Feeding Behavior and Habitat Use of Western Sandpipers (*Calidris mauri*) and Least Sandpipers (*Calidris minutilla)* in the San Juan Islands, Washington during Summer 2021

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ABSTRACT

Coastal ecosystems are important for shoreline species. As anthropogenic changes increase, shoreline species become more vulnerable to habitat loss and degradation. Habitat loss and usage is especially relevant to our study site near Jakle's Lagoon, San Juan Island, WA; which is classified as an area of conservation and known to be a stopover site for migratory shorebirds. We studied the differences in abundance, behavior and habitat use between Western Sandpipers *(Calidris mauri)* and Least Sandpipers *(Calidris minutilla)*. Focal behavioral observations were recorded every 20 seconds in 3 minute intervals. Abundance was taken through scanning and counting every 20 minutes. Our results indicate that Least Sandpipers and Western Sandpipers used and were distributed through the area slightly differently during foraging. Despite these differences, both species used our study area as a stopover site for mainly feeding, leading to our conclusion that Jakle's Lagoon and its adjacent shorelines are important areas for migratory shorebirds despite the current level of human disturbance.

Keywords: Western Sandpiper, *Calidris mauri*, Least Sandpiper, *Calidris minutilla,* Jakle's Lagoon, behavior, habitat use, energetics

INTRODUCTION

Coastal ecosystems are among the most vulnerable areas to be modified due to anthropogenic change (Adger, 2005). As human populations increase along the coastlines, there are growing concerns of habitat loss, degradation, and population declines for shoreline species (Studds, 2017). Shorebirds that rely on coastal ecosystems are heavily influenced by food distribution (Evans and Dugan 1984). Amphipods, a common food source for shorebirds, tend to decline in population as anthropogenic changes persist (Mouritsen, 2005). As prey abundance decreases, energetic costs for these shoreline birds increases (Evans 1976, Kersten and Piersma 1987). Western Sandpipers *(Calidris mauri)* and Least Sandpipers *(Calidris minutilla)* are migratory shorebirds that use the Jakle's Lagoon area in San Juan Island, WA as a stopover site.

The objective of this study is to observe and understand the different abundance, habitat, and feeding behaviors between Western Sandpipers and Least Sandpipers near Jakle's Lagoon. By understanding the differences between the two species, we can reaffirm the importance of Jakle's Lagoon as a migratory stopsite for Western and Least Sandpipers and better manage future developments. Our null hypothesis states that there will be no significant difference in abundance, habitat, and feeding behaviors between Western Sandpipers and Least Sandpipers. Our alternative hypothesis states that there will be a difference between the abundance, habitat, and feeding behavior between Western and Least Sandpipers.

METHODS

Study Site

Our field site is the shoreline area at the southern end of Griffin Bay on San Juan Island, Washington, USA. It is located between Old Town Lagoon and Jakle's Lagoon, adjacent to

Jakle's Lagoon's parking lot (Fig. 1). This location is well-known as a stopover site for migratory shorebirds (Kunze 1984). Shorebirds can feed and rest on a variety of substrates the shoreline offers, including vegetation, rocks, and sand. The area of the substrates alter as the tidal height changes.

Abundance and Tidal Height

We conducted an observational study from August 10 to 13, 2021, during both high tides each day. For abundance, we counted the total number of shoreline birds by scanning through 8×42 binoculars, recording time and counting in 20-minute intervals. We also determined tidal height using the recorded time and tide height from NOAA's Friday Harbor tide station (National Oceanic and Atmospheric Administration, 2021).

Behavior and Habitat Use

We used the method of focal animal sampling to record behavior and habitat usage. Every 3 minutes, we selected a different random individual to observe through binoculars. A 20-second interval behavioral observation was recorded 9 times in 3 minutes. Behaviors were labeled into 6 different categories, including resting, walking, vigilance, maintenance, probing and flying. The category labeled resting included behaviors such as sitting, standing, and head tucked to the side. The category labeled walking consisted of walking and running. Maintenance was recorded when bathing and preening behaviors were observed. Vigilance included the movement of head, looking around, and long stares in particular areas. Flying was recorded when observed individuals lost contact with the ground and were visibly seen in the air. Habitat (i.e. substrate) usage was also recorded for each observed behavior. We determined habitat usage by observing what substrate the observed sandpiper was standing on. The categories of habitat usage included water, sand, rock, and algae.

Prey Abundance

In order to understand why the sandpipers were found in certain habitats, and why they were not found in others, we decided to take prey abundance samples on the last day of our study. With a 10 cm diameter coring device inserted 2 cm deep into the sediments, we collected epifaunal and infaunal prey in core samples. Three samples, (10 paces apart to increase coverage) were taken where we observed a feeding flock probing. Stepping back 10 paces to an area that was not observed to be used by sandpipers, we then took three additional samples (also 10 paces apart). We ended up with six total samples. Afterwards, we soaked the samples in freshwater and sorted the prey within 24 hours of collection. Although we found many different organisms within our core samples, we decided to focus on the prey we directly saw the birds eating: amphipods. We dried the prey in each sample after sorting, then weighed the total mass of prey in each sample. Then we calculated the energy of one amphipod using the average mass of samples divided by the average count of individuals in each sample.

The energy density of prey in each sample was calculated using the following equation:

$$Prey\ Energy\ Density = \frac{Mass\ of\ Prey\ in\ Sample}{Volume\ of\ Sediment} \cdot Energy\ Content\ of\ Prey$$

We used the average energy content of common prey species (15.1 J/mg dry weight) of Least Sandpipers in the equation (Boates and Smith 1979). The volume of the sediment was calculated using the coring device's size. The calculated value of the equation represents the energy of prey per volume of sediment.

Energetics

We used the following equation to calculate an individual sandpiper's daily energy requirement:

$$Number\ of\ Prey/Day = \frac{Daily\ Ingestion}{Energy/Prey}$$

We used the caloric daily ingestion (14.3 kcal/day) of a similar species called Spotted Sandpiper from a 1973 study (Kuenzel and Wiegert 1973). The equation's calculated value represents the number of prey that a sandpiper must consume to support their daily activities.

In order to expand on our study, the cost of disturbance-induced flight in the habitat was also calculated. The energy need for flight was calculated by the following equation:

$$Cost\ of\ Disturbance = Flight\ Cost \cdot Flight\ Time$$

The average cost of flight across species is about 11 times the species' basal metabolic rate (Norberg 1981). The equation's calculated value represents the average total daily cost of sandpipers flying away from disturbance in our study site.

RESULTS

Abundance and Tidal Height

Our results looked at 112 observations during high tide at Jakle's Lagoon over a period of 4 days (Fig. 2). With regards to our abundance data, we found that the count of sandpipers increased with tide height.

Habitat

The time spent on different habitats differed between each species. We found that the Least Sandpipers on average spent most of their time (60%) on rocky habitat. Western Sandpipers on average were found to spend even amounts of time across all habitats, spending 25% of their time on water, 25% on sand, 25% on rock, and 25% on algae habitats. Other species spent 78% of their time on sand (Fig. 3).

Focal behavioral study

Behaviors were labeled into 6 different categories. The category labeled resting includes behaviors such as sitting, standing, and head tucked to the side. The category labeled walking consists of walking and running. Maintenance is when observed behaviors are bathing in water and preening. Vigilance includes the movement of head, looking around, and long stares in particular areas. Flying is when observed species lose contact with the ground and are visibly seen in the air. The most frequently observed behavior across all species is probing, which indicates the act of pecking beak to ground.

The Least Sandpipers were found to have spent 40% of their time probing, 26% resting, 14% walking, 12% maintenance, 7% vigilance, and less than 1% flying. The Western Sandpipers spent 44% of their time probing, 22% resting, 19% walking, 6% maintenance, 8% vigilance, and less than 1% flying. The other species spent 61% of their time probing, 6% resting, 0% walking, 33% maintenance, 0% vigilance, and 0% flying (Fig. 4). Across all different species, the behavior of probing was the most frequent behavior.

Location of Probing

The behavior of probing was observed across all species across 4 different habitats (Fig. 5). The Least Sandpipers were observed to be probing the most frequently 52% of the time on rock habitat. Whereas the Western Sandpipers were observed to be probing most frequently on habitat algae, at 40% of the time. Other species were observed to be probing 50% of the time on habitat sand.

Prey Abundance

Prey abundance was taken through 6 total samples. Each sample was taken in different substrates to represent different habitats. Sample 1 consisted of sandy habitat, sample 2 included

a mixture of algae rock and sand, and lastly, sample 3 was sandy with a mixture of smaller rocks. Samples 4, 5, and 6 were dry, rocky substrates. The average count of individual amphipods was 68 per sample and the average mass per sample was 0.9811 g. The highest amphipod energy density, 50717 kJ/m^3, was calculated from sample 1. The second highest amphipod energy density was 12904 kJ/m^3 from sample 2. The third highest amphipod energy density was 2713 kJ/m^3 in sample 3. Samples 4-6 had the lowest amphipod density energies at 0 kJ/m^3 each (Fig. 6).

Energetics

The daily energy needed for a sandpiper is 59,831 J/day (Kuenzel, 1973). One amphipod was 218 J/individual according to our calculations. We conclude that one sandpiper needed to eat 275 amphipods everyday to meet their daily energy requirements.When disturbance occurred, both the Least and Western sandpipers flushed and flew to a different location with an average flight time of 6.25 seconds. We calculated the energy cost of flight when the sandpipers flushed. For every 6.25 seconds of flight, 23 J/day was used by one sandpiper. This amount of energy is equivalent to an additional 0.1 amphipod needed daily in order to make up for the daily energy cost of disturbance.

DISCUSSION

Summarized, our results indicate that the overall abundance of both sandpiper species was the highest with higher tide heights. This is consistent with another Friday Harbor Lab 2018 student research project in the same area. At Jakle's Lagoon, it was also found that shorebird abundance increased with tidal height (Dorsett et al. 2018). However, this is inconsistent with many other studies that state the opposite; shorebirds in other areas are generally known to increase in abundance at lower tides (Burger, 1977). We hypothesize that this could be due to

their method of escaping from disturbance. We observed that when flying due to disturbance, or when flying due to the presence of a predator, shorebirds would fly offshore over the water before coming back to land on shore. Higher tides could provide shorebirds a way to be close to their onshore food source, and also to be able to more quickly escape over water in the case of predation. Another hypothesis is that our study site allows shorebirds to feed when other nearby stopover sites are covered in water by higher tides. Further comparison between our area of study and other stopover sites on San Juan Island could overall give insight into why this pattern has persisted across years of study.

From our habitat use study, we found that for both species, probing behavior was displayed the most. The Jakle's Lagoon area is most likely used as a feeding area. As for the specifics of the habitat and substrate use, there are different observed feeding behaviors between the two species, consistent with our hypothesis. It was observed that Western Sandpipers probe on habitats equally - probing slightly more on habitats containing algae and probing slightly less on rocky habitats. In comparison, Least Sandpipers probed the most on rocky habitats. Western Sandpipers have a larger variety of prey in their diet compared to Least Sandpipers - allowing them to use different habitats or substrates when feeding (Franks et al. 2020, Nebel et al. 2020). This aligns with the known nature of mixed feeding flocks avoiding interspecies competition through diet (Novcic, 2016). This finding that both species used rocky habitats when foraging however does not align with our prey sampling data - where the highest abundance of amphipods was found within our sample with mostly sandy substrate and not rocky substrate. One explanation could be that the rocky area covers more of the shoreline, and is more available for foraging at high tide.

Our overall finding from our prey abundance study was that one sandpiper will need to

eat an additional 0.1 amphipods in our study site in order to make up for the disturbance-induced flight they experience daily. This is only 0.04% of one sandpiper's daily prey intake, indicating that human disturbance at our study site is not currently significantly impacting these two species of interest. One undocumented disturbance we observed was motorboat disturbance within 20 m of our study site on the fourth day of our study. There was a very low abundance of birds in the area overall. In the case that human disturbance continues to increase from tourism and boating, disturbance-induced flight and overall displacement from fear may negatively impact migrating shorebirds, which are known to pick stopover sites based on high food abundance and low predation risk (Pomeroy et al. 2006).

In consideration of climate change, it is projected that prey abundance will decrease with rising temperatures - posing a threat to migratory birds that rely heavily on feeding zones in order to make their annual trips (Morrison et al. 2007). Rising sea levels will further cover shorelines that shorebirds feed on, decreasing the amount of stopover sites worldwide (Bildstein et al. 1991). Buffer zones should be established as needed in order to prevent pedestrian and offshore disturbance from flushing birds can help protect the area as a stopover site for migratory birds. Although current levels of disturbance are not significant enough to be harmful, increased disturbance can cause migratory birds to abandon the site - leading to more habitat loss. (Gillespie et al. 2017). With the classification of Jakle's Lagoon and the surrounding area as an area of conservation, further management should take into consideration the future impacts of human disturbance and climate change.

One limitation we encountered was density and observer bias. With higher tides, more birds could be pushed to congregate further up shore, allowing us to count and observe them more easily. To account for this in later studies, we suggest better training observers to spot the

birds, along with again taking data at a range of different tide heights. Regarding our prey abundance calculations, we only took samples in a small area on one day, focusing on one type of prey. This lack of coverage could have skewed our data - especially with our core samples being taken on a sandy area during wildfire season - where the last feeding flock was seen (even as they were mostly seen on rocky areas on other days). Additionally, sandpipers have a larger range of diets than simply amphipods. A larger scaled study in the future could increase temporal and spatial coverage, and also analyze many different types of prey that sandpipers eat as well.

We recommend that future studies in this area expand on questions regarding abundance, habitat use and behavior in comparison with other stopover sites to address whether sandpipers are using this area as an alternative to others on the island. Another recommendation is to further investigate the effects of pedestrian disturbance in the area. Finding the flight-initiation distance, along with how often the birds are disturbed at this site on a long term scale could help with future management.

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FIGURES

Figure 1: Location of study site at the southern end of Griffin Bay, between Old Town Lagoon and Jakle's Lagoon in San Juan Island, WA during 10-13, August 2021 (48°27'58.5"N 122°59'56.9"W) (Google, 2021).

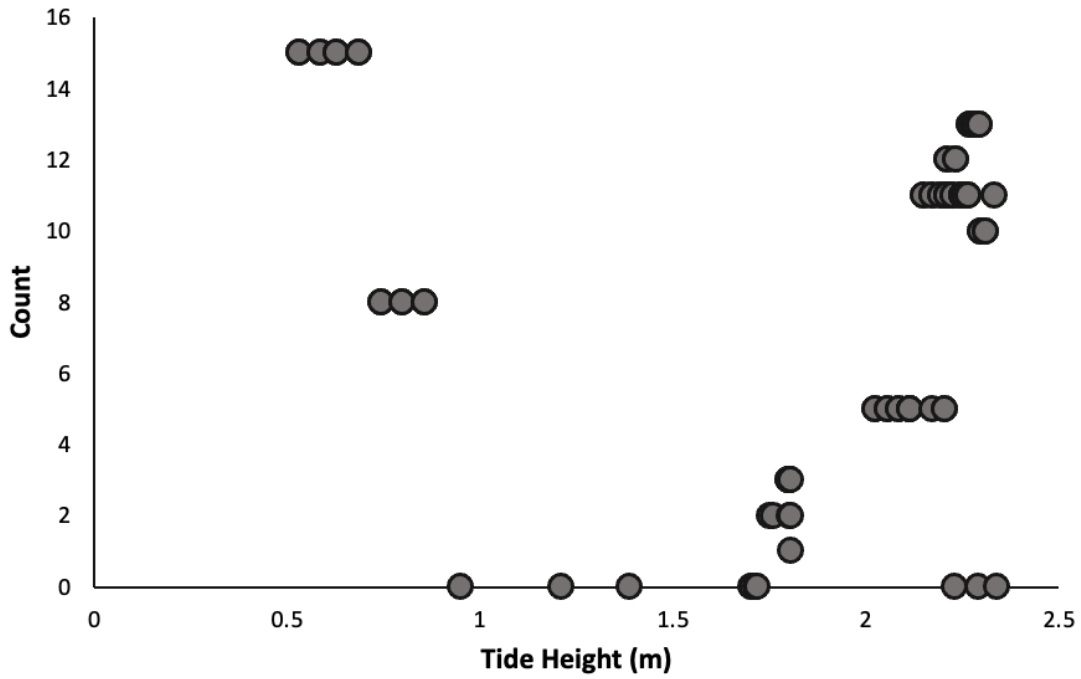

Figure 2: The count of sandpipers for different tide heights. Count starts from the lowest number of 0 to the highest number of 16. Tide height starts at 0m to the highest height of 2.5m. Starting at tide height 1m to 2.5m, the count of sandpipers increases as tide height approaches 2.5m. There are 6 observations below tide height 1m with outlier counts of 8 and 15.

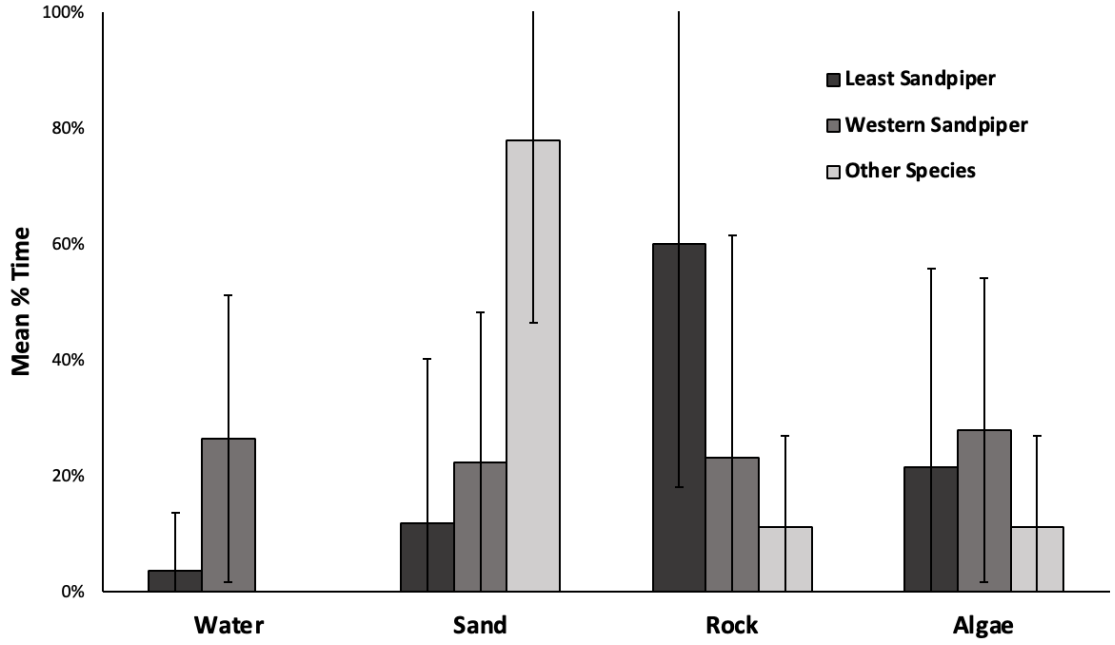

Figure 3: Mean time spent across different species in different habitats. Different habitats are labeled as water, sand, rock, and algae. Least sandpipers are labeled in black bar graph, Western sandpipers are labeled in dark grey bar graph, and other species are labeled in light bar graph.

Figure 4: Mean time spent on different observed behaviors for each species. Behaviors consist of resting, walking, maintenance, vigilance, probing, and flying. Least sandpipers are labeled in black bar graph, Western sandpipers are labeled in dark grey bar graph, and other species are labeled in light bar graph. Probing is the most frequent observed behavior across all species.

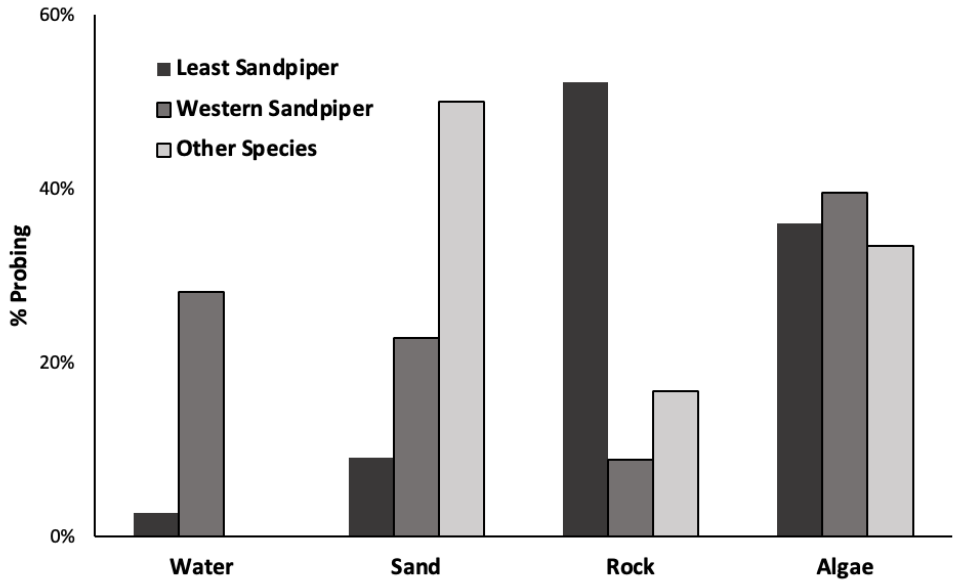

Figure 5: The amount of time probing for different species across different habitats. Least sandpipers are labeled in black bar graph, Western sandpipers are labeled in dark grey bar graph, and other species are labeled in light bar graph.

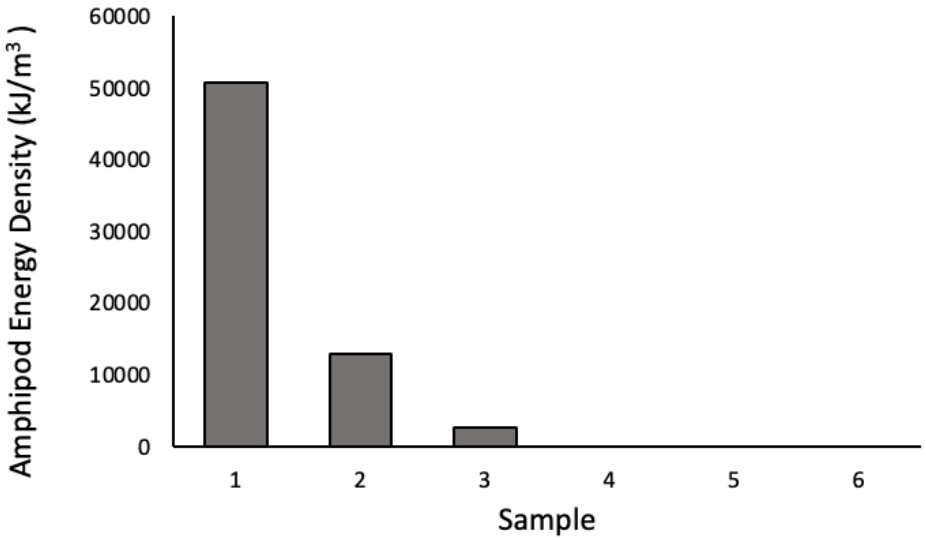

Figure 6: The calculated amphipod density energy in units of kJ/m^3 across different samples.