Flocking and flushing behavior in roosting gull (*Laridae*) flocks on San Juan Island

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Abstract

Roosting behavior is known to provide a variety of benefits to flocking birds; however, the behavior of roosting gulls has received limited study. In particular, the impact of human disturbance on these roosting flocks, especially as human activity on beaches increases, is the subject of almost no recent research. To address this knowledge gap, we collected abundance, behavioral, and disturbance data at two sites on San Juan Island. We found some evidence for behavior variation based on time of day, position in the flock, and age, as well as strong evidence for behavior variation based on site. Specifically, gulls at South Beach, a site with more human disturbance, spent more time alert and moving; gulls at Argyle Lagoon, a site with less human disturbance, spent more time resting and preening. Most flushing events we observed involved dogs (70.2%) or only humans (19.1%); in general, flushing frequency was correlated with human and dog abundance. After flushing, gulls were either displaced down the beach or into the water; repeated disturbance eventually resulted in all gulls being displaced to the water. Our findings help characterize the behavior of gulls in roosting flocks and demonstrate that these flocks are frequently impacted by disturbance, which may result in frequent energetic or opportunity costs. Long-term research is necessary to determine whether these costs impact gulls at the population level and across longer time scales. We recommend further research in this field to continue expanding our understanding of gull flocking behavior and the impact of human disturbance on coastal wildlife.

Keywords: California gull, *Laridae*, roosting flock behavior, flushing, human disturbance, South Beach, San Juan Island

Introduction

Roosting flocks refers to the congregations of birds that gather for purposes other than feeding (Schreiber 1967). Sites for roosting vary based on species preference (e.g., close to feeding locations), and flocks typically have a strong loyalty to that location for decades (Eiserer 1984). Roosting is believed to provide several ecological and behavioral benefits, including increased safety from predators (through group vigilance and the dilution effect), thermoregulation (by resting together), and opportunities for information sharing within the flock (Lehtonen and Jaatinen 2016, Lack 1968, Evans 1982). Furthermore, the information center hypothesis proposes that avian roosting flocks are an adaptation that birds have developed to share information on unpredictable, high concentrated feeding areas. They also allow unsuccessful foragers to learn where to feed (Ward and Zahavi 1973, Weatherhead 1983). Members of the Laridae family, commonly known as gulls, frequently form large roosting flocks along coastlines and other open habitats. While the benefits outlined above may explain why roosting behavior occurs in general, little specific research has been dedicated to gull behavior within these flocks.

Meanwhile, the impact of human activities on bird behavior is becoming increasingly significant, especially in coastal areas where recreational activities overlap with important bird habitats (e.g. on San Juan Island, where tourists and locals are able to kayak, boat, and walk their dogs near shorelines). Current research indicates that human disturbances disrupt roosting flocks and often trigger an alert-to-flight sequence, where the birds are first vigilant and then fly away when they feel a threat enter their flight initiation zone (i.e. the distance a human or other potential predator can get before flushing the birds) (García-Arroyo and MacGregor-Fors 2020). This response incurs energy consumption, including the loss of rest or foraging time, increased energy expenditure due to repeated flights, and possible effects on thermoregulation (Collop 2016).

While previous studies have documented various bird responses to disturbances, less attention has been paid to such responses for gulls in non-breeding seasons. Evidence shows that roosting gulls tend to re-land at the same location before flushing (Burger 1981). However, there is a lack of current information on flushing behavior on gull roosting flocks and individual activities.

We aim to fill in this important knowledge gap, as gulls spend a substantial portion of their daily cycle roosting, and repeated disturbances during this time could affect individual energy budgets and, ultimately, population dynamics. Our objectives of this study are threefold: (1) to characterize the size and composition of gull roosting flocks, (2) to describe individual behavior within these flocks, and (3) to quantify the impacts of human disturbance on flock behavior.

Methods

Study Site

We collected data from 12–16 August 2025 at South Beach (48°27'23.0"N 123°00'05.8"W) and Argyle Lagoon (48°31'12.4"N 123°00'52.6"W) on San Juan Island, WA, USA. Both locations had reliable gull flocks that were easy to observe and are recreational sites with regular human activity. At South Beach, a 3.23 km stretch of shoreline, observations were conducted on a trail below a lookout at Cattle Point Road (48°27'27.1"N 122°59'33.9"W), 134 m away from the beach. We conducted closer observations of the flock on the driftwood wrack 15 m away.

Argyle Lagoon was used as a supplementary data location when no gulls were present at South Beach (e.g., 13 August due to strong winds). Observations were made along the 250 m sandbar that splits up Argyle Lagoon and Argyle Lagoon San Juan Islands Marine Preserve. We remained 30-60 m away from the gull flock.

Observations generally occurred at 9:30 and 14:00 for two hours each, totalling about four hours each day. On 16 August, observations were only done in the morning.

Abundance Counts

Abundance counts were conducted every 20 minutes. During a count, the number of gulls on the beach, the number of gulls in the water within 200 m of shore, the number of humans, and the number of dogs were recorded.

Focal Sampling

We used focal sampling to identify individual behavior within the gull flock. Focal sampling was conducted with a Celestron 20-60x80mm straight zoom spotting scope (Celestron, LLC, Torrance, CA) on a tripod. We divided the flock into thirds and rotated between each zone for every focal sample. The scope was moved randomly within the zone, and the gull in the center of view was our focal animal. We first note the species and age (i.e., adult or juvenile) of the gull. Then we determined the percentage of nearby juveniles (of the closest ten gulls) surrounding the focused individual. Each gull was sampled for three minutes and behavior was categorized every 20 seconds as either alert (i.e., looking around, moving head), moving (i.e., walking around), preening, foraging (i.e., head in water while swimming, pecking at the ground for food), loafing (i.e., lying/sitting down), or resting (i.e., eyes closed and/or sleeping). Position of the gull was also noted down as either being beach edge (i.e., on the edges of the flock that was not next to water), middle (i.e., surrounded by gulls), or water edge (i.e., right next to the water).

Flushing Behavior

We took opportunistic samples of flushing behavior (i.e., flying away from the source of disturbance, moving to the left or right side of the flock, flying into the water) during our field observations. Videos of flushes were taken to record time length of flush, cause of the flush (i.e., humans, dogs, other random occurrences), action of disturber (i.e., walking, running, standing, sitting), direction of disturber (i.e., approaching the flock or not), and finally, the direction the flock flew. The location of the flock was pinpointed by being parallel to the flock on the trail or sandbar. We then used Google Maps to note down coordinates of the flock after each flush and use Google Maps's measuring tool to calculate the distance the gulls traveled on the beach.

Data Analysis

We used linear regressions and two-sample T-tests to analyze the relationships between different variables. For comparisons based on time of day, position, and age, only data from gulls on South Beach was used. For all statistical tests, $\alpha = 0.05$. Microsoft Excel was used to conduct all statistical analyses.

Results

Abundance

At South Beach, total gull abundance ranged from 130 to 1600, human abundance ranged from 0 to 15, and dog abundance ranged from 0 to 4. All three values varied based on the day of observation (Table 1). Total gull abundance was negatively correlated with time of day ($p < 0.00001$; Fig 1a). Total human and dog abundance also had a weak negative correlation with time of day ($p < 0.00001$; Fig 1b). On average, 69.2% of gulls were on land. This proportion was negatively correlated with both human and dog abundance ($p < 0.00001$; Fig 2).

At Argyle Lagoon, total gull abundance ranged from 41 to 153, human abundance ranged from 0 to 10, and dog abundance was generally 0, with one count of 2. Total gull abundance was positively correlated with time of day at this location ($p = 0.000035$; Fig 3a), while total human and dog abundance was negatively correlated with time of day ($p = 0.03242$; Fig 3b). On average, 95.8% of these gulls were on land. No correlation was found between this proportion and human abundance.

Flock Composition

At South Beach, the majority of individuals were California Gulls (*Larus californicus*), although small numbers of Heermann's Gulls (*Larus heermanni*) and Glaucous-winged Gulls (*Larus glaucescens*) were also identified. At Argyle Lagoon, the majority of individuals in the morning were Short-billed Gulls (*Larus brachyrynchus*), although California Gulls made up a slight majority towards the end of our observation period (coinciding with larger flock sizes at that location).

In regards to age, estimates based on scanning indicated that both flocks had an adult majority (60-90% adults). However, estimates based on focal sampling varied in relation to whether the focal bird was an adult or juvenile, with adult birds having an average proportion of 0.244 ± 0.247 (mean ± SD) juveniles nearby and juvenile birds having an average proportion of 0.631 ± 0.287 (mean ± SD) juveniles nearby (Fig 4).

Behavior

Limited interactions were observed between individuals. Gulls on the beach maintained relatively even spacing and did not appear to interact, aside from occasional instances of displacement and kleptoparasitism. Vocalizations were mainly observed during flushing and when additional gulls joined the flock.

At South Beach, focal gulls spent the majority of their time alert (average of 41.4%) or preening (32.7%), followed by resting (16.2%); moving (4.9%) and foraging (2.2%) were the least common behaviors (Fig 4a). Based on initial graphing, we identified apparent differences in the proportion of time spent alert and time spent resting based on time of day, position within the flock, and age (Fig 5). Specifically, the average proportion of time spent alert appeared to be higher in the morning, for birds on the edge, and for adults, while the average proportion of time spent resting appeared to be higher in the afternoon, for birds in the middle, and for juveniles. However, none of these differences were statistically significant. Comparing South Beach and Argyle Lagoon, meanwhile, revealed several statistically significant differences in behavior: gulls at South Beach spent more time alert ($p = 0.0009$) and moving ($p = 0.0415$), while gulls at Argyle Lagoon spent more time resting ($p = 0.0147$) and preening ($p = 0.0251$) (Fig 4e).

Disturbance

We recorded a total of 47 distinct flushing events, with 2 occurring at Argyle Lagoon and the remainder occurring at South Beach. Of these flushes, 70.2% (N = 33) involved a dog, 19.1% (N = 9) only involved humans, and the remaining 10.6% (N = 5) were due to either unknown causes or (in two cases) the presence of a Great Blue Heron (*Ardea herodias*). For flushes where more detail regarding the disturbance was recorded, 64.3% (N= 27) involved walking (rather than running) and 90.5% (N = 38) involved actively approaching the gull flock (rather than just being present nearby). There was also a positive correlation between the average number of humans and dogs on a beach in a given hour and the number of flushes that occurred that same hour (Fig 6).

We observed three distinct levels of response: walking, partial flushing, and full flushing. Walking entailed moving away from the source of the disturbance without taking flight, and was often accompanied by a partial flush (i.e. gulls closer to the disturbance would take flight, while those somewhat further away would start walking). Partial flushes (the most common response) entailed only a portion of the flock taking flight, and often occurred in succession when a source of disturbance continuously approached the flock. Full flushes entailed the majority of the flock taking flight at once, and were relatively rare. We did not have enough data to reliably link each type of response to the cause characteristics we identified.

Once flushed, gulls landed either further down the beach or in nearby waters. Gulls who returned to the beach were displaced between 0 m (i.e. they returned to the same location) and 1430 m. On average, they were displaced 284.95 m. Gulls who landed in the water would eventually rejoin the flock, either swimming or flying back to shore. For each flush we observed, we noted that at least a portion of flushing gulls would land in the water, and repeated flushing (e.g. due to continuous approach) eventually resulted in all gulls being displaced to the water.

Discussion

Our study found an apparent trend that both time of day and flock structure strongly influenced gull behavior. During the weekdays, there were more people and dogs present at South Beach in the morning. This may have caused the gulls to be more vigilant during this time as disturbance risk was higher. In contrast, in the afternoon, roosting flocks tended to gather at the far east side of the beach, farther from the parking lot, and spent more time resting. This is probably because there is less human activity in the far east side, as fewer people tended to walk that far. Within flocks, edge-positioned individuals were more vigilant and flushed first, while centrally positioned gulls benefitted from the protection of surrounding conspecifics. This suggests a clear trade-off between vigilance and safety, where edge birds are at higher risk but may provide early warning for the rest of the flock. Our findings are similar to a study on Black-headed gulls (*Chrioicocophalus ridibundus*) where individuals at the edges of flocks tended to scan their environment more frequently compared to gulls in the middle of the flock (Novčić and Vidović 2021). In our study, adults seemed to act as sentinels, scanning more frequently, whereas juveniles spent more time resting – conserving their energy, suggesting age-based roles within roosting groups.

Differences in gull behavior based on site is likely due to the amount of human disturbance they are exposed to. South Beach flocks displayed higher vigilance and more frequent flushing, which reflects their greater exposure to human activity and dogs. Argyle Lagoon on the other hand, had more gulls resting and preening more often, which is consistent with the absence of dogs and less human disturbance.

Most flushing events were linked to human activity, particularly due to the presence of dogs and people approaching the flock. Repeated flushing often displaced gulls on the beach onto the water nearby. While a previous study by Burger (1981) indicated that roosting gulls tend to re-land in the same location after a flush, our data showed that gulls on average displaced by 284.95 m and sometimes fragmented into smaller flocks. In addition to flushing flight costs, individuals will spend more energy swimming back and thermoregulating (Schmidt-Nielsen 1972). Flushed gull flocks also have less opportunity to preen or rest due to frequently disrupted recreational use of beaches.

Future research presents several opportunities for improvement. For example, our counts were done visually, which were not always precise, especially in high gull density flocks, as we could only roughly estimate the number of individuals. Future research should adopt more precise counting methods, such as photography or drone monitoring, to improve accuracy. Additionally, our study was short and did not allow us to account for variable weather impacts on abundance or behavior. Previous studies showed that vigilance may decline with higher wind speed due to a lower chance of predation (Beauchamp 2015). This could be a reason why the more protected roosting flock at Argyle Lagoon rested and preen more compared to more exposed South Beach. Other causes of disturbance like vessels and non-gull species interaction should also be considered flight alarm behaviors in gull roosting flocks. These factors led to variations, and future research should take them into account.

In summary, our findings show that human disturbances significantly impact gull roosting flocks. This is especially important in repeated disturbances as it interrupts gulls' resting, feeding patterns, and group cohesion due to the higher energy costs of flushing. We found that very little current research has been done on gull roosting and disturbance, so small-scale studies like ours can help build the foundation for understanding these dynamics worldwide.

Long-term monitoring is necessary to capture changes of roosting flocks between different seasons and years. Short term observations like ours do not provide us with a bigger picture of the consistent pattern of roosting gull flocking and flushing behavior. There should also be further research on the dynamic relationships between different species in mixed-species flocks and the relationship between disturbance types and flight alarm responses to help deepen our understanding of the behavioral ecology of gulls. Gulls are not only numerous and conspicuous seabirds but also ecological indicators of the health of coastal ecosystems (Furness 1997, Blight 2012). Most research on human impacts on gull flocks has focused on urban settings with topics like seasonal variation in habitat use (Pais De Faria et al. 2021). Other researchers have also looked into flushing behavior on breeding colonies due to human intrusion (Burger and Gochfeld 1983). By studying gull roosting habitat and disturbance behaviors, we can gain a deeper understanding of how human activities widely affect coastal wildlife. This highlights the need to formulate management measures to balance the recreational utilization of coastlines with the protection of key habitats for gulls and other seabirds.

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Figures

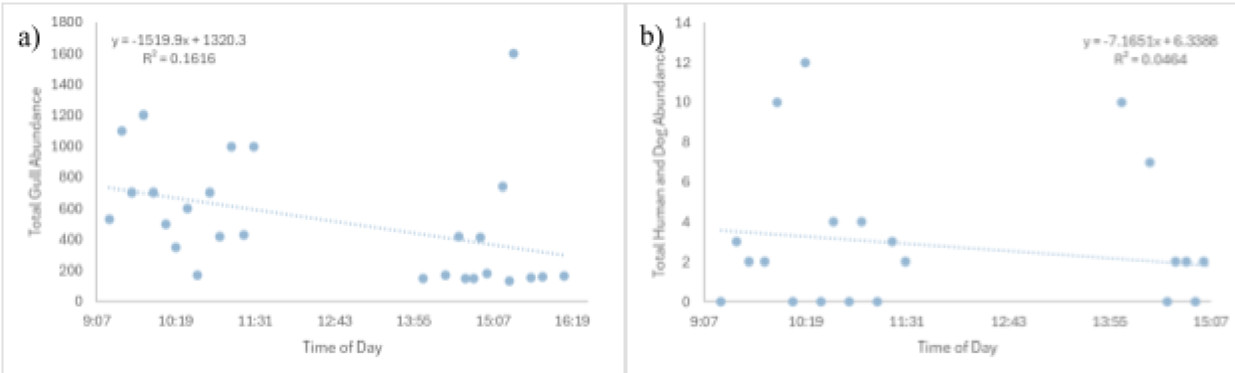

Figure 1. Total gull (a) or human and dog (b) abundance in relation to time of day. Each point represents one abundance count from South Beach (N = 34).

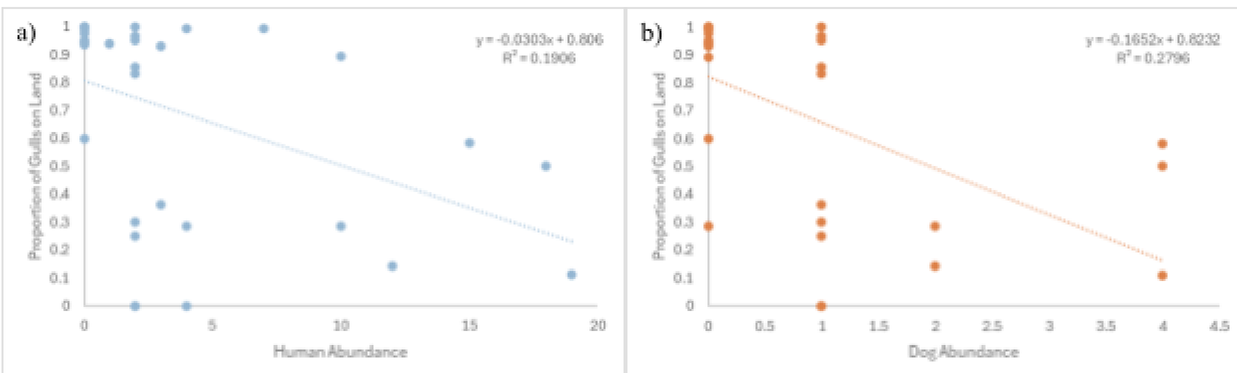

Figure 2. The proportion of gulls on land in relation to a) human abundance and b) dog abundance. Each point is based on one abundance count from South Beach (N = 34).

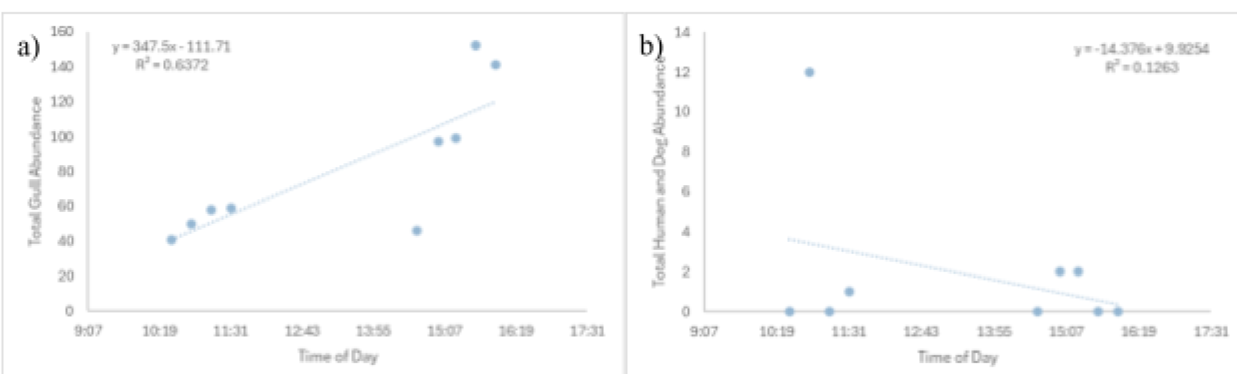

Figure 3. Total gull (a) or human and dog (b) abundance in relation to time of day. Each point represents one abundance count from Argyle Lagoon (N = 9).

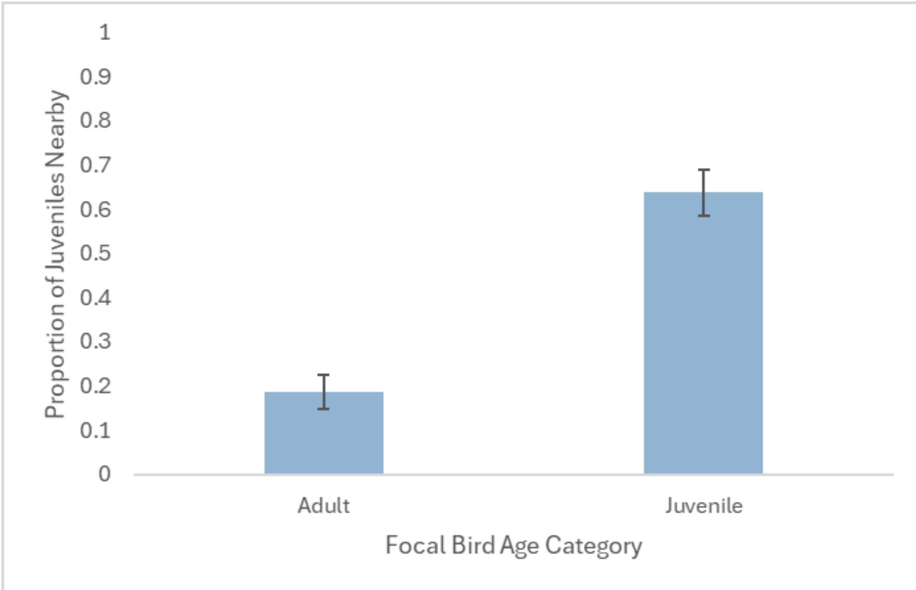

Figure 4. The average proportion of nearby juveniles (estimated based on the number of juveniles in the closest 10 birds) in relation to whether the focal bird was an adult (N=21) or a juvenile (N = 25). Error bars represent standard error.

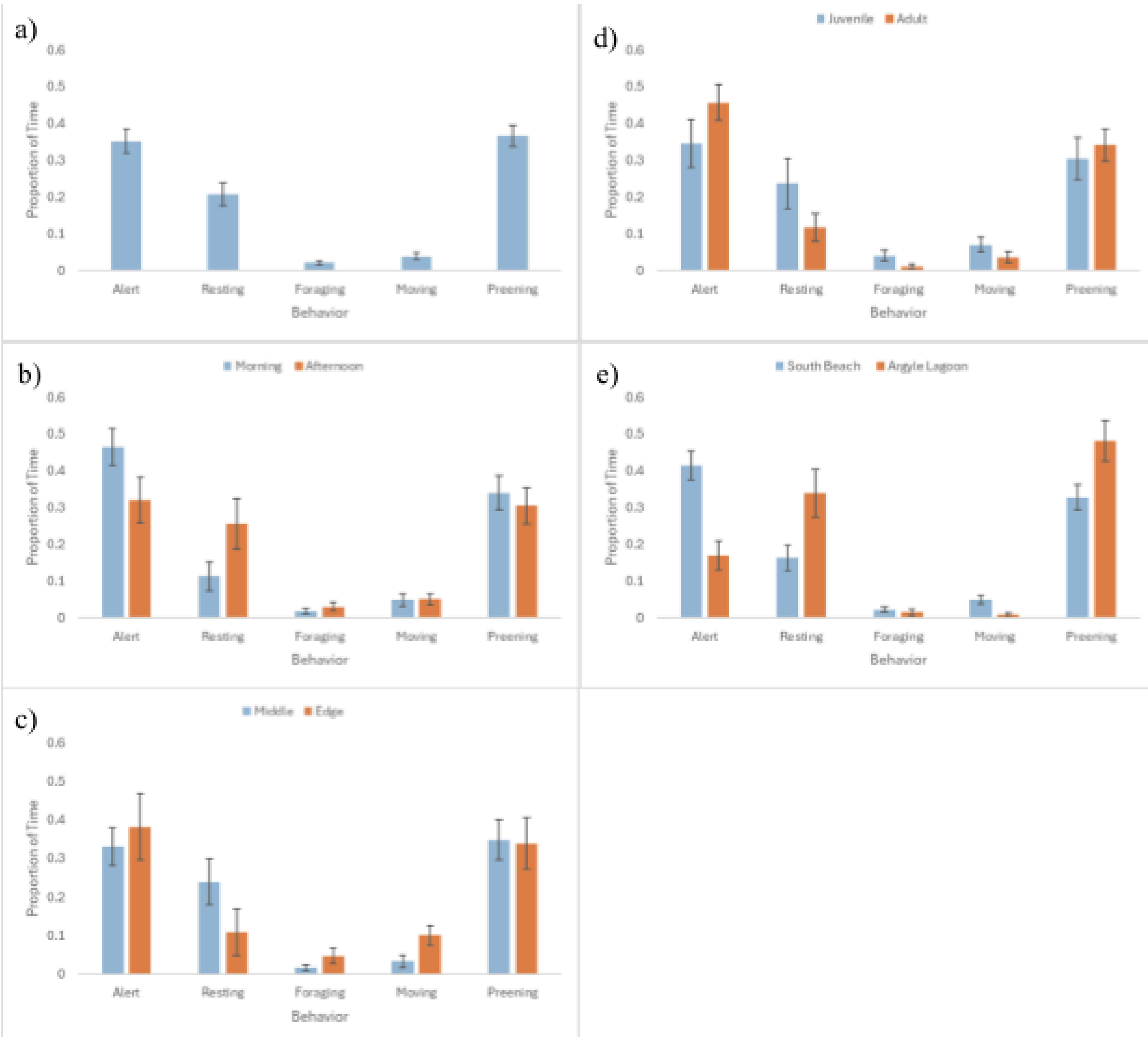

Figure 5. The average percent time for each behavior category a) overall and when comparing b) morning and afternoon, c) birds on the edge vs middle of the flock, d) juveniles and adults, and e) birds at South Beach and Argyle Lagoon. Error bars represent standard error. A total of N = 117 focal birds were observed.

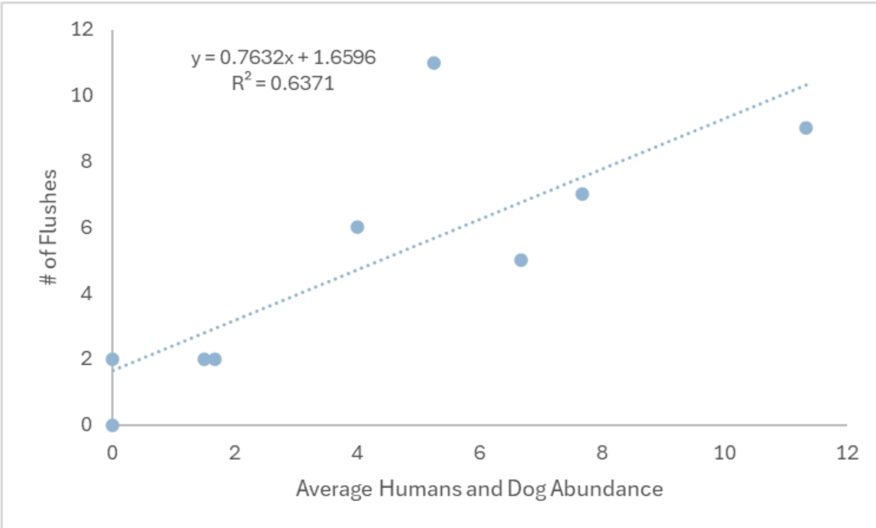

Figure 6. Number of flushes in relation to the average number of humans and dogs. Each point represents an hour; the y-axis shows the number of flushes recorded, while the x-axis shows the average total abundance of humans and dogs based on abundance counts in that hour.

Tables

Table 1. The range and average for gull, human, and dog abundance. Observations on 8/13 were collected at Argyle Lagoon; the others were collected at South Beach.

	Total Gull Abundance		Human Abundance		Dog Abundance	
Date	Range	Average	Range	Average	Range	Average
8/12	410-1600	842.7	0-2	0.364	0-1	0.273
8/14	130-700	294.4	0-10	3.313	0-2	0.563
8/16	155-1260	823.6	1-15	6.286	0-4	2.143
8/13	41-153	85.67	0-10	1.667	0-2	0.222