Bringing coastal wetlands back to life

Only recently has the importance of coastal wetlands and salt marshes really come to light. They act as a unique habitat for many species and also provide a wealth of ecosystem services. Dr Kenny Raposa from the Narragansett Bay National Estuarine Research Reserve is not only involved in the active restoration of these habitats but is also investigating the efficacy of these restoration projects by comparison with a reference network of unimpacted wetlands.

Historically, humans have damaged important coastal wetland ecosystems almost beyond repair. The building of railways, roads, narrow culverts, dikes and poorly designed bridges has led to the prevention of tidal flow across these fragile and unique environments. Furthermore, agricultural runoff, reclamation of land and other upstream contamination has further threatened this habitat. It is imperative that we act to restore these wetlands and, to achieve this, scientists must provide solid data that first demonstrates the damage that these issues cause, but also attempts to capture, statistically, improvements through on-the-ground restoration activities.

Dr Kenny Raposa from the Narragansett Bay National Estuarine Research Reserve located on Prudence Island in Rhode Island works on tidal marshes in Rhode Island and along the US Atlantic coast, with one focus being on monitoring the success of wetland restoration efforts. His research has examined which areas of wetland are most susceptible, and what methods are best utilised for restoring those wetlands. He shares this work with colleagues within the National Estuarine Research Reserve System (NERRS), a network of 29 reserve programs designated to protect and study these estuarine systems. Having this network of protected sites allows for restoration efforts within impacted wetlands across the country to be compared against nearby reference wetlands – all using a standardised set of sampling approaches and analysis methods.

Deep groundwater well installation.

WHY ARE WETLANDS IMPORTANT?

Coastal wetlands represent a suite of unique and fragile ecosystems which provide important habitats for many species of plants, animals, and bacteria. One common type of coastal wetland is the salt marsh, where the mixture of riverine freshwater and tidal salt water allow areas – colonised by plants – to produce brackish, hypoxic, and peaty ground. Life here has adapted to this specific biological niche found nowhere else on Earth. However, anthropogenic disturbance can alter these natural systems leading to a loss of native species and allowing for the introduction of unsuitable invasive species to dominate some of these habitats.

Salt marshes also provide a natural barrier between the sea and the land, allowing for storm protection, biochemical buffering for rivers, a protective nursery space for young organisms, and a valuable source of eco-tourism and other ecosystem services. Perhaps most importantly, these wetland marshes capture and store large amounts of carbon dioxide, the protection of which is essential to address climate change.

Nag Marsh, Rhode Island.

Duke Marine Lab Marsh, North Carolina.

RESTORING SALT MARSHES

Restoring salt marshes, which have been damaged by the loss of tidal flooding is theoretically simple – remove the barrier.

Hope for coastal wetlands relies on using the NERR sites as models or living laboratories to monitor restoration.

By deconstructing dikes, removing roads or widening culverts, we can immediately bring the tide back into a salt marsh. However, this is easier said than done; more on that later.

Raposa and colleagues are monitoring previous restoration projects, primarily along the east coast of America to evaluate the success of restoration for various biotic and abiotic factors in salt marshes. To do this, he implements a "before, after, control, impact" (BACI) approach. This means a site will ideally have a breadth of data from before the tidal restoration, after, and also a reference (control) area which always remains tide unrestricted. From this, any changes at the restoration site can be measured and then verified against the control site to ensure any unique variation would be primarily due to the restoration activities at the site.

For example, Sachuest Point Salt Marsh, in Rhode Island, was investigated during the time period of 1996 to 1999. Measures of change in vegetation and fish were recorded within two wetland sites, one tidal restricted, and the other unrestricted. As expected, the two sites were initially very different, with the restricted site containing species and vegetative compositions that reflected poor ecosystem health.

When the tide was restored to this restricted site, the ecosystem began to revert back to the structure of a healthy New England marsh. This was observed through a dramatic increase in the fish and shrimp populations and species richness, and the stunting of invasive vegetation such as the common reed *Phragmites australis.*

THE RESTORATION PERFORMANCE INDEX

Using the same basic methodology of comparing the tide restored area at Sachuest Point to a reference ecosystem, Raposa and the team could begin to create a large-scale evaluation model for coastal wetlands in the USA. Using 5 of the NERRs (National Estuarine Research Reserves), 9 reference sites were selected, and these were used to evaluate the success of 17 restoration efforts. This was completed using a Restoration Performance Index (RPI), a novel approach for evaluating the performance of restoration projects.

The RPI is an evaluation tool which can be used to quantitively compare the restoration success of a coastal wetland site. It is obtained by dividing the ecosystem into measurable categories, monitoring these over time, and relating them to the reference site. A standardised score is then given to each attribute, which can be simply compared to other restoration sites across the country. The score is dependent on the rate at which the particular attribute from a restored site changes towards the reference site value. Examples of these could be fish concentration, water salinity, vegetation cover, or the height and density of invasive plant species. This allows Dr Raposa to evaluate the restoration performance or "success" of these sites across any measurable ecosystem trait, biotic or abiotic, which is an extremely powerful, and potentially very precise tool.

Raposa found that although recovery did occur in tide-restored areas, they did not recover as much as expected, and many RPI scores remained low.

Vegetation data collection at the South Slough Kunz Marsh study site.

Location of two reference sites and three restoration sites monitored by the Chesapeake Bay VA NERR in Virginia.

This shows that it would take an extremely long time for wetlands to reach a point similar to their original or "reference" state, and perhaps they will never quite be the same.

However, methodologically the RPI and use of NERRS sites are very sound. This scoring scale allows the researchers to better understand which ecosystem processes recovered the most, and least. Among sites, the restoration performance of the hydrologic parameters remained relatively similar and high, whereas species density and vegetative composition varied, and were often quite low. It's important to remember that biological processes take a long time to recover, often with a lengthy lag phase after any physical changes have taken place. For this reason, it's useful to complete studies of this nature over long periods of time, allowing growth, death, and seasonality to take its course.

A better understanding of the usefulness of restoration efforts relies on using reference or protected sites which can be found in programs such as the NERRS. Through collaborative efforts, Raposa and his team can continue to push forward data towards policymakers in order to remove, or to better design infrastructure adjacent to or within wetland areas to better allow for the natural hydrological processes which sustain wetlands to occur. One common issue occurs when infrastructure has been built around tidal barriers, making their removal extremely problematic. On occasion, buildings have been built upon these delicate habitats, meaning restoration would be nearly impossible. Reiteration of the biological, aesthetic, and economic benefits of coastal wetlands using scientific collection information will be essential to advise policymakers and stakeholders to back the implementation of restoration projects, and maintenance (or conservation) policies across the US.

The RPI is a standardised scale which can be used to quantitively compare the restoration success of a coastal wetland site.

RISING SEAS – A NEW THREAT

Unfortunately, humans have encouraged a potentially greater threat than tidal restriction: rising sea levels. Coastal marshes are naturally at the front line of this issue, as they could become rapidly flooded, causing plants to drown, in turn leading to overall marsh loss. Marshes naturally maintain a safe elevation through constant capturing of sediment and peat building, however, sea levels might rise too quickly for marshes to keep pace. Marsh elevation building occurs at different rates depending on the specific marsh geology and hydrology, for example, marshes which have become isolated from their rivers will lose the sediment which is so important for maintaining this balance. The tidal restriction could have similar effects.

In yet another study, Raposa and colleagues developed and applied a simple scale of vulnerability to sea-level rise across 16 sites in the NERRS. The outlook was mixed, with many differences between sites. Multiple different factors were seen to affect a marsh's tolerance to rising sea level. These factors included initial marsh elevation, marsh elevation change, sediment supply, the rate of sea-level rise and tidal range. By quantifying vulnerability for each of these factors, scientists can be more informed when developing and designing restoration and protection interventions.

These examples are not simply bound to one country either. Coastal wetlands cover around 6% of the Earth's land, appear on every continent, and are critical to the world's fisheries and the human communities that depend upon them. From swamps to mangroves, Raposa's methodologies can provide ecologists and hydrologists worldwide a basis on which to conduct similar studies, with adaptations made to their specific ecosystem needs. Ultimately, this work should improve our ability to not only restore degraded coastal wetlands worldwide but also help them become more resilient to emerging global threats such as sea-level rise.

Behind the Research

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Research Objectives

Kenny currently focuses his research on marsh responses to sea-level rise, other factors influencing marsh vulnerability including burrowing and predation from marsh crabs, and assessing various types of adaptation projects aimed at building marsh resilience to sea-level rise over time.

Detail

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Bio

Kenneth Raposa earned his PhD in Biological Oceanography from the University of Rhode Island and has been the Research Coordinator at the Narragansett Bay NERR for the past 18 years. His current research focuses on evaluating ways to enhance salt marsh resilience against sea-level rise and other stressors.

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Collaborators

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Personal Response

What are your future plans for research in this area?

"We plan to pursue multiple avenues of future research in this area. One approach will be to return to a suite of historic tidal restoration projects across Rhode Island USA and re-assess vegetation and fish communities to explore the results of these projects after ~20 years. The other approach will be to move away from classic hydrological restoration projects and focus more on new types of adaptation projects that are designed to build resilience of degrading marshes to protect against sea-level rise."

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Narragansett Bay Research Reserve