Investigating the Interconnectedness of Climate Change, Nuisance Mosquitoes, and Resilience of Coastal Salt Marsh Systems

Project Location

New Jersey

Project Duration

November 2016 to November 2020

Project Lead

Richard Lathrop
Rutgers University
lathrop@crssa.rutgers.edu

Project Type

Collaborative Research – generating science that informs decisions

Products

- Higher resolution habitat mapping and modeling accessible via NJFloodmapper
- Enhanced techniques for monitoring mosquito populations
- Public outreach materials, including a brochure and downloadable graphics
- Teaching modules for middle and high school educators
- Field survey, forest edge migration, and marsh change mapping data sets
- Journal articles summarizing scientific techniques and findings (in development)

Project Partners

- Rutgers University
- Jacques Cousteau National Estuarine Research Reserve
- Atlantic County Office of Mosquito Control
- Bergen County Mosquito Control
- Burlington County Office of Mosquito Control
- Cape May Mosquito Control
- Hudson County Mosquito and Vector Control
- Monmouth County Mosquito Control Division
- Ocean County Mosquito Extermination Commission
- Barnegat Bay Partnership
- North Atlantic Landscape Conservation Cooperative
- New Jersey Division of Fish and Wildlife
- New Jersey Department of Environmental Protection

Project Webpage

nerrssciencecollaborative.org/project/Lathrop16

Overview

Changes to salt marsh habitats from sea level rise are likely to affect the production and location of nuisance mosquito populations, which has implications for human health. Understanding how coastal ecosystems are being impacted by climate change, and how nuisance mosquito populations are changing, is critical to ensuring mosquito control agencies and coastal managers make the most informed decisions going forward.

Through data collection, mapping, and modeling efforts, this project increased clarity about marsh habitat change to inform mosquito control and coastal restoration efforts in New Jersey. Marsh-upland edge mapping and modeling suggest that this region is and will be a hotspot for change; field sampling confirmed these “new” habitats can serve as breeding areas for mosquitoes. The project team also developed environmental DNA (eDNA) assays for the most common salt marsh mosquitoes in the Mid-Atlantic United States. Working closely with mosquito control agency personnel, major advancements were made in mosquito surveillance through the deployment of drone-based sampling of breeding pools paired with the eDNA analyses. The team developed outreach materials to inform the public about health risks posed by mosquitoes, including how climate change might exacerbate those risks, and a teaching module for middle and high school educators.

Project Approach

Mosquito control agencies and other land management partners (end users) aided in the design and implementation of a research program to inform management actions, plans, and strategies. Using an adapted mediated modeling collaborative approach, end users and researchers actively collaborated throughout the project. Based on their input and feedback, the project centered on the following two main research objectives:

1) The development of strategies to identify salt marsh mosquito productive hotspots, including eDNA approaches to identify the presence of key salt marsh mosquito species and drone-based sampling of mosquito breeding pools; and

2) An assessment of past and projected future changes in the salt marsh landscape that could serve as salt marsh mosquito breeding hotspots.

To address the first research objective, the team focused on developing and evaluating the use of eDNA approaches for monitoring mosquito breeding activity. At present, mosquito control agencies periodically visit possible mosquito breeding locations to collect water using a long-handled dipper that they visually assess for the presence of live mosquito larvae or exuded pupae skins. The eDNA approach might be more efficient and effective in documenting the presence of mosquito breeding activity. Accordingly, a key first step was the development of quantitative PCR (qPCR) techniques from laboratory-raised mosquitoes. The team successfully developed qPCR assays for the five main salt-brackish marsh mosquito species (*Aedes sollicitans, Aedes taeniorhynchus, Aedes cantator, Culex salinarius, and Anopheles bradleyi*).

The lab assays were developed to determine the presence of a particular mosquito using an environmental sample. To collect eDNA, the team undertook intensive sampling at salt marsh field sites across the New Jersey coastal zone. These field sites were located in collaboration with the mosquito control agencies to coincide with locations that they identified as known or potential problem mosquito breeding areas. Initially, efforts focused on the examination of salt marsh soil cores for the presence or absence of mosquito DNA from mosquito eggs and egg shells. When this approach proved insufficiently sensitive or consistent, the team shifted to evaluation of eDNA from water samples collected from standing water pools where mosquito larvae hatch and grow. One problem faced by the mosquito control agencies is that the marshes can be exceedingly difficult to traverse on foot, making it nearly impossible to physically access some mosquito breeding pools and collect water samples. Working with county mosquito control agencies, the team developed and tested a drone-based system to collect water samples from salt marsh pools for later eDNA analysis.

To address the second research objective, the team mapped the present salt marsh landscape and assessed past and projected future changes that could serve as salt marsh mosquito breeding hotspots. Using high-resolution aerial imagery coupled with existing GIS data, the team mapped present day marsh habitat types. Using historical aerial photography, the team documented how dramatically the interface between coastal salt marshes and adjacent forests has shifted inland. Coastal forests have declined, died back, and then been replaced by expanding salt marsh, thus opening up new habitats where salt marsh mosquitoes could potentially breed. Field sampling confirmed that these forest dieback zones could serve as “new” mosquito breeding habitats. The team used the Sea Level Affecting Marshes Model (SLAMM) to map projected future change in this marsh-forest interface zone. The resulting maps were incorporated into a publicly accessible web-based map viewer to provide ready access to the end user community.

Results

The team successively employed qPCR techniques to develop assays for the most common salt marsh mosquitoes in the Mid-Atlantic United States. Working collaboratively with the county mosquito control agencies, the team successfully demonstrated the efficacy of drone-based water sampling coupled with the eDNA analysis to document the presence of breeding mosquitoes. The development of these multi- versus single-plexing qPCR techniques represents a major advance in mosquito surveillance.

Discussions with end users suggested that the eDNA approach shows promise both for its efficiency and its effectiveness in documenting the presence of mosquito breeding activity in conjunction with existing operational monitoring by mosquito control agencies. In particular, eDNA approaches were deemed to be useful means of detecting the presence of known species breeding in new geographic locations and/or newly occurring species (e.g., range expansion, invasive introductions). The general consensus among end users was that eDNA approaches are not ready for operational monitoring of hatch events where time is of the essence to inform treatment decisions such as aerial spraying. The present turnaround time of approximately two days between collection and processing was too long (as compared to dip netting). This project opens up new avenues for the continued collaboration between the research community and government agency practitioners to further develop these eDNA approaches for the monitoring of mosquito populations.

The marsh-upland edge modeling and mapping suggests that the marsh-upland transition zone is and will be a hotspot for change. Field sampling confirms that these "new" habitats can serve as breeding areas for the target mosquito species and thereby represent an area of concern for the mosquito control agencies. High-resolution mapped outputs produced by the project have been incorporated into a web-based information portal (*NJFloodmapper.org*) to provide access to end users about the present and future projected status of the New Jersey coastal marshes.

Benefits

- Better understanding of how salt marshes are likely to change in New Jersey as a result of climate change and sea level rise, and, subsequently, salt marsh mosquito breeding hotspots.
- Major advancement in mosquito surveillance that includes drone sampling and new eDNA approaches to detect the presence of the four main salt marsh mosquito species breeding in New Jersey.
- Increased end user access to updated public outreach materials about the health risks posed by mosquitoes and how people can protect themselves.
- Development of educational modules that focus on the project's research efforts, including the impacts of climate change on mosquitoes and their habitats, eDNA, and DNA extraction.

What's Next

The project team plans to further refine the modeling of projected marsh changes by including updated information about the present rates of vertical accretion in salt marshes. Working with a three-state (Delaware, New Jersey, and Pennsylvania) network of collaborators, the team has acquired an extensive compilation of marsh surface elevation data. To aid in explaining geographic patterns of accretion, the team has extracted a complementary set of elevation, marsh vegetation, and marsh alterations (mosquito ditching, farm diking, and Open Marsh Water Management). The team will then employ a structural equation modeling approach to develop an explanatory model that can be used to extrapolate spatially. Once the structural equation modeling of accretion analysis is completed, they will rerun the SLAMM (V6.7) marsh change models and share the updates via *NJFloodmapper.org*.

About the Science Collaborative

The National Estuarine Research Reserve System's Science Collaborative supports collaborative research that addresses coastal management problems important to the reserves. The Science Collaborative is managed by the University of Michigan's Water Center through a cooperative agreement with the National Oceanic and Atmospheric Administration (NOAA). Funding for the research reserves and this program comes from NOAA. Learn more at nerrssciencecollaborative.org or coast.noaa.gov/nerrs.