Investigating the Effects of Rising Salinity on Coastal Amphibians and their Communities

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Introduction:

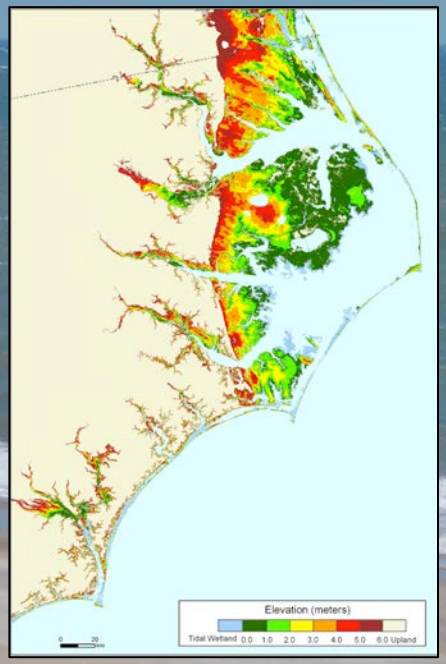
North Carolina's coastline is predicted to be severely impacted by accelerating rates of sea level rise, and wetlands and ponds along North Carolina's coast will become increasingly saline. Consequently, amphibian populations that occur in salt intruded habitats are likely to experience novel environmental conditions and increased abiotic stress.

Amphibians evolved 360 million years ago and have successfully invaded every ecosphere on the planet - with the notable exception of the marine biome. Porous skin and the inability to concentrate and excrete salt are well-documented traits that may preclude amphibians from occupying marine ecosystems.

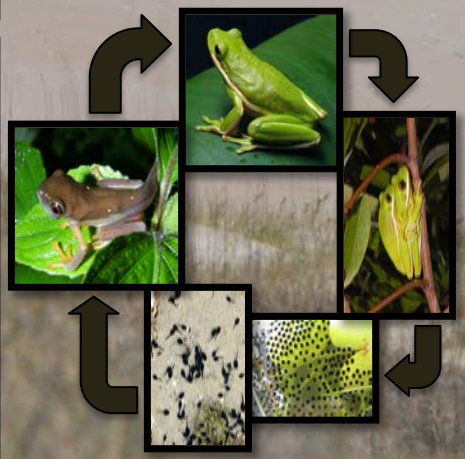
However, populations of anuran species are known to persist in coastal wetlands with frequent salt-water incursions. Therefore, we suggest that the classical assumption that amphibian physiology and life history precludes their ability to persist in saline environments needs re-evaluation.

Few studies have considered how the mechanisms that maintain osmotic balance during each stage of the anuran life cycle interact with, associate with, and influence tolerance to brackish conditions, biotic interactions, phenotypic plasticity, and community organization.

We propose to address this gap by conducting a series of experiments that links anuran osmoregulatory physiology with behavior, life history traits, and species interactions across stages of the anuran life cycle. Developing a more complete understanding of amphibian tolerance and adaptive responses to saline environments is necessary in order to predict and mitigate the impacts of sea level rise on coastal amphibians.



Elevation Map of Eastern NC. From J.G. Titus and J. Wang. 2008. "Maps of Lands Close to Sea Level along Mid-Atlantic Coast" EPA.



Implications for Management:

Survey: We will conduct a survey to provide geo-referenced information on biotic and abiotic changes along a salinity gradient.

To best respond to climate change, managers will need the following information:

- How rising salinities will affect coastal amphibian populations
- The regions and populations facing the highest risk of incursion and species loss
- Strategies to effectively temper population losses

We will synthesize the results from our investigation into predictive risk maps to equip practitioners to respond appropriately to the challenges associated with sea level rise.

Project 1: Comparative Investigation of the Mechanisms of Salt Tolerance:

Resorb ions and water via active and passive transport in kidney

Lower permeability of skin (pelvic patch) by relocating AQPs

Maintain osmotic gradient by increasing blood osmolality

Reabsorb urine from bladder

- Developing a mechanistic understanding of the differences in saltwater tolerance between and among species may explain the observed geographic variation in species ranges between freshwater and salt-invaded wetlands.
- Understanding differences between and among species will allow us to more accurately predict the effects of SLR on coastal amphibian populations.

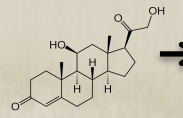
Project 2: Oviposition Site Choice:

Salt Invaded

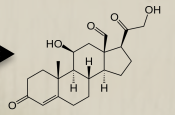
Freshwater

- By avoiding suboptimal sites, females can increase their fitness by decreasing egg/larval mortality. Females may be able to detect and evaluate salinity as well, thereby adaptively mitigating egg and tadpole loss by avoiding pools with high salinity levels -- but this remains understudied.
- We will examine oviposition site choice experiments on coastal anurans andexamine whether there are differences among coastal and inland populations for the ability to make adaptive choices about oviposition sites.
- Increasing our understanding of the effect of salinity on oviposition site choice and offspring success may provide valuable insights about the long-term persistence of coastal amphibian populations and how rising salinity levels may affect population dynamics.

Project 3: Interactions between Salinity, Predators, and Tadpole Development:



Corticosterone



Aldosterone

- In salt-stressed individuals, corticosterone can be converted into the anti-diuretic hormone, aldosterone. This reduction in corticosterone levels may reduce the propensity of tadpoles to assume anti-predator phenotypes, thus increasing risk of predation.
- The interaction between osmotic stress from salt exposure and predation risk is not well studied or appreciated.