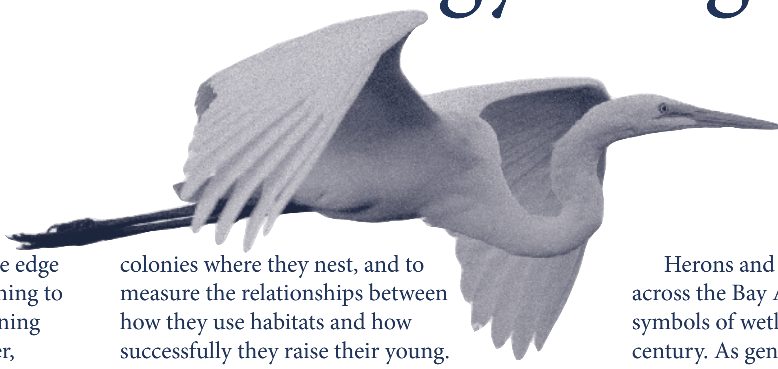
Studying top predators to understand landscape habitat linkages

The Movement Ecology of Egrets

by Scott Jennings



A Great Egret stands tarsus-deep on the edge of a tidal slough, still and silent, seeming to melt in and out of the cold February morning fog. Its long yellow bill stabs into the water, comes up with nothing but drops of water, then strikes again and this time snatches a wriggling stickleback. Having gotten its fill for breakfast (or perhaps not), the egret croaks at something in the sky, then spreads its wings and takes flight, disappearing into the rising mist.

Where did this egret go? Why did it take flight now? Will it come back to this tidal slough tomorrow morning, or will it instead go elsewhere to forage in a flooded pasture? Will this egret's foraging behavior today and tomorrow allow it to raise more young this spring than the rest of the birds in its colony? How do the habitats where this bird forages influence how long it lives? ACR has initiated an exciting new research endeavor, the Heron and Egret Telemetry Project, to answer questions such as these.

We are using tiny, lightweight, solar-powered GPS tags (Figure 1) to record detailed information about Great Egret movement and behavior. These tags will allow us to track individual birds from the wetlands where they forage to the colonies where they nest, and to measure the relationships between how they use habitats and how successfully they raise their young. This is a fundamental pursuit of an emerging field of research termed "movement ecology"—the science of linking the why, where, when, and how of animal movements to the ecological and evolutionary consequences of their behavior (Nathan et al. 2008). A greater understanding of how individual movement and behavior are related to survival and reproductive success will provide a valuable new context to our long-term research on heron and egret nesting abundances across the Bay Area. This expansion of our research will lead to new insights into how these beautiful birds depend on the varied wetland conditions found throughout this urbanized region.

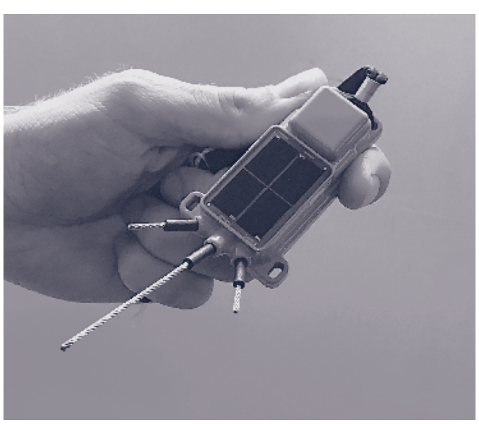


Figure 1. A solar-powered GPS telemetry tag used to generate three-dimensional data on Great Egret movements, postures and behaviors.

Movement ecology of predators guides wetland conservation

Wetlands are the focus of growing attention from scientists and the public for their value as wildlife habitat and for the range of ecosystem services they provide for humans. These services include flood mitigation, removal of pollutants travelling between rivers and oceans, buffering the effects of rising sea levels and increased storm intensity, and aesthetic benefits (Horwitz et al. 2012, Scholte et al. 2016). The San Francisco Estuary is the largest wetland ecosystem in the western United States and provides essential habitat for diverse wildlife, including large proportions of populations of migratory and resident bird species (San Francisco Estuary Partnership 2015). This estuary is a complex, broadly urbanized landscape, with a range of conditions (ecological processes, wildlife values, human land use, recreation, etc.) affected by altered hydrologic patterns and by widespread restoration and conservation efforts (Cohen 2000).

Herons and egrets are ubiquitous in wetlands across the Bay Area and have served as iconic symbols of wetland conservation for over a century. As generalist top predators, they exert top-down influence on the structure of lower trophic levels, altering the abundance and distribution of multiple prey species and, in turn, the effects of their prey on other species (Huang et al. 2015). Food-web connections involving top predators are important elements of healthy ecosystems and may influence rates of carbon cycling (Schmitz et al. 2014). Studying how herons and egrets move across the landscape to select and use habitats is critical to understanding their ecological requirements and, in addition, their role as top predators in sustaining the richness of life in wetland ecosystems.

Research plan

Expanding ACR's heron and egret research to include GPS telemetry will allow us to answer questions about these species' ecological needs that are unanswerable using other methods. The tags we've selected to use in our study collect GPS locations and accelerometry data and send the information wirelessly back to us. Accelerometers collect data on three-dimensional movement that can be used to estimate the energy costs of particular behaviors. Thus, the tags provide data on where birds go and about what they do when they get there.

A key advantage in using GPS telemetry to study animal movement and habitat use is that it avoids the bias that may be associated with field researchers observing individual animals in the field. Rather than choosing when and where to observe animals, a researcher can use GPS tracking to intensively sample behavior and habitat use, and then apply analytical methods to let the animal movements themselves define the spatial and temporal scales of the investigation. Another benefit of using GPS tags is that they generate a tremendous amount of data, measuring animal locations and behavior far more frequently and over much larger landscapes than field observers can. These extensive data will allow us to answer numerous questions in several broad areas. We will begin with descriptive analyses of movement, habitat use, and energetics. This information will provide a foundation for more complex analyses that link individual movements and behaviors to survival and reproductive performance and, ultimately, to population dynamics. Our investigation will be structured around the following five lines of inquiry.

1. Landscape movement and habitat use. We will describe and quantify how individual egrets move across the landscape and the environmental factors that influence their movement and habitat use. This will provide far greater detail about the lives of egrets than previously known.
2. Energy balance. We will investigate and describe individual patterns of energy intake and expenditure across the landscape. We will generate maps of the "energy landscape" of these birds to show how the temporal and spatial costs of movement relate to the benefits of foraging in different areas and habitats.
3. Survival probability. We will quantify the relationships between egret survival and their movement patterns, habitat use, and energy expenditure.
4. Reproductive success. We will quantify the relationships between egret reproductive success (nest survival, number of fledged chicks) and their movement patterns, habitat use, and energy expenditure.
5. Population correlates of individual behavior. We will combine the individual-based aspects of egret behavior and fitness with ACR's long-term studies of regional nesting performance and abundance, to predict how changes in wetland conditions influence the abundance and ecological roles of Great Egrets in the San Francisco Bay area.

ACR's long-term research on heron and egret abundances and reproductive success throughout the Bay Area provides a powerful context for the new telemetry research. This expansion of our work promises new insights into the environmental conditions needed to sustain heron and egret populations. Additionally, this research will set the stage for understanding the role these top predators have in structuring the biological communities where they forage. We will also join collaborative investigations with similar studies in the Midwest and along the East Coast, to reveal how regional populations of herons and egrets differ in their movements, behavior, and environmental requirements.

A nationwide collaboration

This is an ambitious project and we have a tremendous amount to learn, but we are not embarking on this new research alone. ACR is the newest partner in an exciting—now nationwide—science-based education project called "1000 Herons," which integrates the cutting-edge science of GPS telemetry with the unique opportunities for conservation education and outreach this method provides. Key partners in this collaboration are Dr. John Brzorad (Lenoir-Rhyne University, North Carolina), Dr. Alan Maccarone (Friends University, Kansas), Danielle D'Auria (Maine Department of Inland Fisheries and Wildlife), and the U.S. Forest Service's Northern Research Station in the eastern United States.

Drs. Brzorad and Maccarone travelled to California in early June 2017 to teach us the egret capture method they developed and how to safely attach the GPS tags. We use padded foot-hold traps, modified to minimize any risk of injury to the birds, placed in shallow water in egret foraging habitat. We use decoys—lawn flamingoes painted white!—to attract these gregarious foragers from the surrounding area, and a tub stocked with live minnows to guide the birds to the traps. While the traps are set, we hide as close to them as possible (generally 50–100m) so we can release birds as soon as they trigger a trap. Our learning curve during Brzorad and Maccarone's visit was steep, but by the time they left we had attached transmitters to three Great Egrets. These first three egrets were captured at ACR's Toms Point, in northern Tomales Bay. Our goal for the rest of 2017 is to deploy an additional 11 tags, in San Pablo Bay and Suisun Marsh, to study the movement ecology of egrets throughout the area covered by our long-term monitoring of regional nesting colonies.

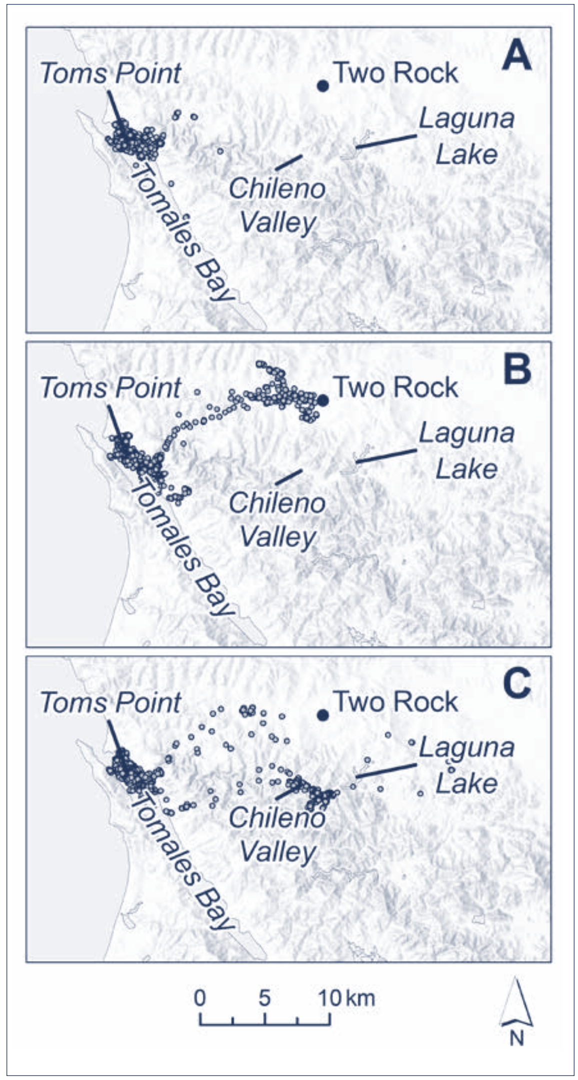


Figure 2. Location data for our first three tagged birds during two weeks in June, 2017. Each dot represents the location of the bird, collected by GPS tag every five minutes.

Initial data reveal interesting patterns

The tagged egrets are already providing a fascinating window into the lives of these birds. For example, although all three birds were captured at Toms Point, and all of them continue return there, they are showing interesting individual differences in where else they go (Figure 2). While the first Great Egret (GREG_1) has remained on Tomales Bay, the other two egrets have spent substantial time inland. GREG_2 has focused its inland time in the Fallon–Two Rock area, in the broad fields and rolling hills of the lowlands

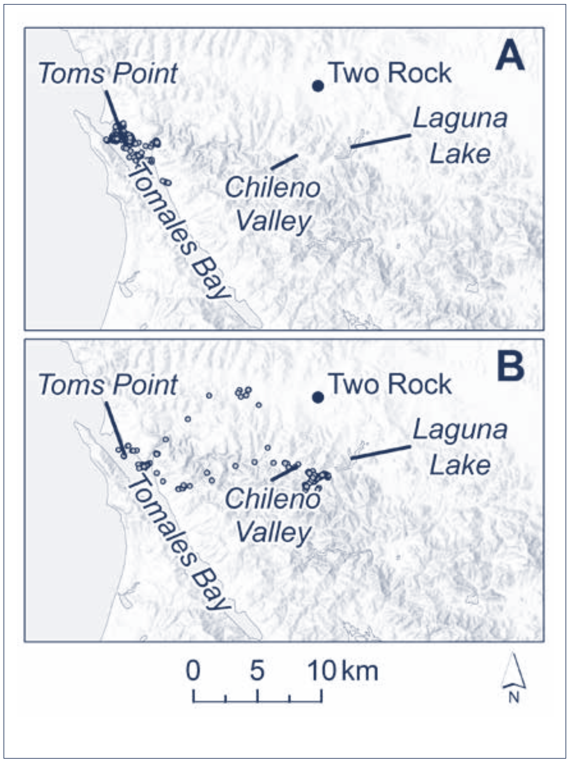


Figure 3. Location data for GREG_3 (A) during a period of several days when eelgrass beds were available for foraging in tidal areas several hours per day versus (B) a period of days when the eelgrass beds were available for less than a few hours per day.

between Petaluma and Bodega Bay. In contrast, GREG_3 has spent most of its inland time in Chileno Valley and, interestingly, has traveled near Laguna Lake but has not visited the lake itself. Both of these birds appear to be focusing their inland foraging at farm ponds and along small creeks, highlighting the habitat values of particular private ranch lands.

Environmental conditions such as tidal patterns also appear to be influencing the movements of our first tagged birds. During low tides, Great Egrets and Great Blue Herons forage in the extensive eelgrass *(Zostera marina)* beds of the intertidal and shallow subtidal areas of Tomales Bay. As the daily tidal cycle shifts from week to week, the amount of time the eelgrass beds are available for foraging during daylight hours fluctuates. These fluctuations in eelgrass availability may be shaping where GREG_3 spends its time. During a week when the eelgrass was available (water level ≤ 1 foot above MLLW) for 3.5–5.4 hours per day, GREG_3 remained on Tomales Bay (Figure 3A). However, during the following week, eelgrass availability dropped to only 0.8–3.4 hours per day, and it was during this time that this bird traveled inland to forage along Chileno Creek and other areas (Figure 3B).

Increasing ACR's commitment to heron and egret conservation

As the Heron and Egret Telemetry Project continues to generate new information on the movement patterns and habitat use of these birds (Figure 4), we will gain important new insights for protecting the lands they rely on—with particular attention to shifting climate and land-use patterns. For example, comparing the time budgets and reproductive performance of birds that stay along the coast (like GREG_1) to those that spend part of their time inland (like GREG_2 and GREG_3) can provide critical information about the relative importance of different habitats.

Additionally, by understanding how current environmental conditions influence egret movement and habitat use, we can predict how climate change or shifting land-use patterns will affect this species. For example, if eelgrass beds begin to drown because they are unable move to higher elevations as sea level rises, then egrets may depend more strongly on inland ponds and creeks. At the same time, shifting precipitation patterns resulting from climate change may alter the hydrology, and thus foraging quality, of these inland foraging areas, possibly affecting the number of egrets that can nest in the region.

Figure 4. A solar-powered GPS telemetry tag transmits information on Great Egret movements and habitat use. Photo by Barbara Wechsberg.

Knowledge about the choices individual egrets make as they move through large wetland landscapes, and how these choices influence egret population dynamics, can help us to guide land managers, agencies, and others working to manage environmental processes and protect the quality of wetlands. This new direction in ACR research will open new opportunities for national and international collaboration and expand ACR's role as a regional leader in conservation science.

Avian Ecologist Scott Jennings is the lead investigator on ACR's Heron and Egret Telemetry Project.

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