Implications of Bald Eagle (*Haliaeetus leucocephalus*) Predation on the Goose Island Glaucous-winged Gull (*Larus glaucescens*) Nesting Colony

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Abstract:

In Washington state, rebounding Bald Eagle (*Haliaeetus leucocephalus*) populations are having both direct and indirect effects on the reproductive success of seabirds like Glaucous-winged Gulls (*Larus glaucescens*). In an attempt to quantify the effects of eagles on seabird nesting colonies and their reproductive success, we conducted a behavioral survey of the Glaucous-winged Gull nesting colony of Goose Island in the San Juan Islands. During a five-day-long field survey, we used interval sampling to establish the percentage of gulls engaging in preening, vigilance, and inactive behaviors in relation to the number of eagles in proximity to the colony. We also tracked eagle attack rates and successes, to see whether there was variability in prey preference. We found that there was little variability in the average percentage of gulls vigilant compared to the number of eagles present. However, the proportion of inactive gulls remained relatively high throughout all days surveyed. We also observed that during periods of high wind, eagles were less likely to be present and gulls were more likely to participate in flying or foraging behaviors. The attack rate seemingly decreased over the study period, suggesting that rates of eagle predation on nesting colonies decrease toward the end of the hatching season. These results suggest that towards the end of the nesting period, gulls may be less at risk for the indirect effects of eagle predation. However, more research is needed over a full nesting period to establish an accurate relationship between gull behavior and eagle presence, which can be used to understand the potential reasons for the decline in other seabird colonies.

Keywords: Bald Eagle, Glaucous-winged Gull, predation, nesting colony, vigilance, Goose Island

Introduction

Sweeping population management policies have often been focused on charismatic megafauna campaigns at pivotal points in the population's decline. Without in-depth surveys of ecosystem-wide effects, conservation decisions that fail to take into account the full impact of a species' recovery can place an unfair burden on prey species in those ecosystems.

One particular example is the recovery of the American Bald Eagle (*Haliaeetus leucocephalus*) which has been heralded as a conservation victory. In the mid-1900s, Bald Eagle populations in Washington State were close to zero, primarily due to environmental contaminants like DDT and PCBs, but also aided by habitat loss (Blight et al., 2015; Kalasz & Buchanan, 2016). DDT was outlawed in 1972 due to its environmental impacts and shortly after, Bald Eagles were placed on the endangered species list (1973) (Kalasz & Buchanan, 2016). Bald Eagle populations rebounded at an astounding rate, reaching approximately 1,334 individuals in Washington alone in less than fifty years (Kalasz & Buchanan, 2016).

With most of Washington State's eagle population residing west of the Cascade Mountains, the increase in predator populations has come at a cost to seabird colonies. Historically, birds have only made up 19% of eagle diets, but decreases in regional salmon availability and increased competition have contributed to a concerning increase in bird predation rates (Henson et al., 2019). Eagles have been found to predate a wide variety of seabirds including Common Murres (*Uria aalge*), sea ducks (*Mergini)*, and Glaucous-winged Gulls (*Larus glaucescens*) (Henson et al., 2019; Parrish et al., 2001).

There may be aspects of eagle rehabilitation that were previously unaccounted for, as their presence has been found to have both direct and indirect effects on nesting bird colonies (Parrish et al., 2001). Direct disturbances come in the form of physical attacks on members of the colony, while indirect effects disrupt self-care behaviors like preening and foraging while increasing caloric cost through behaviors like flushing (Parrish et al., 2001). When a bird or a colony "flushes," they go from standing, laying, or swimming, to flying in response to a disturbance (Barnas et al., 2022). This can lead to increased vulnerability for eggs and hatchlings who are left open to attack by eagles and other predators near the colony (Henson et al., 2019; Hipfner et al., 2012).

In order to understand the consequences of rebounding eagle populations on gull populations, we designed a study that focused on quantifying the direct and indirect effects of eagle predation on the Glaucous-winged Gull nesting colony of Goose Island in the San Juan archipelago. Located in Cattle Pass between San Juan Island and Lopez Island, the 3.8-acre rocky land mass plays host to nesting Pelagic Cormorants (*Phalacrocorax pelagicus*), Double-crested Cormorants (*Phalacrocorax auritus*), Glaucous-winged Gulls, as well as a Harbor Seal (*Phoca vitulina*) haul-out site. Although Bald Eagles have been shown to opportunistically predate cormorants, Glaucous-winged Gulls make up most of the island's population from May to early August and appear to be the primary targets of attack based on preliminary observations. In addition, Glaucous-winged Gull populations have been steadily declining in the same time period of Bald Eagle recovery in Washington (Blight et al., 2015).

From the early 1900s to 1980, there was a consistent increase in gull populations coinciding with increasing access to anthropogenic resources (Blight et al., 2015).

However, from 1980 to 2010, there was a 50% decrease in the Glaucous-winged Gull populations in the North Salish Sea alone (Blight et al., 2015). An explanation for this decline may lay in the gulls transitioning their diets from lipid-rich forage fish to easily accessible, low-nutrient food sources. This change in diet quality has been linked to decreased egg volume and clutch sizes in reproducing gulls, likely leading to lower recruitment (Blight et al., 2015). We believe that increased predatory pressure from growing eagle populations may play an additional role in their population reduction.

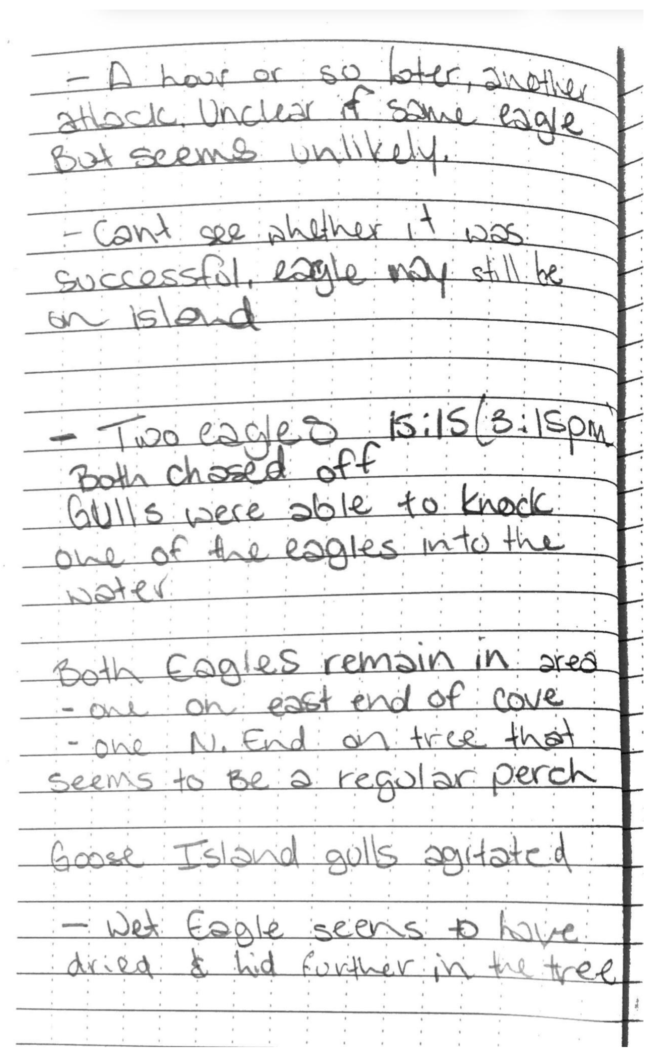
Our study focused on collecting behavioral data from the nesting Glaucous-winged Gulls to assess both the direct and indirect effects of eagle presence on the colony. The intention is to quantify whether these pressures alter gull behavior in a way that has an overall effect on their reproductive fitness. Aside from the rate of attacks, the primary focus was to assess whether peripheral stressors of Bald Eagle presence lead to increased vigilance and a decrease in self-care behaviors like preening and foraging. Data collected from the Goose Island colony can allow us to set behavioral baselines and predatory trends useful in protecting seabird colonies that may decline to at-risk status in the future.

Materials and Methods

Preliminary Surveys

We conducted preliminary continuous surveys at Cattle Pass near the established Glaucous-winged Gull colony on Goose Island for four days. Our observations began on July 23rd and were sporadically conducted, with other observations made on July 29th, 30th, and August 3rd. During these initial surveys, we used binoculars and a Celestron

Ultima 80 scope to observe. We recorded the number of eagles present, nesting territories, and possible ranges and perches that these eagles occupied. The number of attacks that occurred was also recorded; noting the time, the success, the target of the attack, and the gull behavioral response (Figure 1). We did these initial surveys to establish possible eagle locations and to get an understanding of the gulls' behavior when eagles were present.



- A hour or so later, another attack. Unclear if same eagle But seems unlikely.

- Cant see whether it was successful, eagle may still be on island

- Two eagles 15:15 (3:15pm) Both chased off Gulls were able to knock one of the eagles into the water

Both Eagles remain in area
- one on east end of cove
- one N. End on tree that seems to Be a regular perch

Goose Island gulls agitated

- Wet Eagle seems to have dried & hid further in the tree

Figure 1. Image showing an example log of observations made during preliminary surveys.

Gull Surveys

After we established possible nesting sites and common ranges for the eagles, we conducted official interval surveys at Cattle Pass near the Goose Island Glaucous-winged Gull colony over five days. On August 6th, 8th, and 9th, we conducted interval surveys every 15 minutes, spanning from 11:00 to 17:00. On August 10th and 11th, we conducted interval surveys every 15 minutes, but changed our observation duration to 12:00-16:00, due to the lack of activity we noticed within our first three days of observation.

We made observations with a Celestron Ultima 80 scope. To randomize the location we were observing within the colony, we used the Pretty Random number generator app to generate a number between 0-90 which determined the degree we would turn the scope. Zero degrees was considered the leftmost end of the colony, and 90 degrees was considered the rightmost end of the colony. We recorded the number of gulls within the viewfinder of the scope at 40x magnification, the behavior of the gulls, the wind speed, and the abundance of eagles present.

We classified the behavior of the gulls into three categories: preening, vigilant, or inactive. Preening was defined as the gulls cleaning and straightening their feathers. Vigilance was defined as the gulls having their necks raised and actively scanning the area. Inactivity was defined as the gulls loafing or standing with necks not extended and not scanning the area. We also observed several feeding events during strong winds. During these events, it was difficult to quantify the total number of gulls engaging in these activities, so feeding behavior was not officially recorded but was observed and noted on several occasions.

We subjectively classified the wind speeds as gentle, mild, moderate, and strong, because we felt that the closest reported wind speeds from the San Juan airport station were not representative of the location of the colony. During our interval surveys, we also recorded the number of eagles present near the colony by using a Bushnell Spacemaster scope. We defined an eagle to be present if we could see it within our scope, and we assumed that the gulls could also see them from the colony.

Eagle Attack Surveys

We opportunistically surveyed eagle attacks. When attacks occurred, we would record the location of the attack, the potential target of the attack, if the attack was successful, and the gulls' behaviors in response. We classified gull behaviors as defensive or offensive behavior: offensive referred to gulls attempting to attack the eagle by swooping or pecking at it, and defensive behavior referred to when gulls pursued an eagle following an attack.

Data Analysis

Following field collection, all data was digitized and input into an Excel file. We compared several relationships with the data we recorded, including the number of data intervals versus eagles present; the number of eagles present versus the average percentage of gulls engaging in our three behavior categories; wind conditions versus the average preening-to-vigilance ratio; and the number of eagle attacks versus the date of our survey, which included preliminary survey data and our gull survey data. We then performed two ANOVA tests to compare the average percentages of gulls engaging in our three behavior categories and the average preening-to-vigilance ratio with the number of eagles present.

Results

We found that in 97% of our surveyed intervals (106/109) we had at least one eagle present near the colony, with the median number of eagles near the colony being two (Figure 2). When looking at the average behavioral percentages of the colony, we found that there was a consistently high proportion of gulls that remained inactive, but the percentage of gulls engaging in preening, inactive, and vigilant behavior did not significantly vary across the number of eagles present ($p= 0.170$; $p= 0.497$; $p= 0.149$) (Figure 3). However, the standard error of the mean within the percentage of gulls engaging in vigilant behavior decreased as the abundance of eagles increased (Figure 3).

Comparing the number of attacks and the dates of our preliminary and official eagle attack surveys, we saw that the highest number of attacks occurred on the earliest survey day within our preliminary surveys, with five attacks total, and subsequently decreased with our later survey dates (Figure 4). Of these recorded attacks, we saw two successful attacks that each had different targets and locations. The first successful attack occurred on July 23rd, which targeted a chick located on the colony. The second successful attack occurred on August 9th, which targeted a juvenile gull away from the colony in the water (Table 1). All attacks recorded were during mild or moderate wind conditions (Table 1).

Lastly, looking at the average percentage of gulls preening to the average percentage of gulls vigilant, we found that across different wind speeds, there were no significant differences between the mean preening to vigilant ratios of each wind condition ($p= 0.429$) (Figure 5). However, there was a decrease in the preening-to-vigilance ratio during strong winds (Figure 5). Observations were also made during these different wind conditions, and it was noted that during strong winds, many feeding and flying behaviors occurred.

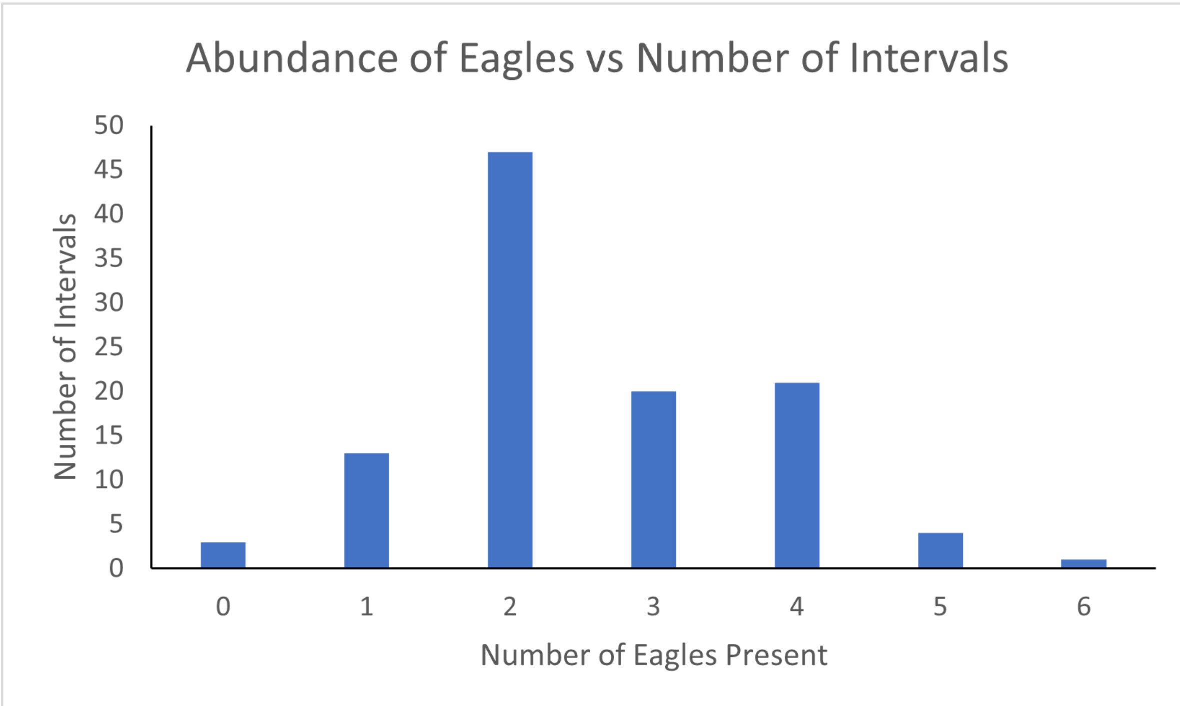


Figure 2. Bar graph showing the relationship between the number of survey intervals vs the number of eagles present.

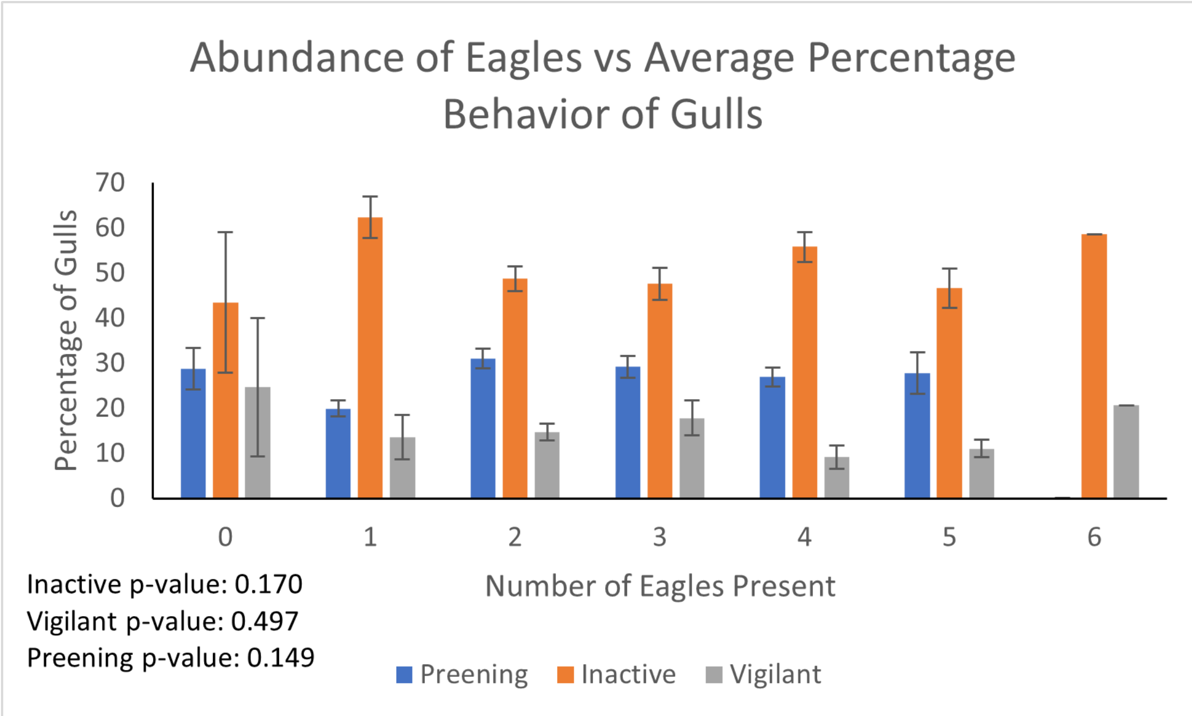


Figure 3. Bar graph showing the average percentage of gulls engaging in three behavior categories (preening, inactive, and vigilant) compared to the number of eagles present. Error bar calculations are the standard error of the mean for the different behavior percentages within the number of eagles present.

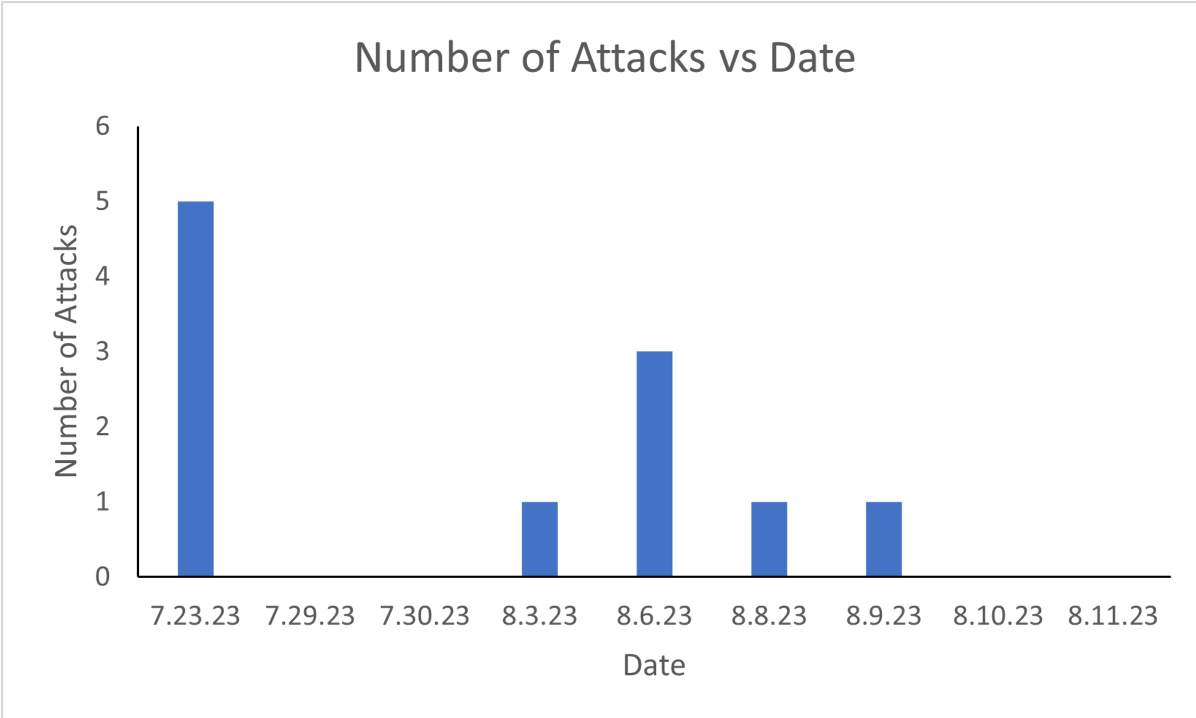


Figure 4. Bar graph showing the number of attacks compared to the dates of our preliminary and official eagle attack surveys.

Table 1. Table showing the observations recorded during our eagle attack surveys. N/A signifies that data was not collected for that attack.

Date	Time	# of Gulls Engaging in Offense Behavior	# of Gulls Engaging in Defense Behavior	Success/Failure	Age of Eagle	Wind Strength
8/6/2023	12:49-12:52	N/A	5 gulls following eagle	unsuccessful; unknown target	mature	Mild
8/6/2023	3:56-3:58	N/A	1 gull following eagle	unsuccessful; unknown target	mature	Moderate
8/8/20	3:02-	N/A	1 gull following	unsuccessful;	mature	Mild

23	3:03		eagle	unknown target		
8/9/2023	12:41-12:46	3 gulls	~5 gulls at the beginning, dropped off to only 2 gulls	successful capture and kill of juvenile gull	mature	Mild

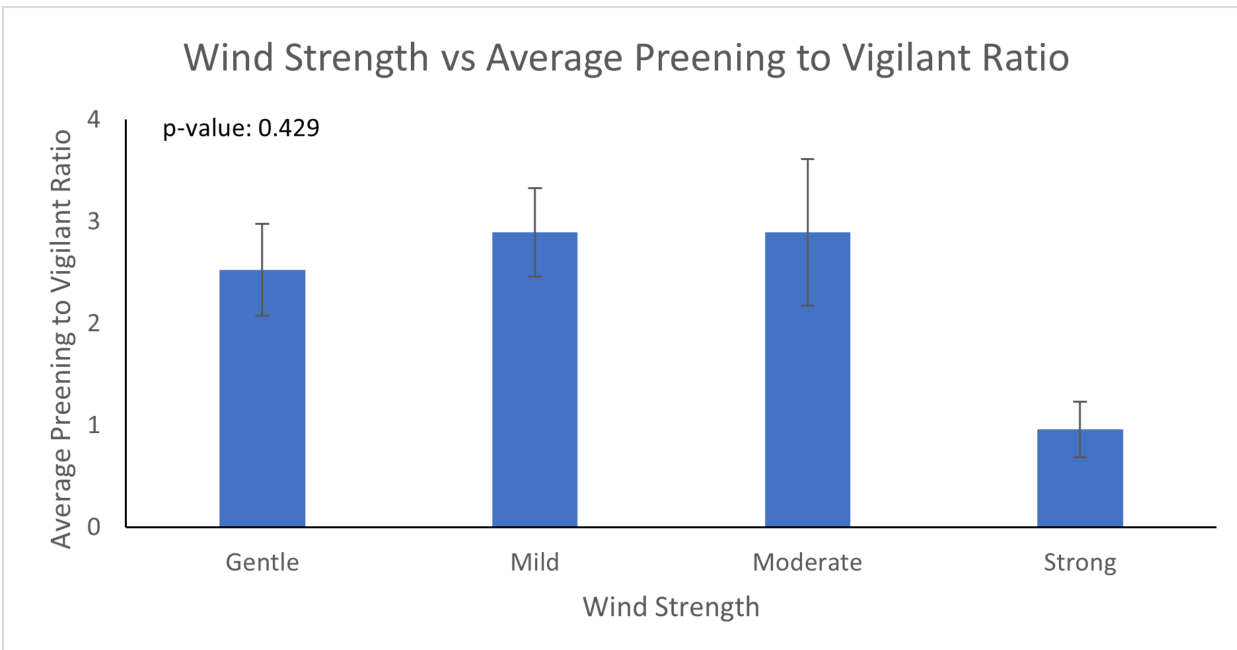


Figure 5. Bar graph showing the average preening percentage of gulls to the average vigilant percentage of gulls ratio. Error bars are the standard error of the mean of the different preening to vigilant ratios within each wind strength.

Discussion

From our surveys, we observed that there were eagles present approximately 97% of the time, and therefore we can surmise that gulls are experiencing a similar level of eagle presence when they are not directly observed. We noted a consistently high percentage of inactive behavior for the duration of our study period. Early August nears the end of the gull hatching period (White et al., 2006) and we propose that the high level of gull inactivity may be attributable to the end of the brood-rearing season. During the hatching season, parental gulls forage for themselves and their offspring, which can be an energetically demanding period. This may be the reason they are consistently inactive, as they have spent most of their energy for the past several months trying to support themselves and their young. Despite eagle presence increasing, they might not have the additional energy to be extremely vigilant. Since we did not see a change in the rate of gull vigilance as eagles increased, it may be the case that the rate of vigilance is always at a heightened baseline level because there are always eagles present. However, we did see a decrease in standard deviation variability of vigilance as the number of eagles present surpassed three, suggesting that there is a regular level of vigilance as eagle presence approaches three or more eagles, compared to the highly varied percentages of vigilance when less than three eagles are present. With this information, we can predict that beyond three eagles present, around 10% of the flock are vigilant. Gulls must be able to carry out their life processes in this environment, and presumably are able to determine when constant eagle presence is threatening or benign.

Within the earliest days of our observations, we saw the highest number of eagle attacks, with that number decreasing by the end of our study period. In order to make sense of this trend, we looked at other studies that observed Glaucous-winged Gulls' nesting periods and eagle predation. Eagle presence around Glaucous-winged Gull colonies peaks in late June, coinciding with late incubation and early hatching, likely because these prey provide a higher caloric value than underdeveloped eggs (White et al., 2006). We think that the eagles may recognize early hatchlings as prey worth the risk of venturing onto the colony, due to the hatchlings' poor eyesight and inability to fly, compared to later in the nesting season when the juveniles have improved sensory and flight abilities. Since we did not observe our colony during a full hatching season, we cannot definitively state the extent to which eagle presence varied throughout the gulls' hatching season. However, a future study would consist of surveying the colony for an entire nesting season to obtain a better understanding of the way both eagle and gull behavior varies based on the development of gull chicks.

We observed gulls engaging in a larger variety of behaviors in subjectively higher wind speeds, with noticeably lower preening-to-vigilance ratios compared to lower wind conditions. During our observations, no eagle attacks occurred during strong winds (Table 1) and we observed fewer eagles in the vicinity of the nesting colony. Both of these findings may suggest that gulls perceive eagles as less threatening in windy conditions, and may use the opportunity to perform behaviors that put them at risk in calmer wind conditions. During the windiest intervals of observation, large flocks of mostly juvenile gulls could be seen returning to the colony at a time, and we speculate that a decreased eagle threat could allow juvenile gulls the opportunity to develop their flight skills.

Looking at some specific limitations within our study, one aspect that impacted data collection was our physical location. Cattle Pass extends from the southeast end of San Juan Island, facing the southwest side of Goose Island, approximately 1100 ft away. As a result, we did not have an entire view of the colony, which limited our observations to only half of the colony. In order to have more accurate and applicable colony results, we would ideally have teams working on both Lopez Island and Cattle Pass in order to see the east and west sides of Goose Island.

As eagle populations in the Pacific Northwest continue to climb (Henson et al., 2019), we can expect to see increased predation and competition for prey. Eagles may respond to these pressures by shifting their historical diet composition to include more shorebirds, changing the dynamics of all trophic levels above and below, including those of Glaucous-winged Gulls. As our observations and other studies have shown, nesting seabird colonies may be most at risk during their early to mid-nesting seasons, and as competition for prey increases, we may see even more significant declines in their populations. It is important to identify these interrelated trends early on to prevent a drastic ecosystem shift that, in conjunction with climate change, is likely to persist for decades to come.

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