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**Statement of Work**

# Extinction risk of specialist marsh birds as sea levels rise

## Introduction

Crutzen (2002) first proposed that Earth has entered into a new geological epoch - the Anthropocene, a time period defined by human activity. Perhaps the most fundamental change is the increase in the amount of carbon dioxide in the atmosphere, leading to dramatic observed and predicted changes in Earth's climate. Byproducts of climate change include rising sea levels and increases in storm frequency and intensity (Wong. et al. 2014), which are altering coastal wetlands worldwide. Species extinctions are also a consequence of climate change and extinction rates are predicted to increase greatly over the next century (Oppenheimer et al. 2014).

Specialist species use a narrow range of resources, often benefitting from a set of conditions unused by other organisms (MacArthur 1972), but this strategy also constrains resource options if habitat changes occur. Specialist species are thus especially vulnerable (Futuyma and Moreno 1988, Devictor et al. 2010) and specialism is one of the most important factors determining global extinction risk (Dennis et al. 2011).

Ever since Gause's early research, we have understood that alternative life history traits evolve because two species cannot occupy the same ecological niche indefinitely (Gause 1934; Hardin 1960). Species using different niches within the same ecosystem, therefore, may face different threats or may have evolved different strategies to ameliorate their effects. Sympatric species have filled niches and evolved breeding strategies over long evolutionary time scales, but how will these species fare if an abiotic factor they are adapted to changes rapidly?

Tidal marsh bird specialists persist in coastal wetlands throughout their lives. Tidal marshes are characterized by daily tidal inundations that correspond with the lunar cycle, with especially high spring tides occurring every two weeks. High spring tides threaten all birds nesting in tidal marshes, because the low vegetation causes birds to nest close to the ground. To avoid nest failure due to high spring tides, tidal marsh specialists have adapted in a variety of ways, including their nest placement, nest structure, and synching their reproductive cycles with the tides. These adaptations have been well studied in the Saltmarsh Sparrow, but much less is known about the suite of other specialist bird species that live alongside them (Humphreys et al. 2007, Bayard and Elphick 2011, Elphick unpublished data).

Sea level rise may be the most persistent threat to tidal marsh ecosystems. The global mean sea level has risen since 1900 and is predicted to rise up to 74 cm (2 ½ feet) more by the end of the century (Wong et al. 2014). This corresponds to marsh loss at a rate of 1-2% per year (Pendleton et al. 2012). Marshes will not only diminish in size, but also change in vegetative composition (Field et al. 2016, Hunter et al. 2016). Sea level rise also contributes to higher water levels and increased flooding in tidal marshes (Wong et al. 2014). It is well documented that one tidal marsh specialist species, the Saltmarsh Sparrow, will go extinct by 2060 because increased flooding due to sea level rise will inhibit adults from successfully fledging chicks in between high spring tides (Field et al. 2016). The project I propose will expand beyond using a single species, but rather a suite of species, to better understand how tidal marsh ecosystems as a whole will be impacted by sea level rise.

I propose to conduct a comprehensive examination of specialist extinction risk due to sea level rise. I will focus on the suite of bird species (Seaside Sparrow, Willet, and Clapper Rail) that inhabit coastal marshes, but which demonstrate an array of different nesting traits and behaviors and thereby provide broad-based information about how sea-level rise is affecting the

ecosystem. Differences occur in nest sites, nest structure, incubation time, egg size, the ability for chicks to survive nest flooding, and the ability for adults to manipulate nests upon flooding.

Specifically, I seek to determine:

1. How does extinction risk due to sea level rise vary across specialists that use coastal marshes differently?
2. What life history traits ameliorate the impact of sea level rise and reduce extinction risk?
3. What can population trends of specialist bird species tell us about the ways in which marsh inundation patterns are changing?

By answering these questions, I hope to better understand how sympatric species may be more or less adapted to a rapid, ecosystem wide change. I also hope to provide management suggestions through better understanding the nest site requirements for each species.

**Methods**

Data will be collected at two sites in coastal Connecticut: Hammonasset Beach State Park and East River Preserve between mid April and July. I will combine traditional area searches to locate nests, with the use of a thermal imaging camera to enhance the detectability of the more cryptic species. Collection of data on nest site, nest structure, nest monitoring, and nest fate procedures will follow existing protocols developed by the Saltmarsh Habitat and Avian Research Program (Ruskin et al. 2016; www.tidalmarshbirds.org). I will determine GPS location, site elevation, distance to nearest tidal waterway, vegetation thatch depth, height and species of tallest vegetation, average vegetation height, and percent cover of focal plant species. To understand nest structure, I will measure nest height, thatch cover, woven nest canopy, degree of canopy cover, and entrance orientation. I will collect paired data at random marsh sites for every nest found, to describe available conditions. To determine nest fates, I will monitor nests every 3-4 days until the nest is no longer active. At each visit I will record the number of eggs and chicks and information related to nest fate. Willet and Clapper Rail nests will be visited every day in the week preceding hatching to increase the accuracy of nest fates because in these species young can leave the nest within a day of hatching.

To detect behaviors that reduce reproductive risk, I will place small, unobtrusive wildlife video cameras near a random sample of nests during the days around the highest spring tide. Cameras will be turned on remotely using Bluetooth 1.5 hours before the spring tide and finish recording 1.5 hours after the spring tide and record for a total of 3 hours. My sample size will be 30 video recordings per species, for a total of 90 recordings. Using the video footage, I will quantify the frequency by which chicks of each species successfully climb or swim during a flooding event and the frequency by which adults add vegetation to nests as flooding occurs or retrieve eggs that have flooded out of nests.

To better understand the differential risk of eggs flooding out of nests, I will experimentally test the rate of flooded eggs from nests across species. I will place a 20 cm aluminum ducting pipe 4cm into the soil surrounding an inactive Seaside Sparrow, Willet, or Clapper Rail nest. I will then place mock Seaside Sparrow, Willet, or Clapper Rail eggs (that represent the size and mass of each species' eggs at the onset of incubation and immediately before hatching) in the nest. I will slowly add water to simulate flooding, and count the eggs that have flooded out. Nest domes (grasses surrounding the nest that are manipulated to cover the top of the nest) have been shown to minimize egg flooding in the Saltmarsh Sparrow (Humphreys et

al. 2007). The Seaside Sparrow, Willet, and Clapper Rail create woven nest domes in various frequencies. I will perform the same experiment on nests that contain woven nest domes to determine whether the function of nest domes is to constrain eggs from flooding out of nests.

Data will be analyzed using various regression techniques in the R statistical environment.

**Portions of Work Completed:**

My lab is one of several that collaborate in the Saltmarsh Habitat and Avian Research Program (SHARP, http://tidalmarshbirds.net/). During the summer of 2016, I collected data for SHARP at both of my proposed sites, working with the same species. Advanced knowledge of these sites will be very helpful to me upon starting my data collection in summer 2017.

The SHARP group has collected demographic data on my target species for the past six years, focusing primarily on the Saltmarsh Sparrow. The SHARP data set includes data for nearly 100 nests of each of my target species. These data will be used to augment field data that I collect.

**Benefits to Coastal Wetlands:**

Sea level rise is causing tidal marshes to flood more frequently, reduce in size, and change in vegetative composition. Sea level rise will inevitably impact many tidal marsh species and understanding the impacts on a suite of tidal marsh bird specialists will help to understand how marshes will be impacted ecosystem wide. Furthermore, the majority of tidal marsh avian work in the Northeast has focused on detailed demographic work on the declining Saltmarsh Sparrow (Wiest et al. 2016, Elphick et al. 2015, Field et al. 2016). By studying extinction risk on an array of specialist bird species, rather than a single species, my data will indicate the likely changes to the ecosystem as a whole.

To date, no published study has been completed on Clapper Rail demography in Connecticut, the current northernmost edge of the species' range. The Clapper Rail is declining at a rate of 13% per year in Connecticut and 9% per year regionally (Correll et al. 2016). The findings of this project may guide management decisions, as it may illuminate threats to Clapper Rail reproduction or demonstrate that more research needs to be put into other life stages of this species.

**Budget:**

| Item | Cost | Frequency | Total Cost | Justification |
|---|---|---|---|---|
| Connecticut College | $55.00 | 10 weeks | $550.00 | Coastal field housing is required for me to collect field data daily. |
| GoPro HERO Session | $200.00 | 10 | $2,000.00 | Small, durable, compact video camera that is cost effective. |
| GoPro Smart Remote | $80.00 | 1 | $80.00 | GoPro Smart Remote will allow me to set up camera units at nests prior to flooding and begin recording synchronously using Bluetooth. |
| GoPro Large Tube Mount | $40.00 | 10 | $400.00 | GoPro video camera will be attached to a pole using this mount and staked into the ground next to nests for video recording. |

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|---|---|---|---|---|
| 64 GB Lexar microSDXC Memory Card | $80.00 | 10 | $800.00 | GoPro video camera purchase does not include memory card. |
| GoPro Portable Power Pack | $50.00 | 10 | $500.00 | GoPro Portable Power Packs will be used during video recording to extend GoPro video camera battery life beyond ~1.45 hours. |
| Miscellaneous | $50.00 | 4 months | $200.00 | Flagging tape, field notebooks, raw materials for mock eggs, GPS batteries, and other field costs that arise. |
| Mileage | $0.54 | 870 miles | $469.80 | This figure represents a portion of the gas mileage I will incur traveling to field sites 6 days/week over 10 weeks. Round-trip ~64 miles, totaling 3,840 miles over the field season ($2,073.60 at the standard mileage reimbursement rate of $.54/mile*). |
| | | **Total** | **$4,999.80** | |

*https://www.irs.gov/uac/newsroom/2016-standard-mileage-rates-for-business-medical-and-moving-announced

**Sharing research results with a larger audience:**

My lab group and the Saltmarsh Habitat and Avian Research Program (SHARP) maintain strong relationships with the United States Fish and Wildlife Service, Atlantic Coast Joint Venture, the North Atlantic Land Conservation Cooperative, and numerous state agencies and NGOs engaged in wetland protection. SHARP investigators, including my advisor, are also taking the lead in the development of a coordinated eastern US coastal marsh bird conservation plan. Through these connections, I will both seek frequent stakeholder feedback on my work and have a natural conduit to disseminate my research findings. Additionally, I will present my research findings at regional and national conferences (e.g. Connecticut Conference on Natural Resources in March 2018; Society of Wetland Scientists' 2018 Annual Meeting; The Waterbird Society 2018 Annual Meeting) that brings together management personnel from government and non-governmental management agencies.

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