Keeping up with sea level rise: natural and human influence on salt marsh migration

by Nancy Balcom

When my sons were small, we often vacationed on Cape Cod. At low tide, the bay side offered opportunities to walk far out from our beach blanket to look for critters and examine the unusual patterns of bird footprints and snail trails in the wet sand. Once the tide turned, however, we needed to pay closer attention to our meanderings and work our way back to the dry sand faster than the incoming waters were rising, or be overtaken.

This anecdote could serve as an extended metaphor for migrating salt marshes and accelerating sea level rise. Like my sons and I dodging the incoming tide, rising seas persistently nudge nearby landscapes to move out of the way, or be subsumed. But exactly how is that working in the real world, and what are the challenges to successful marsh migration — widely seen as essential to preserving these critical habitats? Two researchers funded by Connecticut Sea Grant probed these questions to yield some significant and applicable findings.

"It makes good sense to combine social science and ecological data into conservation planning and policy," said Chris Elphick, one of the researchers.

Tucked in along the fringes of the coastline, salt marshes provide important ecosystem services. Many fish species utilize marshes as nursery areas. Certain bird species nest among the marsh grasses. Crabs and other small invertebrates, birds and mammals find food and shelter in tidal salt marshes. The dense root systems and peat of these marshes trap contaminants, sediments and nutrients and absorb water and wave energy during storms. Various marsh grasses and plants differentiate by elevation into distinct zones, as the tidal cycles inundate these vibrant and picturesque landscapes and then recede. But a thriving marsh can shift to barely surviving when changing conditions outpace the ability of a salt marsh to adjust, or the marsh is blocked from naturally moving upslope and landward ahead of rising sea level.

Shimon Anisfeld studies the ability of tidal salt marshes to migrate under accelerated sea level rise conditions. A senior lecturer and research scientist in the Yale School of Forestry and Environmental Studies, he conducted fieldwork in marshes at Hammonasset Beach State Park in Madison and Sherwood Island State Park in Westport starting in 2014. While his work there seeks to understand the mechanism of a key environmental phenomenon, it's also a labor of love.

"To me," said Anisfeld, "while aesthetics is in the eye of the beholder, there is a beauty and charm to salt marshes that hopefully people notice."

Working with postdoctoral researcher Andrew Kemp (now an assistant professor at Tufts University) and graduate student Katharine Cooper, Anisfeld examined the upslope progression of marshes into different upland types, specifically wooded areas and mowed lawns. They discovered that the type of marsh vegetation colonizing the two areas was quite different, and found some evidence suggesting that marshes might be able to move more quickly into lawns, given the lack of shading and the shorter lifespan of lawn grasses compared to trees. Prioritizing low-slope lawn areas for protection may help facilitate marsh migration as sea level rises.

The team also worked with park staff to create "no-mow zones" in marsh-adjoining lawns.

"To figure out the extent of marsh in the mowed areas, we had to get down and look closely at the plants in mowed areas to differentiate the marsh grasses from regular grasses," Anisfeld recalled. "Once we established the upper edge of the marsh, we suggested adding 10 to 20 meters (about 30 to 60 feet) to the new no-mow zone to give the marsh somewhere to move."

From a practical land management perspective, the researchers concluded that establishing no-mow zones is an effective strategy to facilitate migration.

"There are two benefits to no-mow zones adjacent to a marsh," said Anisfeld. "First, marsh plants can grow to their full height, improving the marsh habitat and increasing its ability to attenuate storm effects. In addition, woody marsh plants that cannot withstand mowing, such as marsh elder and groundsel trees, will start to grow in the migrating marsh."

This succession of marsh plants can be seen in both parks. At Sherwood Island, park supervisor James Beschle reflected on the no-mow areas of the lawn adjacent to the marsh one day this fall.

"It's important to find a balance that protects both nature's and people's interests in the park," he said. "The marsh provides important protection during storms. If we keep mowing the uplands, then there's no natural seeding of marsh plants, so we have to do what we can."

A model airplane club uses the short paved runways installed on part of the expansive lawn area adjacent to the marsh for takeoffs and landings. Beschle believes that over the long-

Above: A kayaker paddles near the marshes at Bluff Point State Park.

Left: Chris Field (photo courtesy of Chris Field)

Center: Shimon Anisfeld

Right: Jim Beschle, park supervisor at Sherwood Island State Park, stands near one of the "no-mow" zones adjacent to the salt marsh. Photos: Nancy Balcom

term, the park will be able to accommodate the hobbyists' ongoing use of the runways while allowing the marsh to continue to expand naturally into the no-mow zones.

Anisfeld plans to alternate annual visits to see the continued effect of the no-mow zones in each park. Both Beschle and William Mattioli, director of facilities at Hammonasset, believe that it's important to permit researchers to utilize the parks as living laboratories to learn lessons that can potentially be applied elsewhere.

Anisfeld and Kemp, together with graduate student Jamie O'Connell, also developed a new approach to reconstructing salt marsh migration. Typically aerial photographs are analyzed to determine changes in the landward extent of marshes over time. However, in areas where upper marsh edges intersect mowed areas of land or are obscured by trees, plant species cannot be differentiated using aerial photos to determine the actual marsh edge.

The marshes in the two parks are adjacent to mowed lawn, rendering aerial photographs useless in determining how far "up" and "in" these marshes have migrated over time. Anisfeld and his co-workers collected sediment cores at regular intervals across the marsh-to-upland continuum, and tested the cores for the presence of foraminifera, single-celled marine organisms with shells that are preserved in marsh but not upland sediments. The researchers used the presence of foraminifera to identify wedges of salt marsh peat lying overtop pre-existing upland soil. They also used radioactive isotope tracing to identify where the marsh-upland surface boundary was in 1963.The process identified the depth in the sediment of the layer of cesium-137, a time marker left from the atmospheric deposition of the isotope from nuclear weapons testing that peaked in 1963. Further calculations enabled the researchers to determine the total vertical ("up") and lateral ("in") distance each marsh migrated between 1963 and 2016.

The Avalonia Land Conservancy, with assistance from Connecticut Sea Grant and the Mystic Aquarium, has been creating a marsh migration buffer at Dodge Paddock / Beal Preserve in Stonington. Photo: Juliana Barrett

They found that the Sherwood Island marsh migrated inland 42 to 51 meters (138 to 167 feet) and the Hammonasset marsh 4 to 5 meters (13 to 16 feet) over the 53-year period. Vertical migration was about 35 cm (14 inches) for the Sherwood marsh and around 10 cm (4 inches) at Hammonasset. Averaged over time, the rate of vertical migration was 6 mm (0.2 inches) per year at Sherwood and 2 mm (.08 inches) per year at Hammonasset.

The presence of foraminifera can be considered a "leading indicator" of marsh migration. Overall, both marshes were migrating roughly in tandem with local sea level rise. However, variations in migration rate over time cannot be determined using this technique. Major coastal storms can play a role in accelerating local marsh migration over the short term. Sherwood Island was impacted by much higher storm surge in 2012 from Superstorm Sandy than Hammonasset, potentially accounting for its faster rate of vertical migration.

Modeling can help predict how a particular marsh may react to rising seas. Warren Pinnacle Consulting, located in Waitsfield, Vt., developed a mathematical model called Sea Level Affecting Marshes Model (SLAMM) that simulates the potential impact of long-term sea level rise on wetlands and shorelines. The Connecticut Department of Energy and Environmental Protection and the University of Connecticut Center for Land Use Education and Research recently collaborated on developing a new interactive SLAMM viewer that shows the impact of sea level rise on the state's 21 largest tidal marshes as well as shoreline roads (see SLAMM viewer: https://cteco.uconn.edu/viewer/index.html?viewer=slamm). The viewer shows the predicted extent of sea-level rise in 15-year intervals starting in 2025.

"Research like mine over time can help verify SLAMM's predictions." Anisfeld said. "Some of our marshes are very hemmed in — both naturally through their location in glacial pockets and anthropogenically, with pretty much nowhere to go as sea level rises."

Indeed, marshes need somewhere to go or rising seas may overtake them. One major complication, however, is that it's just as likely the adjacent landowner is a private citizen as it might be the state, a town or a land conservation organization. The future of tidal salt marshes in Connecticut (and elsewhere) will be largely influenced by adjacent landowners whose activities and decisions could promote or block marsh migration. Connecticut Sea Grant supported a researcher interested in examining the human side of the complicated marsh migration equation.

Elphick, professor in the Department of Ecology and Evolutionary Biology at the University of Connecticut, considers himself a conservation biologist, applied ecologist and ornithologist. Through his research, he tries to determine how ecologists can best guide management decisions that balance conservation of biological diversity with human activities.

Elphick, working with then-doctoral student Christopher Field, who is now at the National Socio-Environmental Synthesis Center, and Ashley Dayer, now at Virginia Tech, set out in 2014 to survey landowners whose properties abut salt marshes in Connecticut. They were asked about their attitudes regarding different types of conservation agreements that could protect migrating marshes.

"We wanted to know whether landowners might be willing to enter into conservation agreements to give nearby marshes somewhere to migrate with sea level rise, or would they be more inclined to protect their upland properties by hardening their shorelines with seawalls," Elphick said.

These agreements include conservation easements where the incentive value is based on the median for the study area; outright purchases at market value; restrictive covenants whereby an entire neighborhood enters a binding agreement to forgo shoreline protection; and future interest agreements. For the latter, if flooding reduces a property's value by 50 percent, ownership of the property transfers to a conservation organization at the fair market value on the date of the agreement.

In addition to assessing the level of support for different agreements, the researchers collected information on demographic and geographic traits, attitudes and beliefs of the landowners to tease out factors that might influence behavior or intentions with respect to these agreements.

"We found that conservation easements, a popular strategy for land protection, are unlikely to be sufficient to mitigate losses from sea level rise," said Elphick. "Some less common conservation strategies like restrictive covenants and future interest agreements appear more likely to be adopted by landowners. However, these are unproven in practice and are likely to be more expensive."

The researchers concluded that failure to factor human behavior into ecosystem modeling and conservation planning can lead to an overly optimistic view of the potential for successful marsh migration. Strategies frequently used by conservation practitioners to increase participation in conservation agreements — such as strengthening beliefs in climate change and increasing awareness of the ecosystem services provided by marshes — had weak or mixed effects on landowner attitudes.

"More than half of coastal landowners were concerned that conservation groups might not act fairly in their efforts to encourage marsh migration," said Field, the lead author of the study. "But fortunately, addressing this prevailing attitude might be relatively straightforward, and could have a big impact on how many people are willing to participate in adaptation options."

Landowners with stronger beliefs about increased flooding or marsh migration indicated a greater inclination to build shoreline protection like seawalls, potentially leading to greater loss of natural coastline habitats. Overall, 22 percent of landowners said they were likely to harden their shoreline within 20 years. On the other hand, landowners whose homes flooded during Superstorm Sandy in 2012 were more inclined to consider selling outright.

"Research that combines social science and ecology is challenging," Field said. "But the insights we can gain into how landowners are likely to determine the future of coastal ecosystems are critical for better understanding conservation and policy options as coastal communities continue to adapt to sea level rise."

Solving the marsh migration equation is far more complicated than dodging the incoming tide.

To learn more about Shimon Anisfeld's work, visit: https://environment.yale.edu/profile/anisfeld/

To learn more about Chris Elphick's work, visit: https://elphick.lab.uconn.edu/

Marsh elder and cedar trees are filling in the marsh upland at Hammonasset Beach State Park in 2019, five years after it became a "no-mow" zone as part of the project. Photo: Nancy Balcom