Feeding Strategies of Great Blue Herons (*Ardea herodias fannini*) in False Bay, San Juan Island

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Abstract

Abundance and foraging habits in Great Blue Herons (*Ardea herodias fannini)* are correlated with habitat type, tide phase and height, and group size in False Bay in the San Juan Islands, Washington. We completed field surveys during 9-18 August 2014 at False Bay to examine general heron abundance and strike rate success for different habitats, tide phases and heights, and heron group sizes. Total abundance was assessed along with location in the bay, habitat type, water depth, and tide phase and height for each individual. We assessed strike rate success for individuals, noting the five criteria above as well. The results from foraging observations indicated that herons at False Bay had greater strike rate successes behind the tideline and in deeper water, and during higher and flood tides. Such success patterns could relate to prey abundance, size, and profitability. We also found the success rate of individual herons to be greater when foraging alone or in groups of six or more. These success patterns could be due to competition factors, as well as herons using one another as indicators of food availability. Additionally, we found heron abundance and success rate appear inversely related in some cases, which may be related to prey depletion. Congruent with findings from previous studies, this study indicates a correlation between heron foraging success and the aforementioned habitat, tide, water depth, and group features.

Key Words

Great Blue Heron, *Ardea herodias,* False Bay, San Juan Island, strike rate, foraging, abundance, tide height, tide phase

Introduction

Wading birds (Ciccniiformes) of the Pacific Northwest exhibit highly specific feeding behaviors in their natal waters. Great Blue Herons (*Ardea herodias fannini*), native to the coastal areas off of Washington, are no exception. Herons prefer to feed in shallow tide flats or shallow fresh water lakes (Meryrrieck 1989). False Bay, a common heron feeding area, has varied terrain, tides, and many other factors that could be responsible for heron success in this region. This study examines topographic and hydrologic factors that contribute to the feeding success of Great Blue Herons in False Bay.

Wading birds rely heavily on hydrologic conditions to maximize their success in prey capture (Khal 1964). There are 28 different types of feeding behavior exhibited by wading birds and the Great Blue Herons use one of the most varied amount seen in one species. They primarily use variations on the “stalk” and “upright stand and wait” feeding techniques, but exhibit many other feeding behaviors (Meryrrieck 1989). All behaviors used by Great Blue Herons can be observed in the intertidal zone of False Bay, Washington, making it an ideal location to monitor their feeding success (Gawlik 2002).

Prey availability depends on prey type and density but also on availability of the prey to the predator. In False Bay, Great Blue Herons’ access to prey depends on the location, habitat type, water depth, tide phase and height, and group size in which the herons feed. In this study, we evaluate ecological factors that lead to the greatest feeding success in Great Blue Herons and discuss how these factors may change prey availability.

Methods

Study Location

Our study site was False Bay, a 225-acre Marine Protected Area that opens into Haro Strait on the southern end of San Juan Island (48.486 °N, 123.068 °W). Surveys occurred between 9 August 2014 and 18 August 2014. The site was divided into three width zones, seven depth zones, and three habitat types. The 3 width zone gridlines ran northwest to southeast, and the seven depth zone gridlines ran southwest to northeast. Each of these zones was defined by natural and man-made markers along the edge of the bay (Fig. 1). The three habitat types used in the study were surf, tide pool, and rookery.

Survey Methods

We conducted total abundance surveys and focal animal behavioral sampling for 2 to 4 hours per day for 7 days during the survey period. National Oceanic and Atmospheric Administration data was used to find low tide times for each day and surveys were conducted mainly during slack flood and slack ebb. Herons were reported to be most abundant in False Bay during tides below 0.3m (Chen and Dalgarn 2013).

Total abundance surveys were taken about every 20 minutes. We recorded time and date and counted all herons visible in the bay. For each individual, we recorded absolute location (zone), habitat type, water depth (ankle, knee, or leg depth; or dry), and distance from the current tideline (estimated in meters). Distance from the current tideline was positive if the bird was inland (dry) from the current tide and negative if the bird was farther out (wet) relative to the current tide.

During focal sampling, two observers randomly selected one heron to continuously watch for 10 minutes. The third observer recorded the starting location of the heron, all strikes and successes during the period, and the size of any fish caught. Strikes were defined as any forceful plunge of the heron's bill into the water and successes were defined as any visible catch of prey. Herons have significant handling time for their prey before eating it, so we were confident that we could identify most, if not all, successes (Dickensen 1947). We used two fish categories: small (less than ½ bill length) and large (equal to or greater than ½ bill length). Observations were terminated if the bird left. Total abundance counts were repeated after each focal sampling. All surveys were conducted with a 15 – 45X scope and 15X binoculars.

Analysis

We compared foraging success rate to the following variables: location of the heron relative to the tide, habitat type, water depth, tide phase, tide height, and group size. Foraging success rate was defined as number of successes divided by number of total strikes per interval and was given in percentages. Water depth was converted to inches using known information about heron proportions. Lengths for ankle, knee, and leg height were estimated to be 4.2 to 6 inches, 8.5 to 12 inches, and 12.7 to 18 inches, respectively (Fig. 2). Group size was defined as number of herons within the same NW-SE and NE-SW zone.

We also compared total heron abundance to tide height and phase to measure if there was a relationship between total abundance and mean foraging success. Mr. Tides was used to determine tide height and phase for each sampling unit. For both foraging success and total abundance comparisons, mean values were calculated for each meaningful category within a variable (habitat type, tide phase/height, or group size) and sample size values and 95% confidence intervals were shown in each graph.

Results

Habitat Type

Our data show a correlation between heron foraging success and distance from the current tideline. We found that herons are about twice as successful when foraging 25 or more meters behind the tide (in the water) than when foraging 25 or more meters in front of the tide (inland) (Fig. 3a). Additionally, herons tended to forage behind the tideline at high tide heights and forage at or in front of the tideline at low tide heights (Fig. 3b).

Heron foraging success and strike rate also differed by habitat. Herons in the surf were about 30% more successful when foraging in the surf versus tidepool (Fig. 4). However, herons in the tidepool had higher strike rates than herons in the surf.

Finally, we observed a pattern between water depth and heron foraging success. Herons in knee and leg deep water were more than twice as successful as herons in ankle deep water (Fig. 5).

Tide Phase & Height

Heron foraging success and abundance differed by tide phase but in opposite directions (Fig. 6). Specifically, herons were about 2.5 times more likely to catch fish while foraging in flood versus ebb tides. However, heron abundance was about 20% lower during flood tides (mean = 9.6 birds) than during ebb tides (mean = 7.3 birds).

Heron foraging success and abundance also differed by tide height but in opposite directions (Fig. 7a-7b). Herons were about 10% more successful in tide heights from 1 to 4 feet compared with tide heights of -2 to 1 ft. However, heron abundance was about 25% lower at tide heights of 1 to 4 ft than at lower tide heights.

Group Size

Individual herons and larger groups of herons had the highest foraging success rates (Fig. 7a-7b). Compared to herons in groups of 2-5, individual herons had a 13% higher success rate and herons in groups of 6 or more had a 17% higher success rate.

Discussion

Our results suggest that Great Blue Herons have the most foraging success when feeding in the deeper surf beyond the tideline, during flood phase at higher tides, and while either alone or in larger groups. Relative to tide phase and height, herons' abundance and foraging success appear related in opposite directions.

Habitat Type

Herons may have greatest feeding success 25 or more meters beyond the tideline due to increased prey availability. Water within 25 meters of the tide may be shallower and contains smaller or fewer fish, reducing herons' ability to see or catch them. Alternately, water behind the tide is likely deeper and contains more or larger fish. In addition, herons usually foraged beyond the tide line during higher tide heights, when water covered a large area of False Bay. We can predict herons' greater foraging success behind the tideline was also due to a greater area of False Bay being underwater, containing fish, and therefore being available to the herons for foraging.

Similarly, we believe that feeding success of herons was greater in surf compared to tide pools due to differences in fish size and abundance. In surf versus tide pool habitats, heron strike rate was lower and success rate was higher, likely resulting in lower energy expenditure in surf habitat. In tide pools, we predict that higher strike rates and lower success rates resulted from a relatively high abundance of small fish that were difficult to capture. Conversely, in surf habitats, heron feeding effort may be lower due to greater abundance of large fish that are easier to see and catch.

We believe herons were most successful in deeper water due to increased fish size and abundance. Deeper water may contain larger sized fish that are easier to see and catch, and larger prey likely would be more profitable for herons (Bancroft et al, 2002). Interestingly, Great Blue Herons most frequently forage in water 6 to 10 inches deep (Willard 1977), while our results show that herons have the highest success rate in water 8.5 to 18 inches deep (Fig. 2, Fig. 5). False Bay's unusually flat topography may improve herons' foraging success in deeper water. As the tide rises, False Bay may have a proportionately larger flat area of prey-rich deeper water than most other heron habitats. It may be beneficial for herons in False Bay to tolerate foraging in a higher-than-preferred water depth in order to take advantage of high prey availability.

Tide Phase & Height

Herons may be more successful during flood phase than ebb phase because of increased prey availability. Flood tides may bring in water and prey from Haro Strait into the shallow bay where the fish and other prey are more accessible to herons. Additionally, flood tides likely increase prey vulnerability within the bay. Tide pools can become anoxic at low tide, but flood tides bring cold water with more oxygen, causing tide pool fish to swim up towards the incoming water, where they are more accessible to predators (Gawlik 2002). During ebb, however, the abundance of fish may be lower since the fish are exiting the bay with the current and because tide pool fish may be less visible.

We believe abundance and foraging success may be inversely related because prey is depleted or herons leave after high levels of foraging success. During flood, when herons are catching fish, as shown by their great success rate at this time, total abundance is lower because the herons may deplete the prey in that area and leave to find another foraging location. Alternately, herons may forage sufficiently and leave for other activities. During ebb, however, the herons may gather and wait for the tide to come in, which would explain why their numbers are highest during this phase.

Herons may be more successful during higher tides versus lower tides due to increased water depth and prey availability, as discussed above. One bias was that nearly all high tides observed were flood rather than ebb tides. Therefore high tides we observed were mainly a result of incoming tides, which were already shown to have increased foraging success, likely due to increased prey availability.

Similarly to our hypothesis above, we believe that herons aggregate in shallow water to wait for the deeper water to come in during which they are most successful. Since they are more successful at higher tides, they may leave when they are done feeding, either due to prey depletion or sufficient foraging. This reduces average abundance number.

Group Size

Herons likely are more successful in larger groups than alone or in smaller groups because large gatherings of herons indicate high availability of food. Prey in marine environments is often unstable through time and space, and herons are known to use one another as indicators of food (DesGranges 1979). Herons congregate around areas of high prey availability and individual herons have been observed to join groups of foraging herons (Krebs 1974). Herons foraging in groups of six to eight have higher success rate than herons foraging alone or in smaller groups (Quinney 1980). Additionally, large groups may have higher food availability because foraging herons often stir up sediment and prey, which can increase foraging success of nearby herons (Willard 1977).

We believe herons are second most successful while foraging alone because there is reduced interference with feeding. Herons generally do not interact with one another while foraging, except for territorial conflicts, and herons foraging alone may be highly successful because there is no competition for nearby prey.

Herons may be least successful in medium to small groups of 2 to 5 because this size group does not provide the benefits of either large groups or single herons. Small groups may not be large enough to indicate high prey availability, but still large enough to create competition for prey and cause territorial behavior, which decreases foraging success.

Conclusion

Herons are large wading birds with a variety of feeding behaviors and strategies to take advantage of their habitat types. In False Bay, we observed that herons had the highest foraging success in deeper water and during flood tides. This is likely because deeper water contains more large fish that are easier to see and catch, while flood tides bring more prey into the bay. Additionally, we found that herons were most successful when foraging in groups of 6 or more, likely because large groups signify areas of high prey availability. Heron foraging success and abundance were inversely related when compared to tide height and phase, possibly because herons gather to wait for good foraging conditions and then leave after depleting prey or becoming full. Future studies might examine the impact of human visitors in False Bay on heron behavior, the range of non-feeding behaviors in False Bay herons, and how heron foraging behavior and success compare in other locations on San Juan Island.

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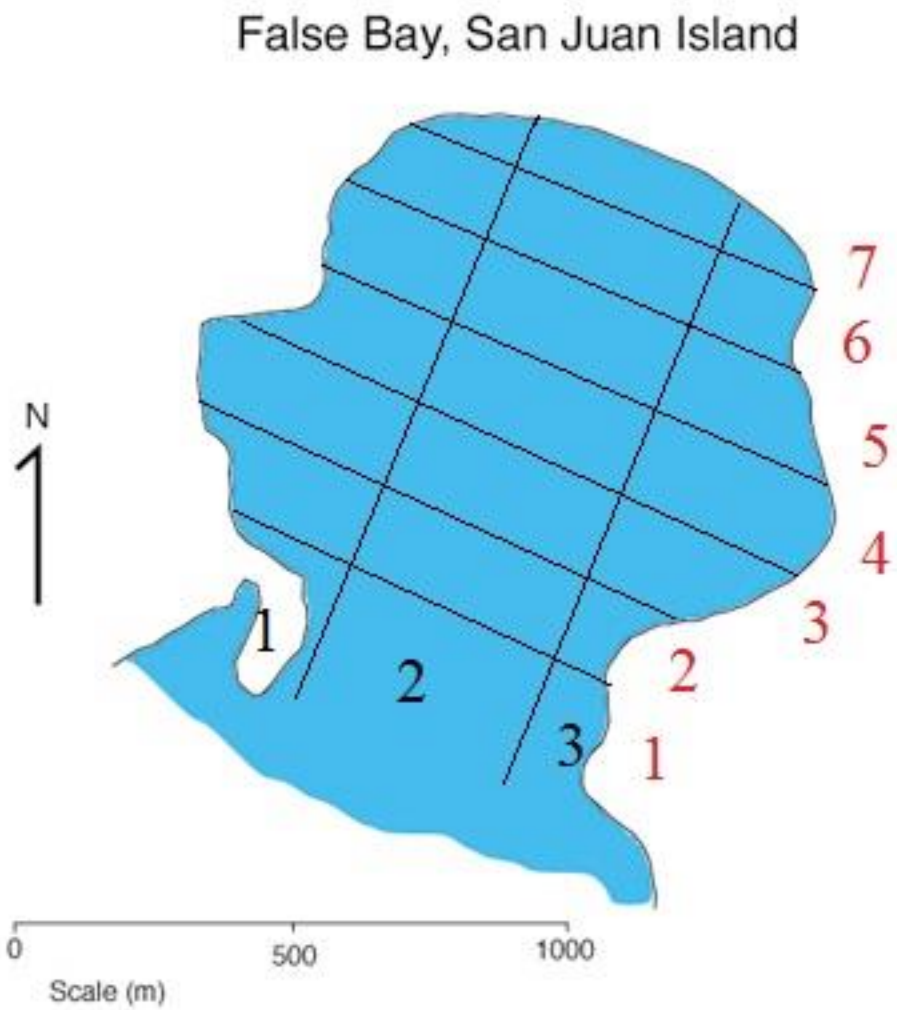

Figure 1: A contour map of False Bay, our survey area. It is marked with the 3 width by 7 depth zones shown that we used to record heron activity. False Bay is located on the south eastern side of San Juan Island and our surveys took place here from 9 to 18 August 2014 (University of Washington).

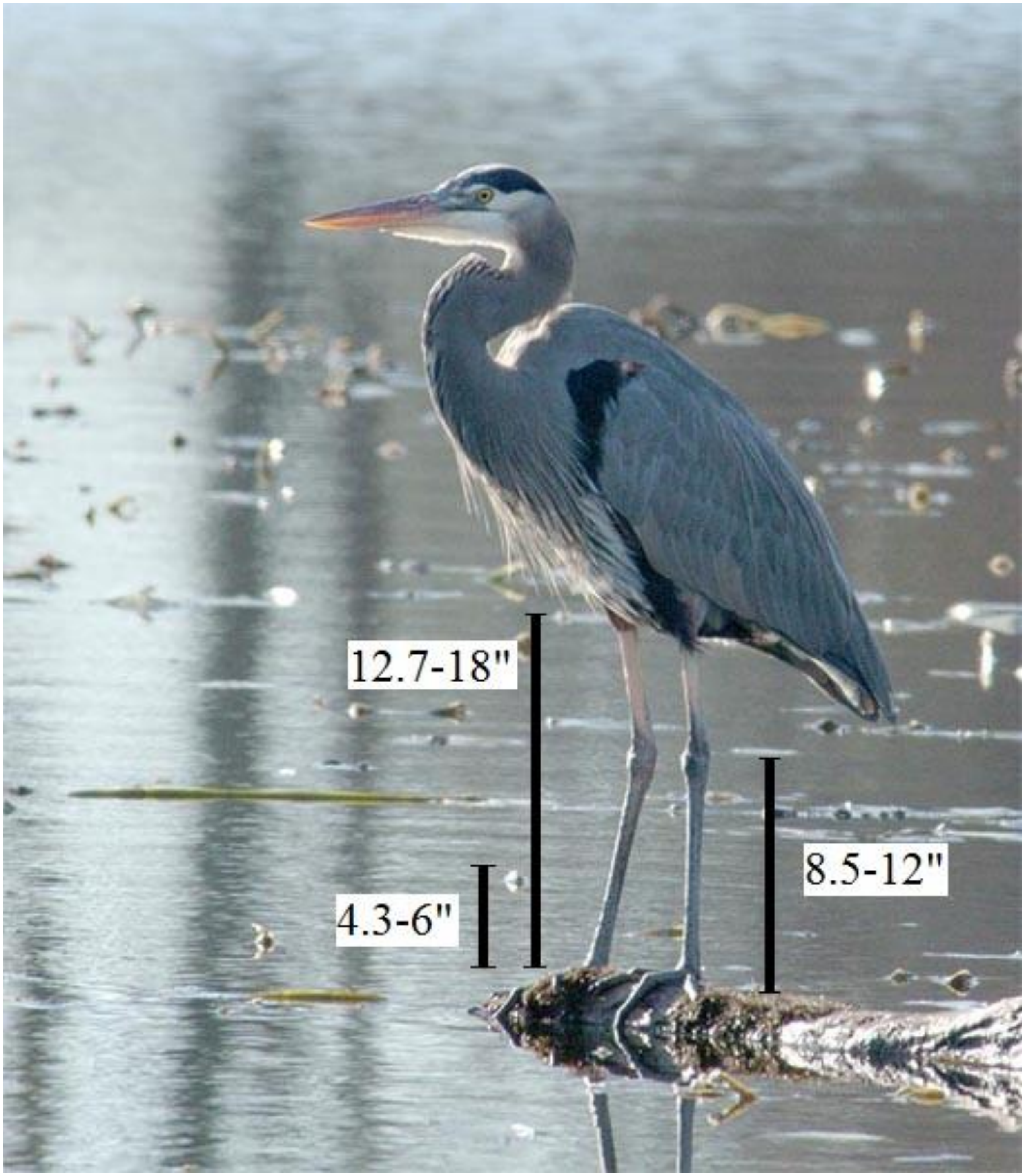

Figure 2: Picture showing estimation of ankle, knee, and leg length of a heron. Herons are 38.2 to 53.9 inches tall (Cornell Lab of Ornithology) and their legs make up about 1/3 of their body. Knee height was estimated at 2/3 total leg length and ankle height was estimated at ½ knee length (Photo credit: Reddit).

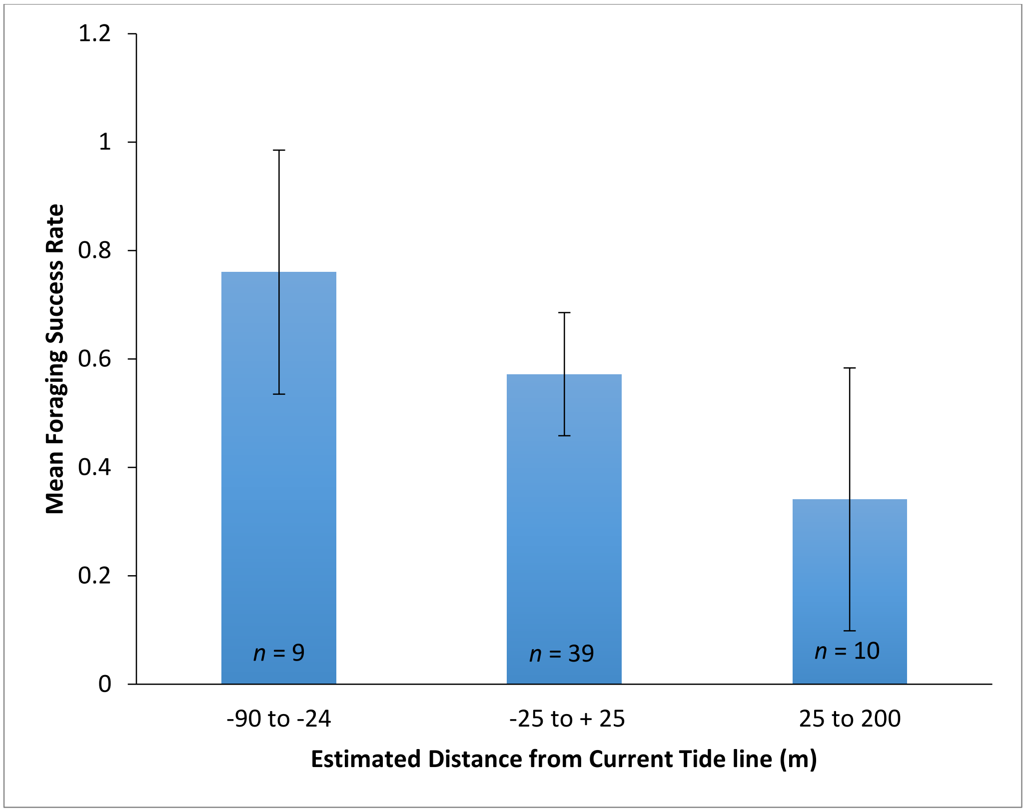

Figure 3a: Great Blue Heron mean foraging success rate relative to distance from the current tideline (estimated) at False Bay in San Juan Island, Washington. Observations were made between 9 and 18 August 2014. Means are presented with 95% CIs. The numbers in bars are the number of sample sizes.

Distance from Tide	Mean Tide Height	95% CI	Sample Size
- 90 to - 24	1.311	0.026	*n* = 9
- 25 to + 25	0.356	0.367	*n* = 39
+ 25 to + 200	0.536	0.602	*n* = 10

Figure 3b: Mean tide heights relative to herons' estimated distance from tide. Observations were made between 9 and 18 August 2014 at False bay in San Juan Island, Washington.

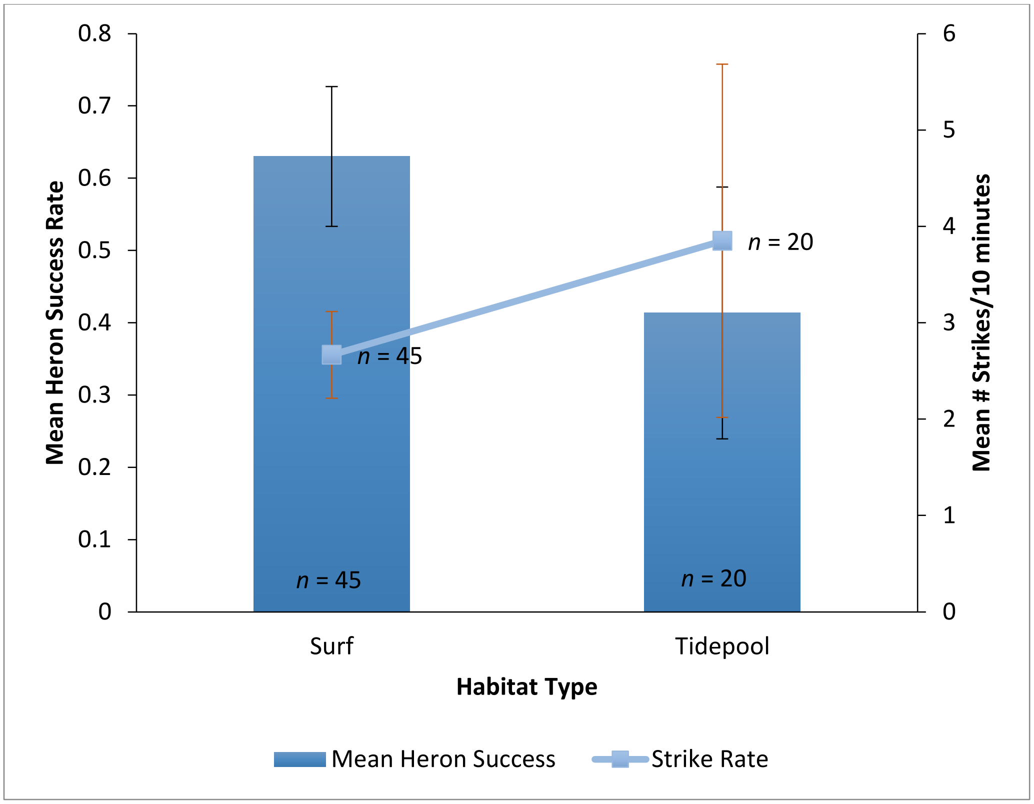

Figure 4: Mean (with 95% CI) foraging success rate relative to habitat type of Great Blue Herons at False Bay in San Juan Island, Washington between 9 and 18 August 2014. The three habitat types we observed were surf, tide pool, and rookery. Rookery was excluded from this comparison because the sample size for this habitat was small.

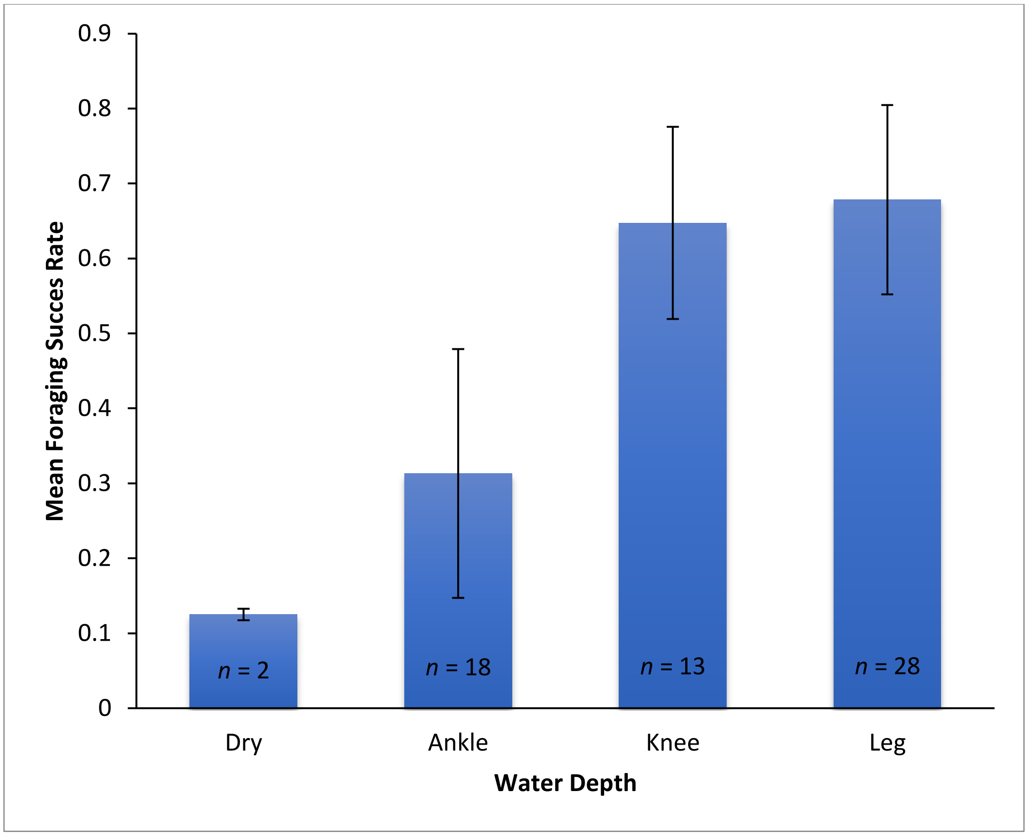

Figure 5: Mean (with 95% CI) foraging success rate in Great Blue Herons relative to water depth at False Bay in San Juan Island, Washington between 9 and 18 August 2014. Water depth was estimated by observation and broken into four categories: dry, ankle, knee, and leg. Counts were determined for each depth.

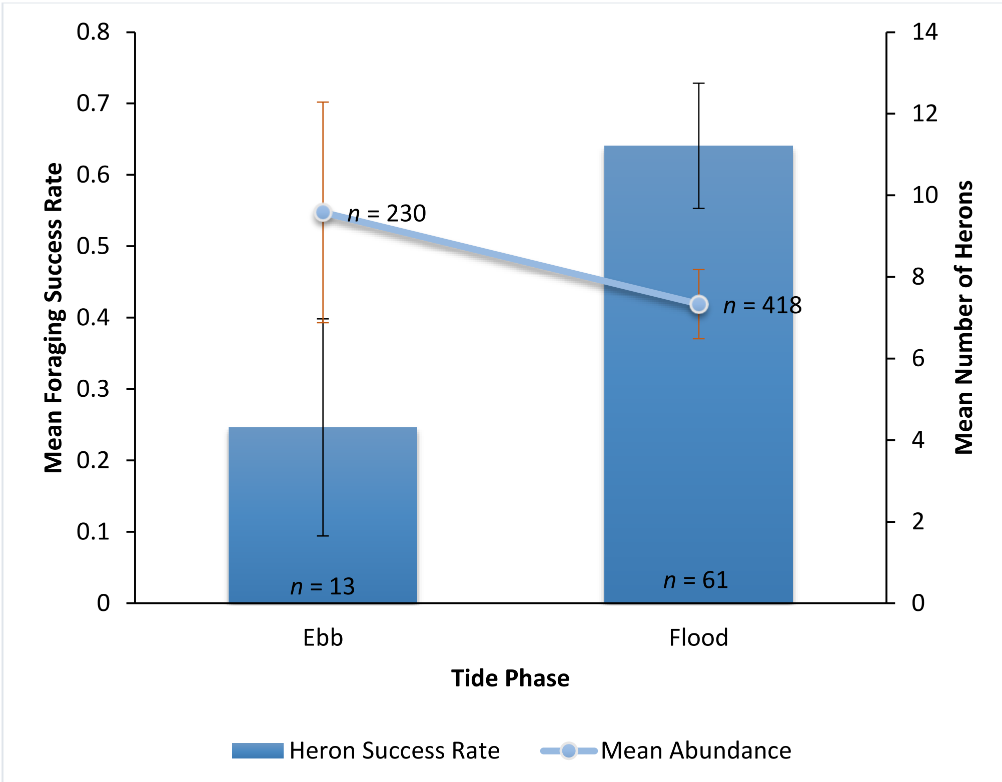

Figure 6: Mean (with 95% CI) abundance and mean (with 95% CI) foraging success rate of Great Blue Herons relative to tide phases at False Bay in San Juan Island, Washington. Data was recorded between 9 and 18 August 2014.

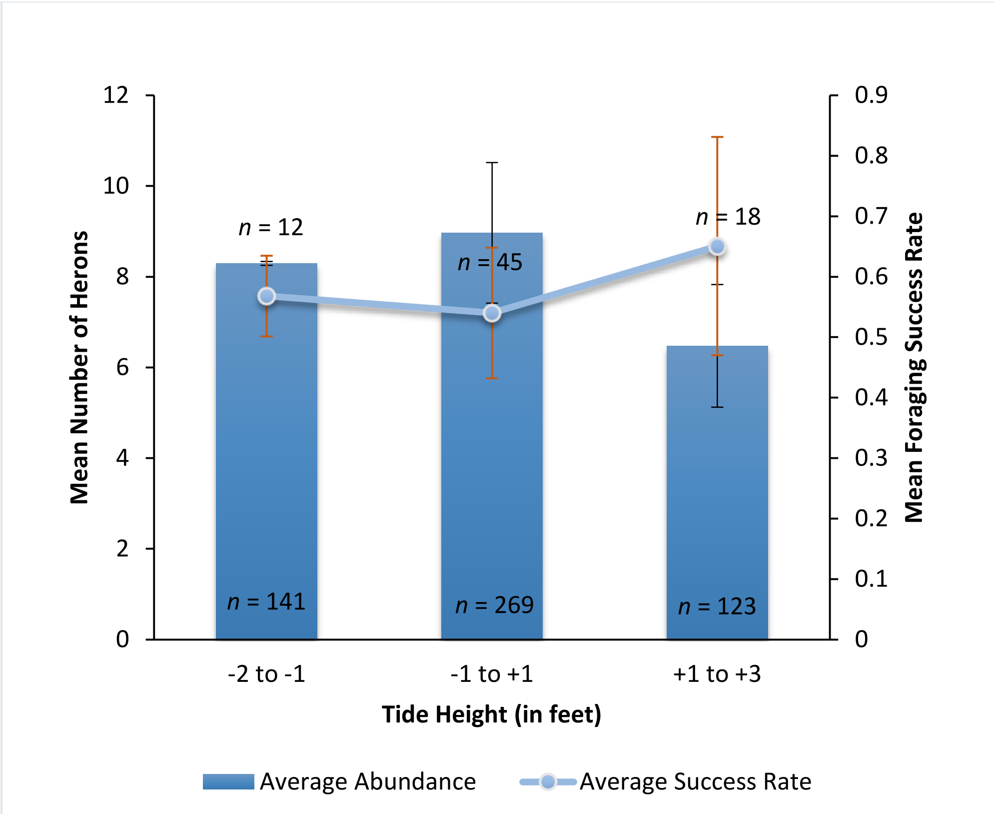

Figure 7a: Mean (with 95% CI) and mean (with 95% CI) foraging success rate of Great Blue Herons feeding during various tide heights. Data was collected in False Bay in San Juan Island, Washington, between 9 and 18 August 2014.

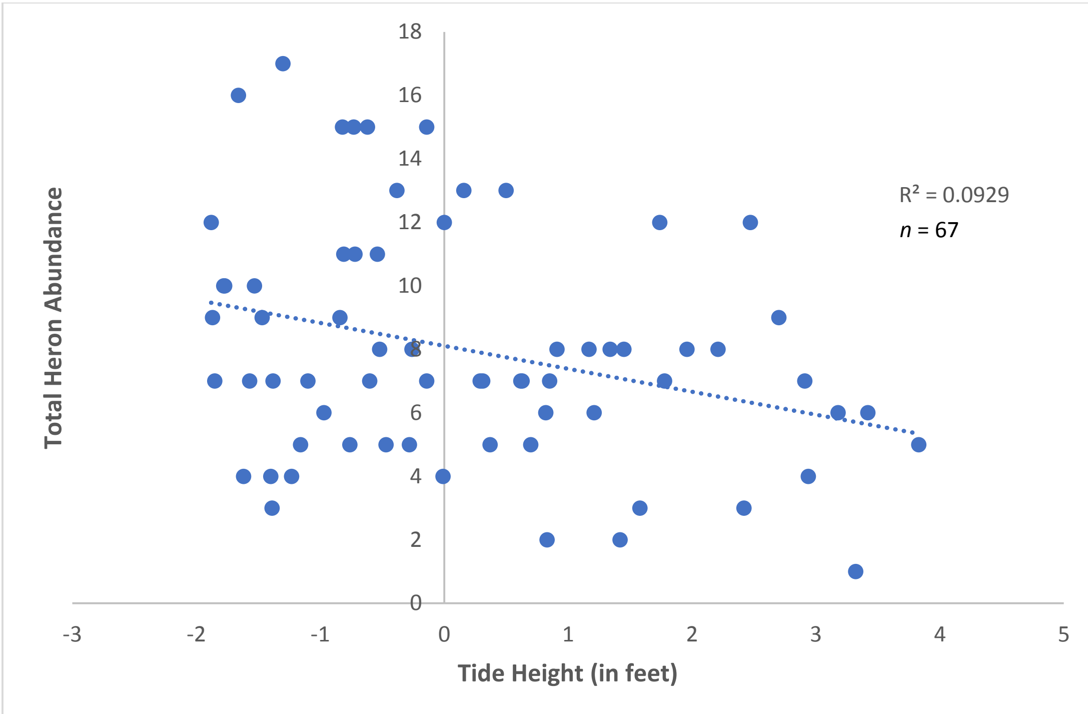

Figure 7b: Scatterplot of total heron abundance during various tide heights. Data was collected in False Bay in San Juan Island, Washington, between 9 and 18 August 2014.

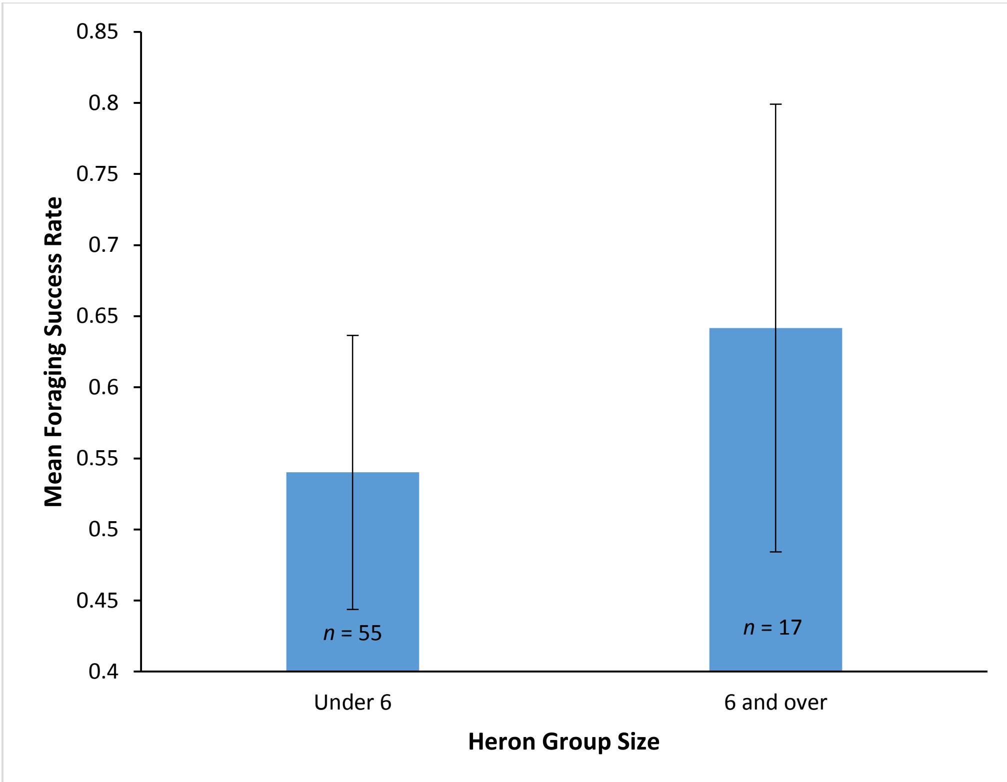

Figure 8a: Mean (±95% CI) foraging success rate relative to heron group size. Observations were taken at False Bay in San Juan Island, Washington between 9 and 18 August 2014.

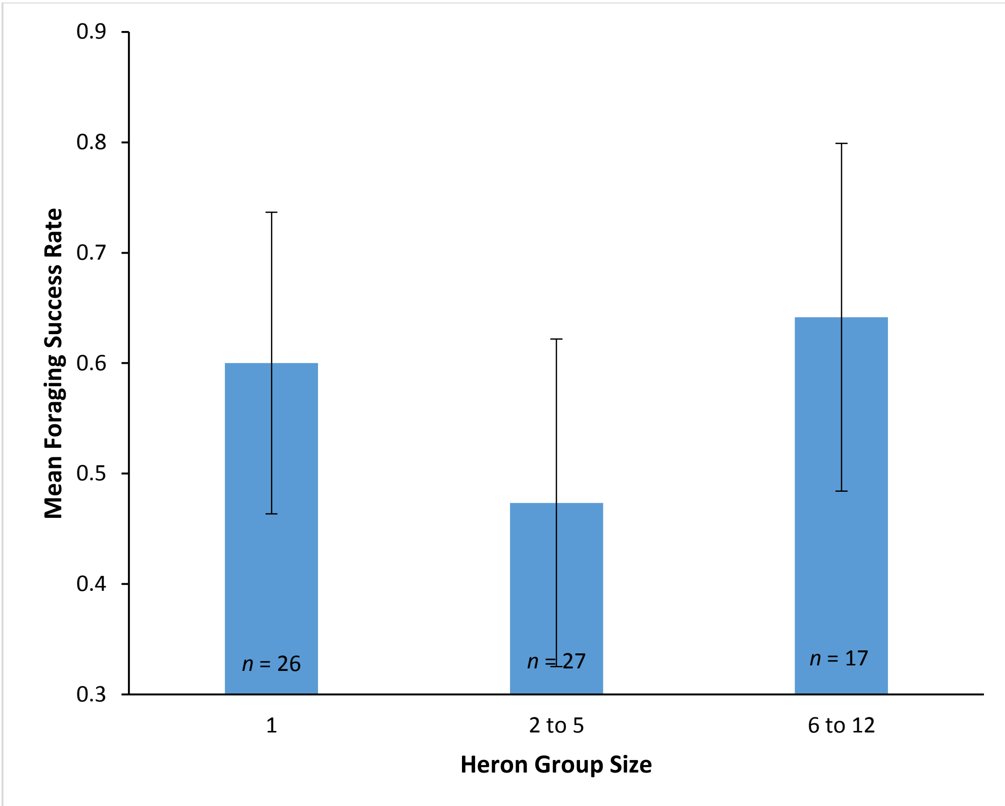

Figure 8b: Mean (±95% CI) foraging success rate relative to group size for individual Great Blue Herons. Observations were taken at False Bay in San Juan Island, Washington between 09 and 18 August 2014.