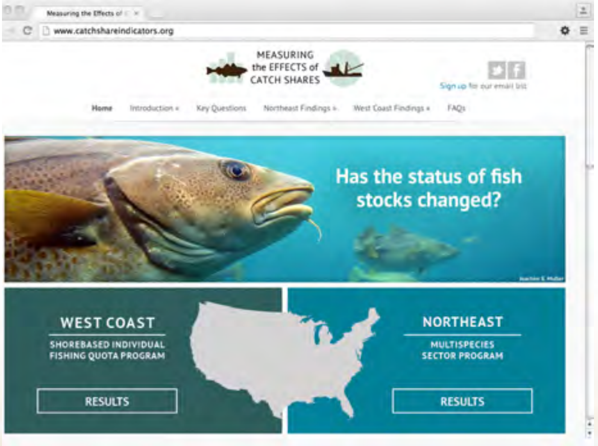
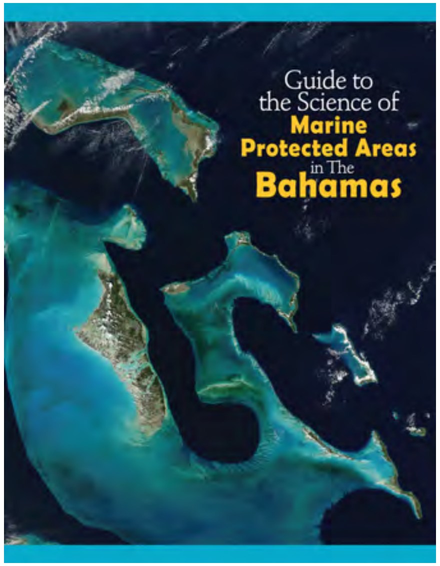
Working Across the Boundary



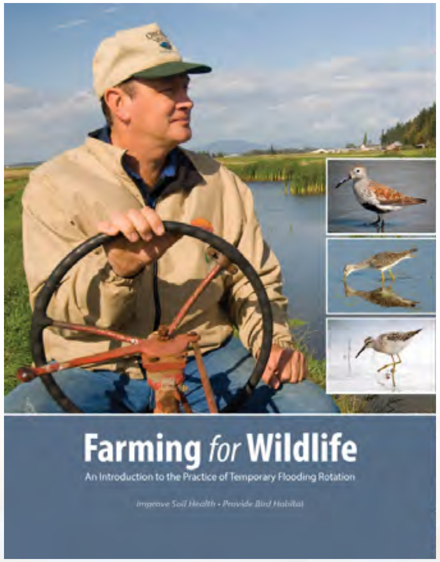
Regional Ocean Planning
Mid-Atlantic Regional Council on the Ocean



Fisheries
MRAG & Moore Foundation



Marine Protected Areas
American Museum of Natural History



Shorebird Conservation
The Nature Conservancy

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Working Across the Boundary

Needs Assessment → Scoping & Planning → Delivery

Needs Assessment

What are the **key linkages** among scientists, decision-makers, managers, and stakeholders that are weak or missing?

Scoping & Planning

How can we best **build or strengthen** the linkage(s)?

What **key messages** need to be conveyed?

Delivery

How can we best **implement** the plan and effectively deliver the key messages?

Information gathering
Writing & editing
Design
Production
Release

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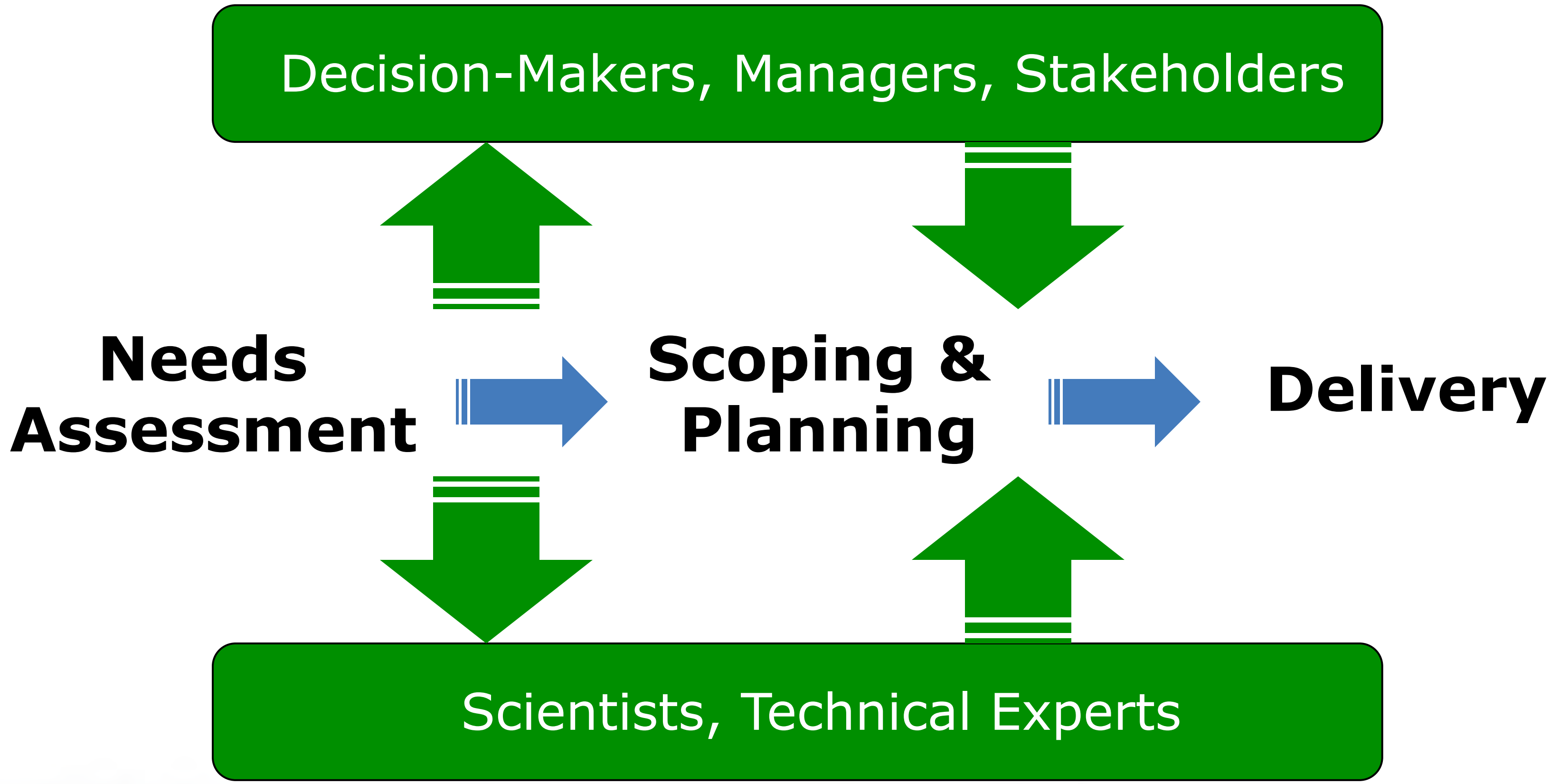
“Adaptive Communications”



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Many Partners

Casco Bay Estuary Partnership

Catalysis Adaptation Partners

CT Dept. of Energy & Environmental Protection

EPA

Great Bay National Estuarine Research Reserve

Long Island Sound Study

Maine Coastal Program

Maine Geological Survey

Maine Natural Areas Program

Mass Audubon

MassBays

MA Division of Ecological Restoration

MA Office of Coastal Zone Management

Merrimack Valley Planning Commission

National Park Service

NOAA

New England Interstate Water Pollution Control Commission

NH Dept. of Environmental Services

NH Fish and Game Dept.

RI Coastal Resources Management Council

Rockingham Planning Commission

The Nature Conservancy

Town of Newbury

USFWS

USGS

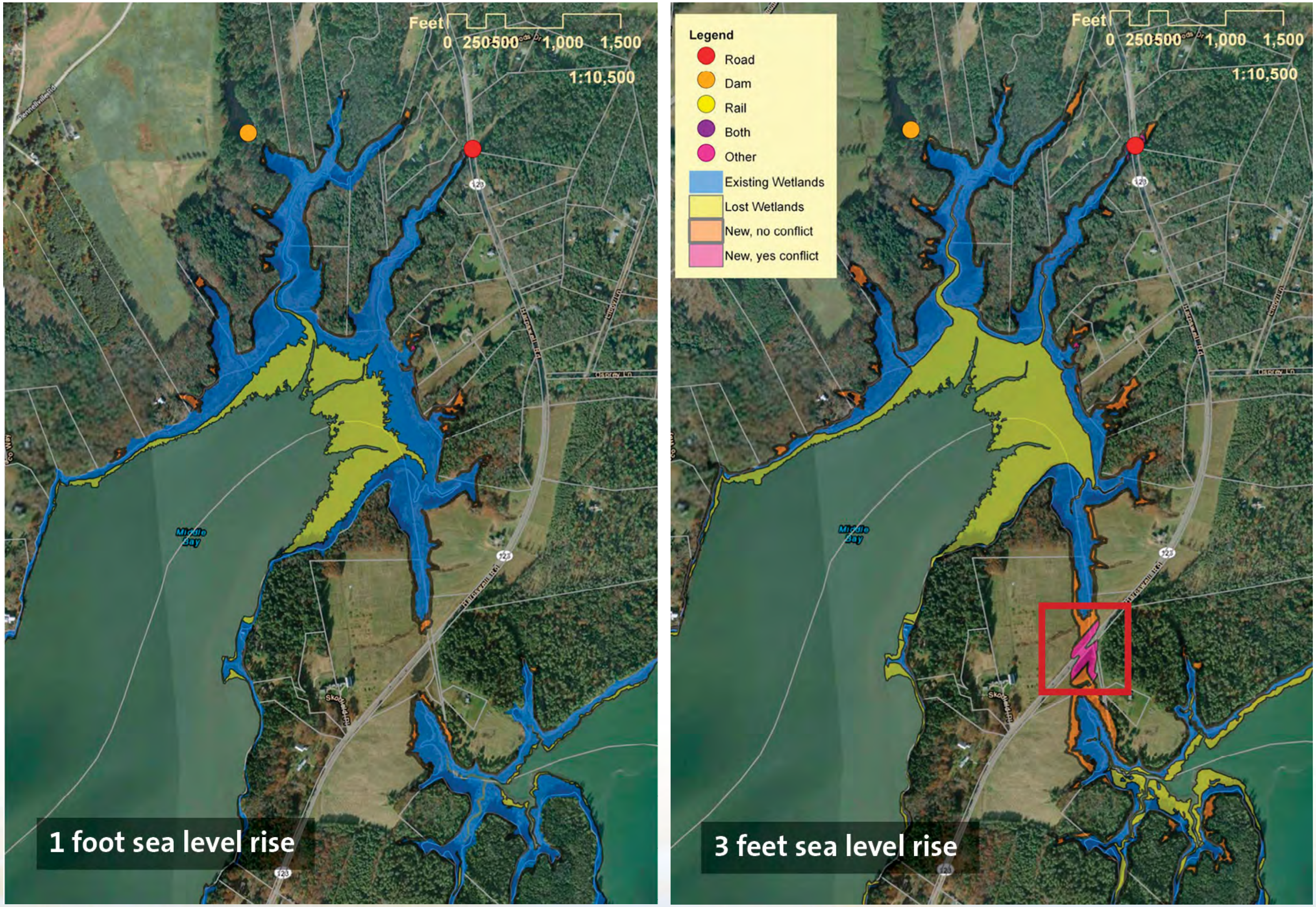
University of Connecticut

University of New Hampshire

Warren Pinnacle Consulting

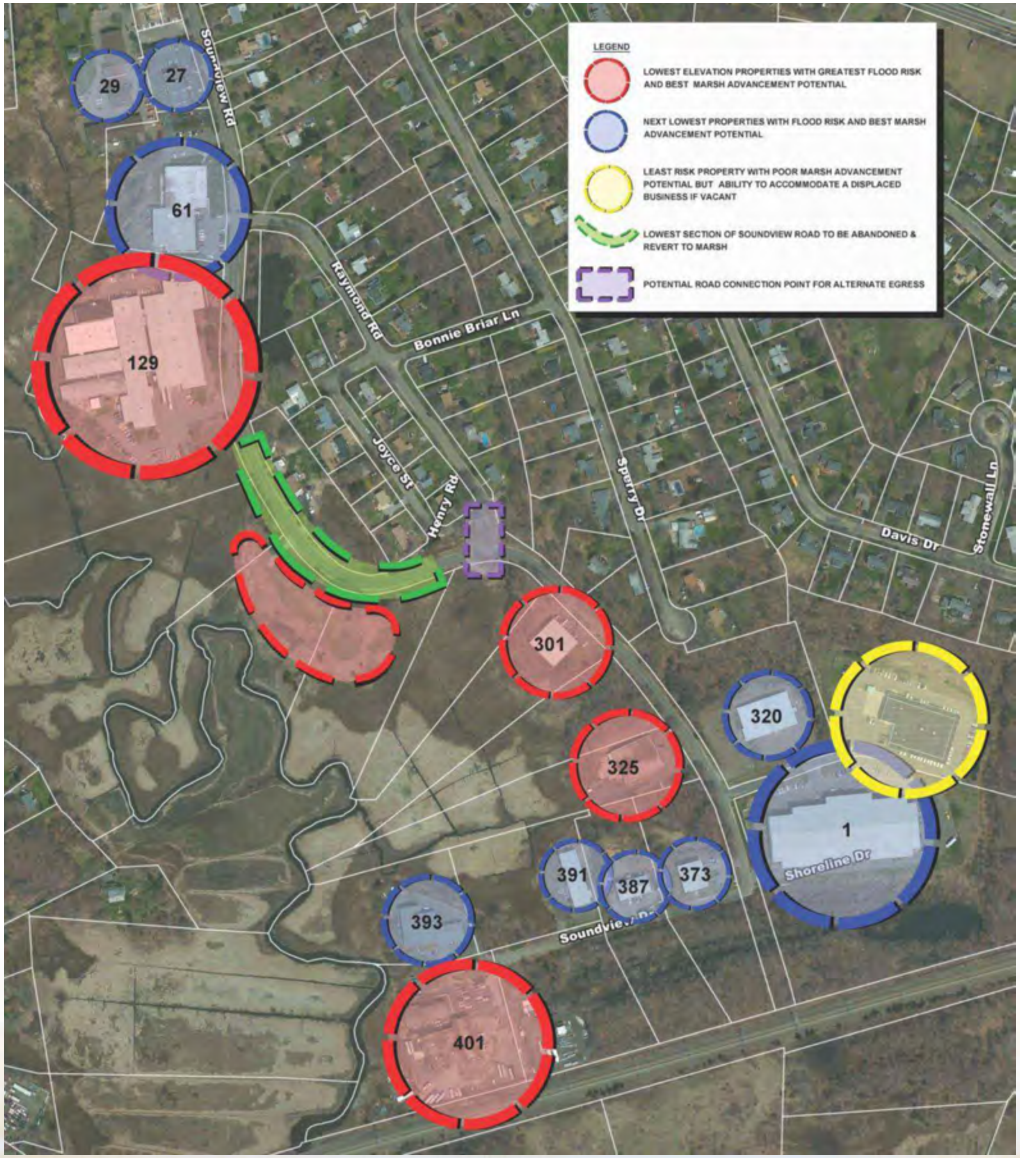
Yale University

Focus on Modeling of Marsh Migration



Credit: Casco Bay Estuary Partnership

…But Not So Much on Management Applications (Yet)



Connecting Marsh Migration with Other Management Priorities

- Protecting Roads & Other Infrastructure
- Reducing Vulnerability of Communities to Storm Damage
- Improving Water Quality
- Maximizing Long-term Success of Habitat Restoration

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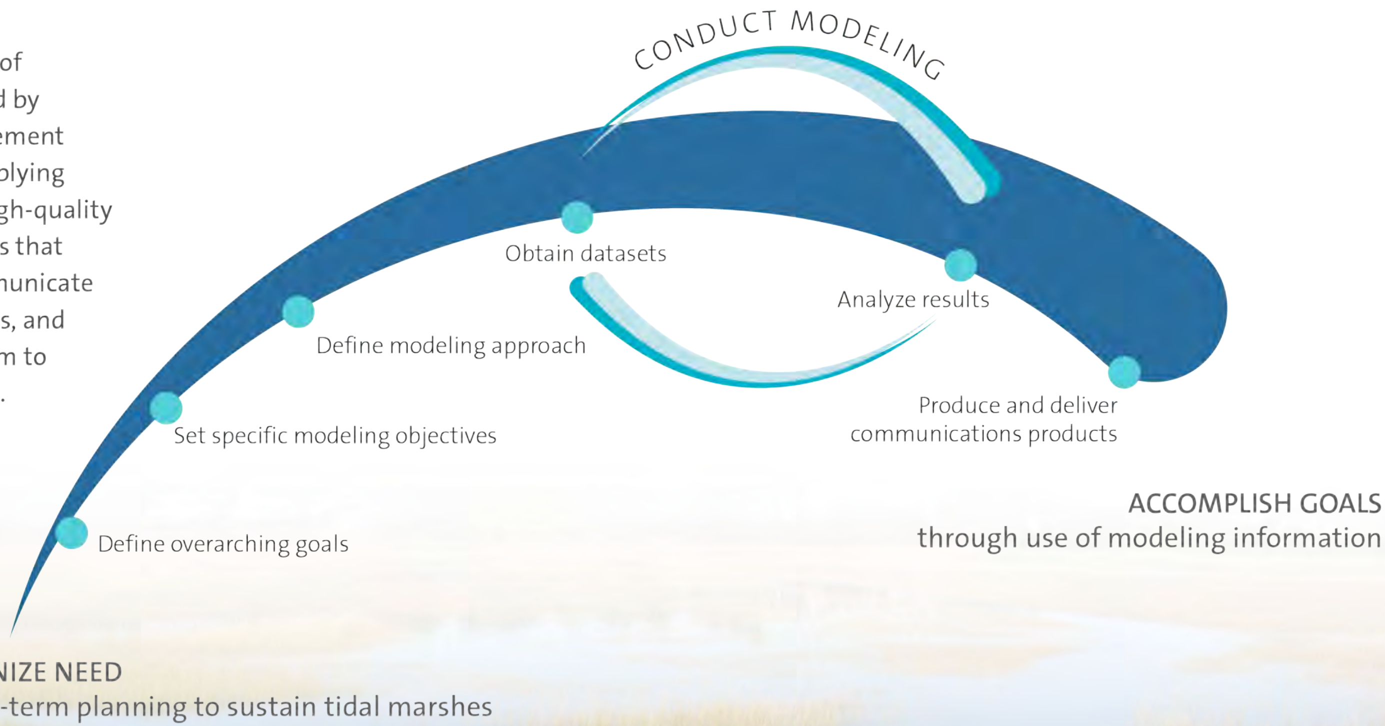
Focus on Modeling of Marsh Migration

Modeling of tidal marsh migration is a rapidly evolving area of scientific investigation that is also being actively applied to management and policy decision-making. While the process of using marsh migration models as decision support tools will vary depending on the specific goals and objectives, this section provides an overview and framework that can be applied in any management context.

THE MODELING PROCESS

The decision-support value of modeling can be maximized by clearly defining the management questions, choosing and applying appropriate models with high-quality data, and producing outputs that clearly and accurately communicate the results, confidence levels, and assumptions in a useful form to managers and stakeholders.



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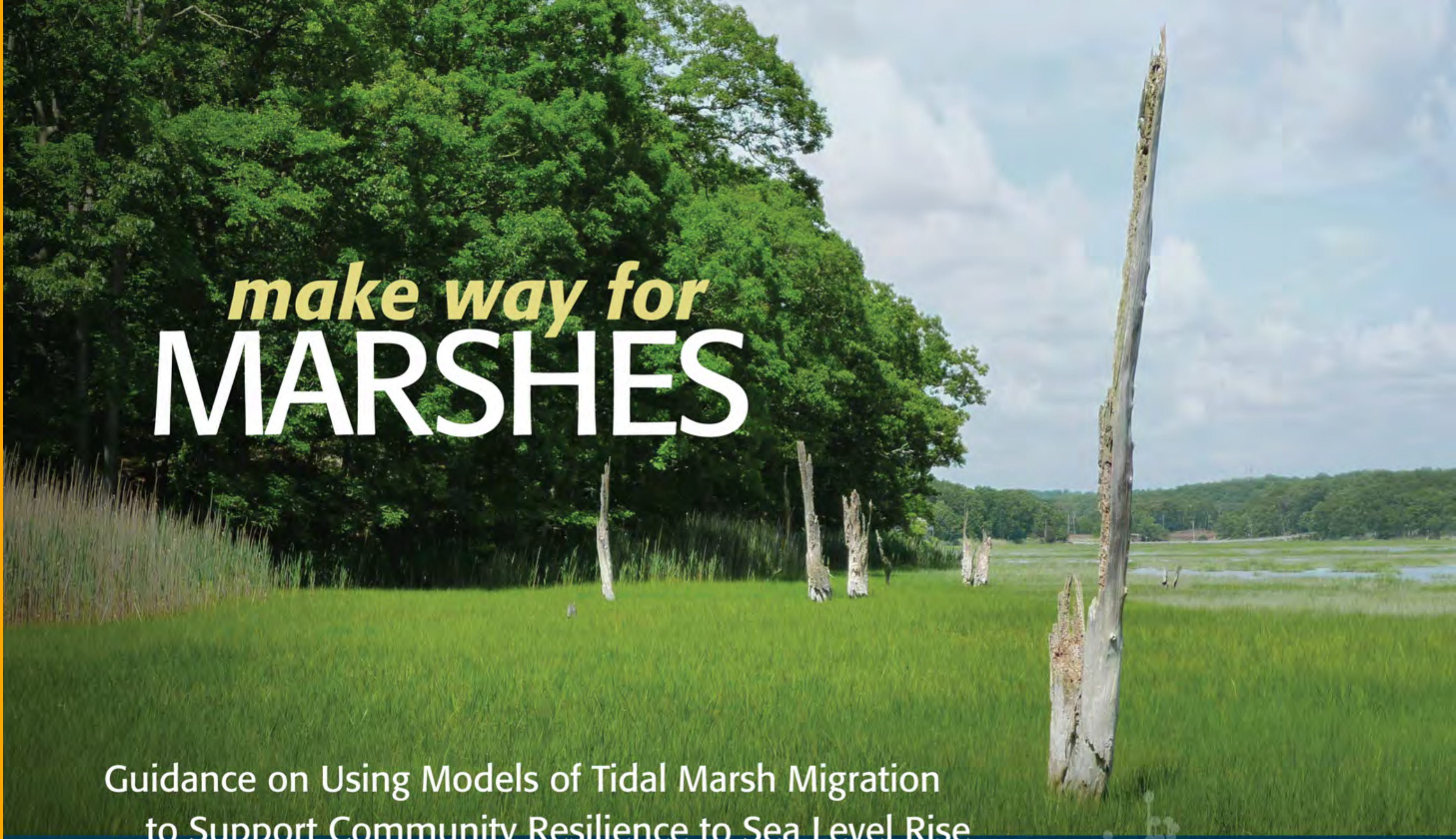
make way for MARSHES



Guidance on Using Models of Tidal Marsh Migration to Support Community Resilience to Sea Level Rise

Three types of data lie at the heart of marsh migration modeling—elevation, land cover, and tide levels. Data are available in various levels of spatial resolution and accuracy, and one of the most effective ways to improve modeling results is to invest in high-quality data. For long-range projections of several decades or more, assumptions about the rate or amount of sea level rise have perhaps the greatest influence on model outputs, as well as being one of the largest sources of uncertainty. Because all data contain inherent uncertainty, it is important to understand the limits of the data being used in the model.

KEY DATA TYPES FOR MODELING MARSH MIGRATION

INITIAL CONDITIONS: Setting the Stage for Modeling

- Elevation
- Land Cover
- Tide Levels

Present-day elevation, land cover, and tide levels provide the foundation for modeling of marsh migration. They represent the initial conditions and set the stage for a model to play out future scenarios. As such, they are sometimes called "time-zero" data. Because elevation, land cover, and tide levels can be measured before being entered into a model, people usually think of them as known conditions. Yet measurements of time-zero data are never perfectly accurate and represent a simplification of the real world. The quality of data fed into a model affects the model results. Following good practices for obtaining and using time-zero data can increase confidence levels of model results.

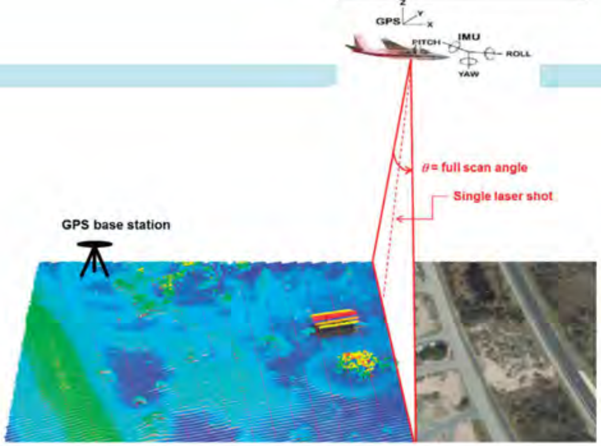
FUTURE CONDITIONS: Parameters that Change Over Time

- Sea Level Rise
- Barriers to Marsh Migration
- Soil Buildup

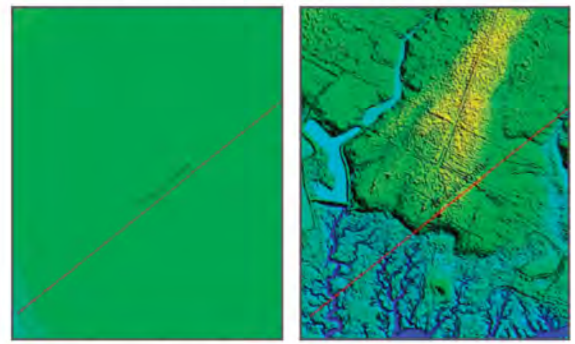
Sea level rise, barriers to marsh migration, and soil buildup are key influences on marsh persistence and migration over time. They are referred to as "time-X" data. Sometimes these parameters can be approximated reasonably well based on present values, but often they are essentially unknowns. Other types of time-X data, such as erosion or storm overwash, are included in some models in an effort to make the model reflect more of the real-world complexities. Understanding the limitations of time-X data is important for proper interpretation of model results.

ELEVATION

High-accuracy elevation data play an important role in modeling of marsh migration because changes in sea level are measured in fractions of an inch and slight differences in elevation strongly influence plant communities in and near tidal marshes. Elevation data are used to create a digital elevation model (DEM) of the marsh and surrounding land surfaces. Data from light detection and ranging (LiDAR) technology are typically used for marsh migration modeling. LiDAR is comparable to sonar, except it uses light instead of sound. Lasers mounted on aircraft emit rapid pulses of light downward, and sensors record the time for the light to bounce back from the ground, which is translated into elevation. LiDAR makes it possible to collect data with horizontal resolution of 12 to 20 inches (30 to 50 cm) and vertical accuracy of 2 to 12 inches (5 to 30 cm).



Conceptual illustration of aircraft-mounted LiDAR technology being used to collect elevation data. Red triangle indicates swath of laser measurements across the ground. *Credit: NOAA*


Comparison of two digital elevation models (DEMs) of the same place produced using data with 10-meter resolution from the USGS National Elevation Dataset (left) and 2-meter resolution from LiDAR (right). *Credit: NOAA*


Actual top of vegetation

Actual middle of vegetation

LiDAR data points classified as ground level
Actual ground level

This image is a visualization of actual LiDAR data from a tidal marsh. The LiDAR measurements of ground level (purple dots) were consistently biased slightly higher than actual ground level because of interference by vegetation. *Credit: NOAA*

NOTES AND TIPS

- **Accurately measuring elevation in marshes is difficult even with LiDAR.** The dense cover of marsh vegetation often throws off the LiDAR measurements by a few inches. However, this issue is less problematic when modeling marsh migration, which focuses on the upland edge where data are often much better. Based on the most-cited potential trends in sea level rise, measurement errors in LiDAR elevation data may cause projections of land cover within marshes to have an accuracy of 20 to 50 years, whereas projections of marsh migration into the uplands may be accurate within 10 to 20 years.
- **Depending on the management purpose of the modeling, it may be preferable to collect elevation data using RTK-GPS (real-time kinematic global positioning system).** RTK-GPS can provide vertical accuracy of 0.8 to 1.6 inches (2 to 4 cm) but requires labor-intensive fieldwork. Another emerging technology is waveform LiDAR, which provides greater accuracy than standard LiDAR but is extremely data intensive.
- **Using elevation data to depict water flow in the marsh (hydraulic modeling) can be difficult and costly.** Data on culverts and underground drainage infrastructure may not be readily available.

Category 3: Rules-based Models

A rules-based model is a set of simple algorithms that serve as a decision-tree of major habitat changes associated with sea level rise without trying to capture all of the processes behind those changes. Rules-based models are a relatively economical way to produce useful results, especially given the many uncertain parameters associated with marsh migration. For this reason, they are the most commonly used models for management decision-making, and they are the focus of the remainder of this report. Rules-based models can be divided into three subcategories based on the number of variables they include: elevation-based models, elevation-and-time-based models, and geomorphic models.

Type of Model	Tide Levels	Sea Level Rise	Soil Buildup	Land Cover	Geomorphic/ Empirical Rules
	Present-day elevation of high tide	Projected increase in sea level	Upward or downward change in marsh surface	Maps of marsh, forest, and other land cover types	Rules defining how land cover changes as sea level rises
Category 3A: ***Elevation-based***	✓	✓			
Category 3B: ***Elevation-and-time-based***	✓	✓	✓		
Category 3C: ***Geomorphic***	✓	✓	✓	✓	✓

Category 3A: Elevation-based Models

Tide Levels + Sea Level Rise

Often called bathtub models or simple inundation models, the simplest of the rules-based models consider only elevation and a user-defined change in sea level with no element of time. In this case, the "rule" is simply a determination of whether dry land will be flooded if the sea level rises by a specified height. These models essentially treat the ocean and coast as a giant bathtub, in which sea level rise is equivalent to adding more water to the tub. Bathtub models produce maps showing where the ocean may be expected to inundate land if sea level rises a defined amount. To interpret the model results with respect to marsh migration, one must look for inundated areas next to present-day tidal marshes and assume that they may turn into tidal marsh if soil, slope, and other conditions are suitable and there is nothing blocking marsh migration. Consequently, this type of model requires additional analysis or interpretation to understand the actual potential of marshes to migrate. However, the simplicity of bathtub models makes them easily understood by non-experts.

EXAMPLE OF ELEVATION-BASED MODEL

Examples of outputs from an elevation-based model used by the Casco Bay Estuary Partnership. Colors indicate wetlands: existing (blue), lost (yellow), new without conflict with existing development (orange), and new with conflict (purple). *Credit: Casco Bay Estuary Partnership*

Guide to Models and Model-based Tools

On the next several pages are descriptions of selected models and model-based tools. The term *model-based tool* refers to a website platform that makes it possible for users to view model results and even adjust some of the variables without digging into the actual model. Models and tools were selected for inclusion based on their relevance and practicality for management applications, and all are rules-based models.

Additional important models exist but are not included because they are not readily applicable to management at present. Examples are the Marsh Equilibrium Model and the Kirwan Model, both of which are expected to become more practical for use in management contexts in the future.

	Model	Main Use	Modeling Platform	Reporting Format	Data	Land Cover	Spatial Scale	Time Scale
Elevation Based	Maine Marsh Migration Team Model, p. 28	Providing initial information for town-level planning and state-wide general analysis	ArcGIS	Printed and electronic documents	Elevation. Highest Annual Tide. Sea level rise of 1, 2, 3.3, 6 feet.	Highest Annual Tide as proxy for upper boundary of coastal wetland (regulatory boundary) and state marsh mapping used to cross-check	Maine coastline (approximately 3,500 miles)	None specified
Elevation Based	Buzzards Bay National Estuary Program Model, p. 29	Evaluating potential expansion and migration of existing salt marshes, particularly those in tidally restricted areas	ArcGIS	Online interactive map	Elevation. High Tide Line. Sea level rise of 1, 2, 4 feet.	Highest Annual Tide as proxy for upper boundary of coastal wetland (regulatory boundary)	Coastline of Buzzards Bay, Massachusetts (310 miles)	None specified
Elevation Based	Casco Bay Estuary Partnership Model, p. 30	Identifying potential areas of marsh migration and possible impacts to existing developed areas	ArcGIS	Printed and electronic documents	Elevation. Tide levels. Sea level rise of 1, 2, 3 feet.	Wetland areas based on tide levels	More than 40 focus areas located in 10 muncipalities around Casco Bay, Maine	None specified
Elevation Based	Marsh Analysis and Planning Tool Incorporating Tides and Elevations (MAPTITE), p. 31	Providing information for restoration of tidal marsh vegetation	ArcGIS	Printed and electronic documents	Elevation. Tide levels. Tidal ranges of plant species.	Vegetation in marsh based on user-defined water-depth ranges for each plant species	Dependent on inputs	None specified
Elevation Based	Marsh Adaptation Strategy Tool (MAST), p. 32	Evaluating and prioritizing potentially inundated sites based on values of interest	Global Mapper GIS	Electronic document	Elevation. Values of sites. Sea level rise.	Satellite imagery	Demonstration project included 3 land parcels	By 2100
Elevation Based	NOAA Sea Level Rise Viewer, p. 33 Marsh Marsh: Advanced Options	Quickly and easily considering potential changes almost anywhere along the U.S. coastline	Internet	Online interactive map	No data input needed. Model uses: Elevation. Soil buildup. Tide levels. Sea level rise (0-6 ft).	Coastal Change Analysis Program (C-CAP)	National coverage with local, state, and regional applications	Default: None specified. Advanced Options: 0, 25, 50, 75, or 100 years
Elevation and Time Based	Coastal Resilience, p. 34	Identifying areas of land at the parcel scale onto which tidal wetlands may migrate, and possible impacts to existing developed areas	Internet, ArcGIS	Online interactive map; printed and electronic documents	No data input needed. Model uses: Elevation. Soil buildup. Tide levels. Down-scaled sea level rise (0-4.33 ft).	National Wetlands Inventory (NWI)	Varies: Selected international, regional, state, and municipal areas, and parcel level	2020, 2050, 2080 scenarios
Geomorphic	Sea Level Affecting Marshes Model (SLAMM), p. 35	Understanding and quantifying potential changes in marsh locations and sizes	Standalone application	Varies: printed and electronic documents, online maps	Required: Elevation. Tide levels. Land cover. Optional: Soil buildup. Development footprints. Other parameters.	NWI	Varies: Less than 1 square mile to thousands of square miles; typically 5 to 50 square miles	Varies: Time increments of 5 to 25 years

Maine Marsh Migration Team Model

The Maine Geological Survey, Maine Natural Areas Program, and Municipal Assistance Program developed a relatively simple "bathtub" model of marsh migration as part of a NOAA Project of Special Merit conducted from 2004 to 2014. The project sought to raise public awareness of sea level rise and marsh migration, and to provide municipalities, conservation groups, and state and federal agencies with information that could be used in planning efforts to allow tidal marshes to migrate.

The model was intentionally kept relatively simple for several reasons: (1) a goal of modeling all of Maine's lengthy coastline, (2) a goal of sharing results at the municipal level where simplicity is an advantage, (3) lack of available data on soil buildup, and (4) available budget. A foundational step in the project was a comprehensive review and improvement of tidal marsh maps for the state, which included extensive field surveys and reconnaissance of over 80 marshes. Based on 113 tidal prediction stations, the team created a dataset of Highest Annual Tide (HAT) elevations for the entire Maine coast. The project focused on HAT because the state's shoreland zoning regulations use HAT as a proxy for the upper marsh boundary for all coastal wetlands.

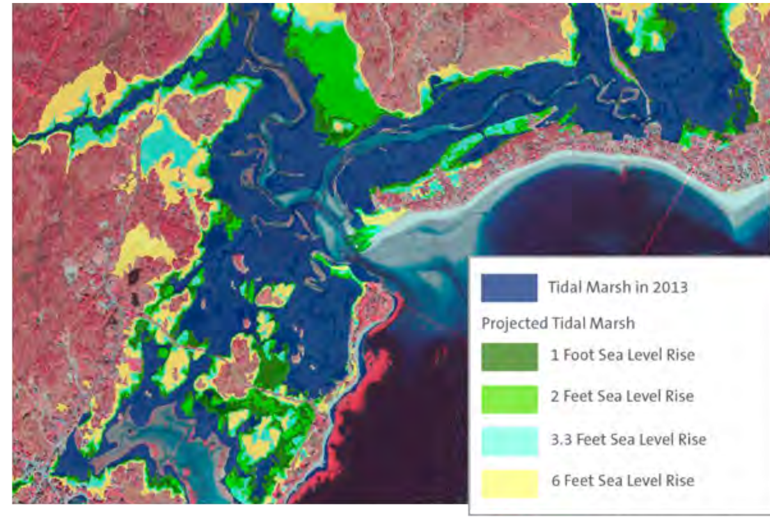
Elevation data for the coastline were developed using LiDAR data collected and processed in 2012. Four scenarios of sea level rise were explored by adding 1, 2, 3.3, or 6 feet to the present-day HAT elevation.

OUTPUTS

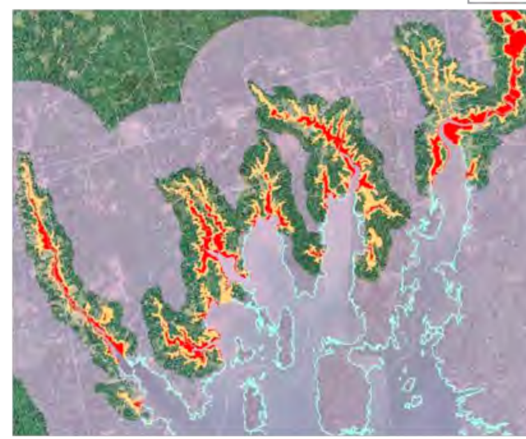
- Statewide dataset of tidal marsh areas (ArcGIS shapefile including 1,158 polygons)
- Maps of current HAT
- Reports for 6 towns on; (a) potential wetland expansion zones, (b) potential inundation areas based on sea level rise and 100-year storm levels, (c) potential impacts on infrastructure, and (d) potential impacts on land cover

FOR MORE INFORMATION

- www.gulfofmaine.org/2/climate-network-climate-initiatives/maine/
- www.waterviewconsulting.com/marshmigration/mainemodel.pdf



▲ Projections of marsh migration at Batson River in Kennebunkport, Maine.



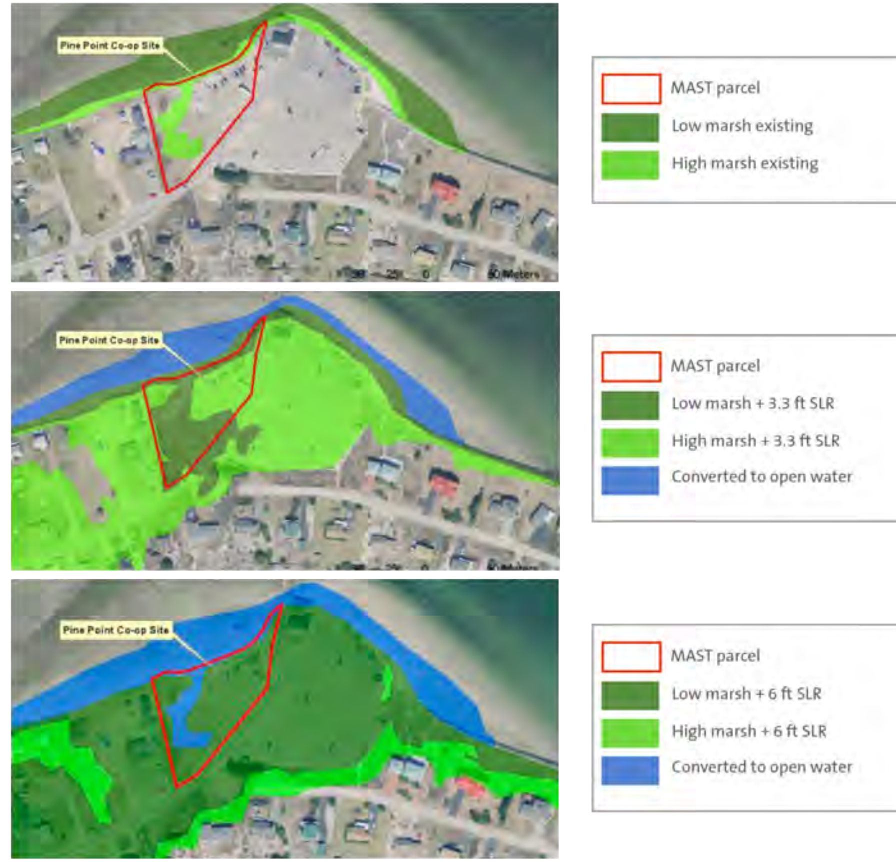
◀ Areas of existing marsh (red) where migration (yellow) is most likely to occur. Purple area is a mask to remove fringing marshes and non-estuarine areas.

◀ Potential marsh migration (blue) onto conserved lands (stippled green).

Marsh Adaptation Strategy Tool (MAST)

A consortium of public- and private-sector organizations in Maine developed the Marsh Adaptation Strategy Tool (MAST) to enable people to evaluate the future values of coastal land parcels under different sea level rise scenarios. MAST facilitates cost-benefit analysis of potential changes in land cover and habitat, and this information could be used in decision-making by government agencies and non-government organizations. The model runs on Global Mapper GIS and uses pre-made digital elevation models (DEMs) for four sea level rise scenarios (1, 2, 3.3, 6 feet) by 2100.

The consortium conducted a demonstration project in which they used MAST to evaluate three land parcels in Scarborough, Maine. For each parcel, a group of experts allocated initial values for 15 ecosystem services. Among the ecosystem services were carbon storage, habitat, flood prevention, and nutrient export. The model then created depth-benefit curves that estimated how those values would change with increasing water depth at each site. Importantly, the shapes of depth-benefit curves used in the model reflect the opinions of the experts who were interviewed; local residents or other people might value ecosystem services differently. The demonstration project suggested that the cumulative expected benefit approach used by MAST has potential to inform strategic land prioritization decisions for conservation and development.



A Marsh Adaptation Strategy Tool (MAST) test site in Scarborough, Maine.

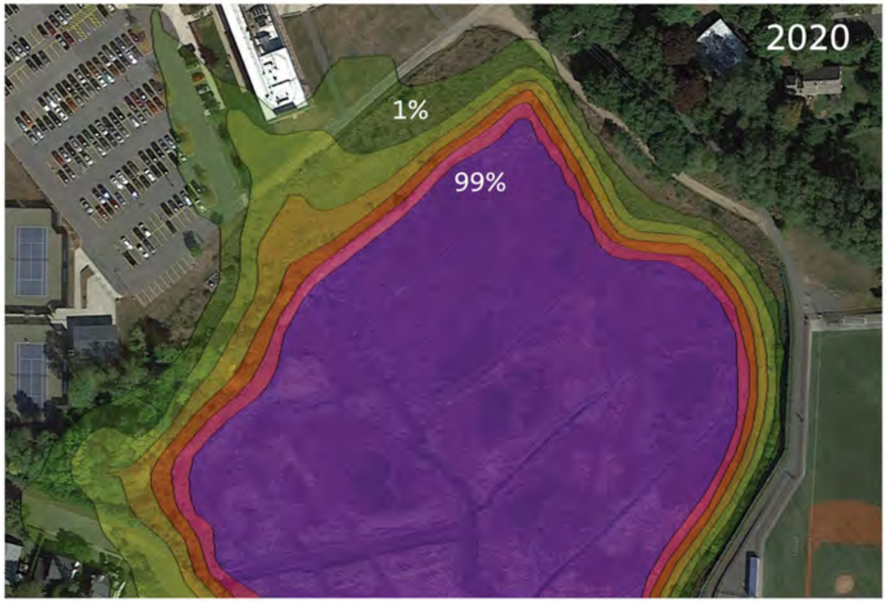
OUTPUTS

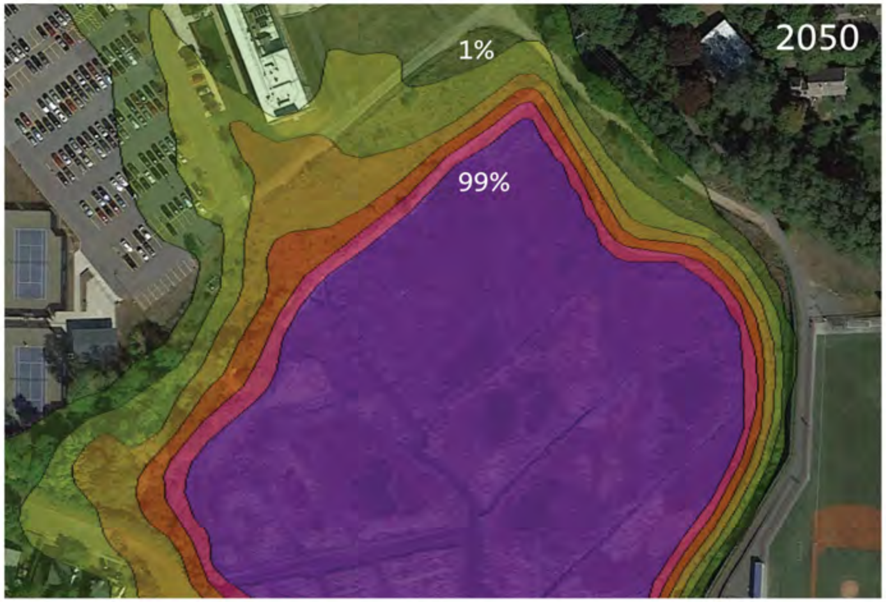
- GIS maps and datasets for land parcels

FOR MORE INFORMATION

- northatlanticlcc.org/projects/demo-project-marsh-migration
- Contact: Sam Merrill, smerrill@geiconsultants.com, (207) 615-7523

HANDLING UNCERTAINTY





These images show model projections of tidal marsh in 2020 and 2050. Colors indicate a range from nearly certain to be tidal marsh (purple, 99 percent likelihood) to extremely unlikely (light green, 1 percent likelihood). This method of displaying model results makes it possible to show the most likely scenario while also accounting for the uncertainties that exist in any model of marsh migration. One source of uncertainty or error not addressed in these model results is the potential for roads, buildings, and other features of developed land to block marsh migration. *Credit: K. Schmid*

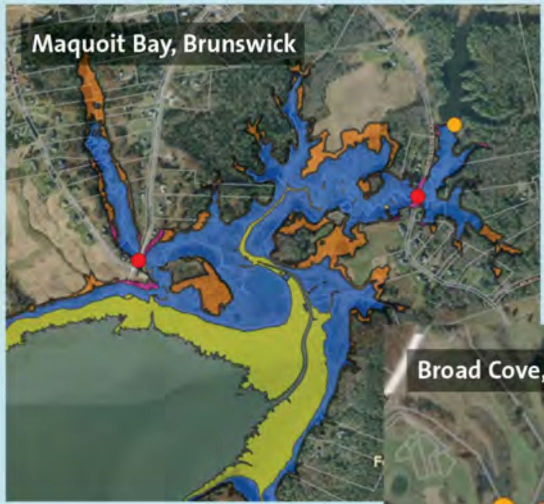
Sea level rise is by far the biggest cause of uncertainty in model results.
Projections of sea level rise vary tremendously and dramatically affect projections of marsh migration.

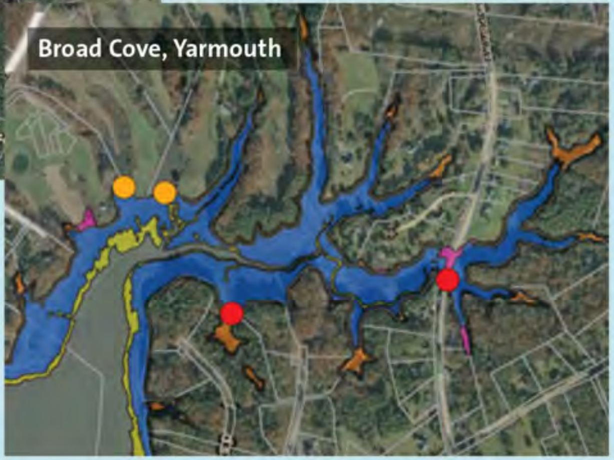
COMMUNICATING FINDINGS

EXAMPLES OF COMMUNICATING FINDINGS

In its study of marsh migration, the Casco Bay Estuary Partnership (CBEP) placed an emphasis on communication of the findings to people who live and work around the Bay. The final project report described the communications process:

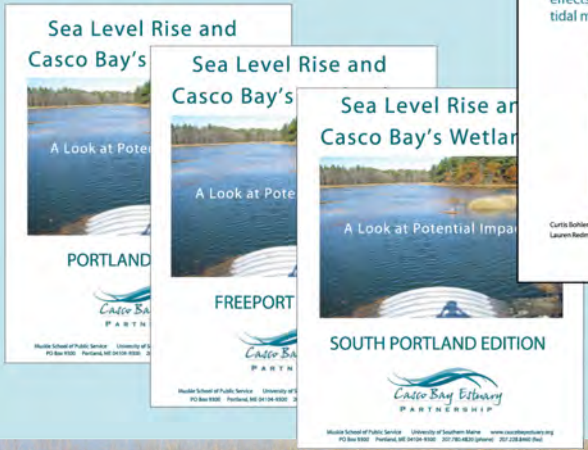
> *One overall goal of the project was to develop methods to make the results of these investigations accessible to local officials, town planners, land trusts and local citizens. While the technical analyses going on in Parts 2 and 3 of this [CBEP] report were underway, a parallel effort was underway to craft materials to communicate major findings to local communities.*
>
> *Here along Casco Bay, with our relatively steep shorelines, the most important information to convey to local communities revolves around the landward migration of wetland[s], the future location of the intertidal zone, [and] identification of areas where marsh migration is likely to conflict with existing infrastructure. More subtle distinctions, such as specifics of whether wetland will increase or decrease overall, or how wetland change will depend on sedimentation rates are of secondary importance. The communications package we developed reflects those priorities.*

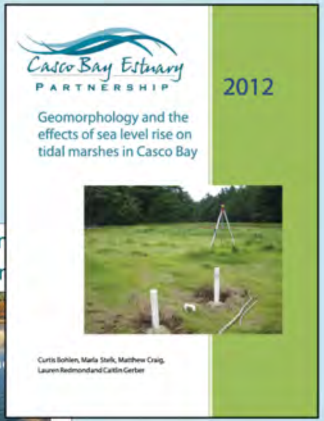




Two examples of maps created by CBEP for 3 feet of sea level rise. Orange areas are potential marsh migration pathways.

CBEP produced reports for individual municipalities. Each contained local maps and a brief summary of findings.





A final report provided technical information.

> *Fourteen municipalities touch the shoreline of Casco Bay. We prepared draft communications packages for each municipality. We prepared a series of maps for each town at a 1:9,000 scale. The maps focus on areas where significant wetland change or landward migration of the intertidal zone are anticipated under significant (3 ft.) sea level rise. The maps show both areas of significant wetland change (based on the wetland change data described in Part 1 of this report), and also areas where present or future areas of wetland may conflict with existing infrastructure.*

CBEP produced a communications package for each town that included a general introduction to the project, a brief discussion of sea level rise in the Casco Bay region, an overview map for the town, and detailed maps for specific locations in the town.

RECOMMENDATIONS

Through collaborative efforts facilitated by the Northeast Regional Ocean Council, including a workshop in December 2014 and the development of this guidance document in 2014 and 2015, more than 50 experts in the science, management, and policy of tidal marshes and sea level rise developed the following recommendations to set the course on this important issue.

A. **Further develop conceptual models of marsh migration in the Northeast.** Region-specific conceptual models are needed to capture and communicate the current scientific understanding of factors that influence marsh migration and important differences in these factors within the region.

B. **Facilitate ongoing interaction among people engaged in marsh migration-related efforts in the Northeast.** Meetings, workshops, webinars, and other interactions are needed to share knowledge and develop collaborations on modeling, management, policy, engagement, and communications.

C. **Launch a regional data initiative in support of marsh migration management.** The data initiative should focus on consolidating and disseminating existing data and results; implementing next-generation methods to obtain higher-resolution coastline elevation data; conducting detailed mapping of marshes and adjacent land cover; building a network of surface elevation table (SET) stations for accretion data; and supporting on-the-ground monitoring of marsh migration in New England.

D. **Develop a web-based information resource about marsh migration in the region.** Agencies and organizations need a place to find and share share data, information, and products. The website should provide easy access to relevant datasets (physical, ecological, economic), decision support tools, and scientific and technical literature.

E. **Promote research, analysis, and planning to maximize the long-term benefits of tidal marsh restoration in an era of sea level rise.** Habitat restoration is an ongoing priority, and more information and tools are needed for decision-making to ensure a future return on investment in restoration projects.

F. **Provide data products and processes for marsh migration planning and management suitable for use at the municipal level.** The products should be suitable for technical and non-technical audiences, and should be disseminated to coastal muncipalities and state regulatory programs.

G. **Develop a toolkit of policy, management, and regulatory approaches—with information on feasibility and costs—to facilitate marsh migration.** Citizens and organizations need this information to take actions that build on the information generated through modeling.

Geneva Wirth

Working Across the Boundary: Lessons Learned

Clearly Identify the Target Audience

"The value is to us. We need to know what each other are doing." - *Steering Committee Member*

Listen and Stay Flexible

"I'm not so certain of the usefulness of fact sheets" [that had been requested in RFP].

Keep a Clear Vision & Stay on Course

Produce a creative brief that serves as a touchstone throughout the project.

Key Messages Are the Key

Focus on identifying the main takeaways for target audience

Refine the key messages as project evolves

Use Multiple Information-Gathering Methods

Literature review provided a foundation of information

Expert interviews added many perspectives and rich information

Workshop was a meeting of the minds to share the latest thinking

Engage Experts Across the Boundary Throughout Project

Multiple opportunities and methods for input and feedback

These interactions are as valuable as the final product.

Focus on Creating a User-friendly Product

Targeted, well-organized content

Accessible, concise writing

Visually engaging design and graphics

Outcomes

Tangible (Boundary object)

- *Make Way for Marshes* document available at northeastoceancouncil.org/marshmigration

Intangible

- Strengthened community of practice
- Replicable knowledge-sharing process

Thank you!

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