Impact of Time and Tidal Current Speed on Alcid Abundance and Behavior in San Juan Channel

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Abstract

Understanding daily abundance and behavior of animals is an important part of conservation research, as changes in these factors cannot be considered without a baseline to reference. Our study is focused on providing this information about the population of alcids in San Juan Channel in relation to different times of day and different tidal currents. The Pigeon Guillemot (*Cepphus columba*), Rhinoceros Auklet (*Cerorhinca monocerata*), Common Murre (*Uria aalge*), and Marbled Murrelet (*Brachyramphus marmoratus*) are all species of the family Alcidae, or alcids, which are commonly found in the San Juan Island area. In this study we conducted observations from the shoreline of Hunt's Point, observing abundance of each species, and categorizing the birds' behavior into three categories: diving, flying and swimming. Trends in data indicate that abundance and behavior were distinct between species and differed with tidal current speeds. We found that Pigeon Guillemots were most abundant during fast ebb currents, Rhinoceros Auklets during slow ebb currents and slack high currents, Common Murres during slack high currents, and Marbled Murrelets during ebb currents and slack high currents. While observing Rhinoceros Auklets, we found distinct feeding patterns throughout the day that shifted at 16:00. We also found consistent patterns in flight direction of Rhinoceros Auklets, where flying north to south was more common during flood currents than during ebb currents. Understanding patterns of abundance and behavior is critical for designing regulations and maintaining healthy populations of these species. Research should be continued over a longer period of time to provide more data and information about these species throughout a wider range of conditions.

Keywords: alcid, tidal current, Cattle Pass, feeding behavior, Pigeon Guillemot (*Cepphus columba*), Rhinoceros Auklet (*Cerorhinca monocerata*), Common Murre (*Uria aalge*), Marbled Murrelet (*Brachyramphus marmoratus*)

Introduction

Alcids, of the family Alcidae, are seabirds commonly found in North Pacific waters. They are all primarily wing-propelled divers, and aside from some variation in diet among species, they mainly feed on small fish and invertebrates. Declines in alcid populations have been recorded in the Salish Sea in recent years, mostly notably among Marbled Murrelet populations. The species of alcids we studied include Pigeon Guillemots (*Cepphus columba*, PIGU), Rhinoceros Auklets (*Cerorhinca monocerata*, RHAU), Common Murres (*Uria aalge*, COMU) and Marbled Murrelet (*Brachyramphus marmoratus*, MAMU). PIGUs are found exclusively in the North Pacific. They usually feed close to shore, in depths of around 10-30 meters, mainly in the water column and sometimes in benthic environments (Ewins 2020). RHAUs are found in more temperate waters of the North Pacific. They prefer to dive within 10 meters of the surface (Gaston & Dechesne 2020). They have distinct feeding patterns throughout the day (Davoren & Burger 1999). COMUs are found in high latitude, cooler climates of the Northern Hemisphere. Their populations are large in both Pacific and Atlantic regions, which include several subspecies that are genetically and morphologically different. They dive to more extreme depths, of up to 100 meters (Ainley, Nettleship & Storey 2021). MAMU are found in North America and Asia. They nest in old growth forests and are vulnerable to anthropogenic effects such as deforestation. There is currently relatively little research done on this species (Nelson 2020).

A component of the “tidal coupling hypothesis” entails the mixed, semi-diurnal tides in this area which have a disproportionately large effect on the abundance of marine prey including plankton and small fish, and thus impact the abundance and behavior of larger predators, including seabirds (Zamon 2003).

We conducted land based surveys in Cattle Pass in San Juan Channel, to assess relationships of alcid abundance and behavior relative to tidal currents and time of day.

Methods

Study area

We performed interval scan surveys and recorded the behavior of various alcid species from the shoreline of a private property called Hunt’s Point (48.46536, -122.95588), along Cattle Pass in San Juan Channel. Using binoculars with a magnification of 10 and diameter of 42 millimeters, we recorded a total of 220 minutes of data over a five day period (August 7-12 2023).

We chose this location because Cattle Pass’s unique bathymetry often creates strong tidal currents, which allows for observation of alcid behavior and abundance throughout a large range of current speeds and directions. We set up in the same location for each session to ensure our view would stay the same, and we divided our observation area into four sectors using landmarks on the shores of Goose Island and Lopez Island (Figure 1). We estimated a halfway point in the middle of the channel and used this to create a range in which we could confidently identify the species and their behaviors.

Field Data Collection

We observed four species of alcids within the sectors: PIGU, RHAU, COMU, and MAMU. We performed two separate observations every day for five days, each lasting about one hour. Observation times varied each day in order to collect data from different times of day, as well as different tidal current speeds and directions. Our study area was large, so we divided it into four sectors, and surveyed two sectors each day. To ensure we gathered equal observations among sectors, we alternated the two sectors we observed every day, with sectors 1 and 3 grouped together and sectors 2 and 4 grouped together. Scan sampling was performed in five minute intervals. We scanned sector 1 or 2 for one minute, sector 3 or 4 for one minute, then three minutes were spent recording and reviewing our data. One member of the team observed sectors 1 and 2, one member observed sectors 3 and 4, and one member recorded observations.

We recorded data of overall abundance of each bird per minute, as well as bird behavior which was divided into three categories: swimming, flying, or diving. Swimming was defined as any time the bird was in the water, regardless of whether it was actively paddling or not. Flying was defined as any time the bird was in the air. Diving was defined as any bird seen actively diving down or coming up from a dive, or any new individual observed in the area without there being any indication of the bird flying to or from the area.

We observed RHAU feeding behavior to determine whether or not tidal current phases and time of day have an effect on RHAU's feeding patterns. In addition to swimming, flying, and diving behaviors, we recorded when RHAUs were carrying fish in their bills while swimming or diving, indicating that they were gathering food for their young.

We also noticed a consistent pattern of alcids flying north to south through the channel. Halfway through our study we began recording flight directions of PIGUs and RHAUs, and collected this data throughout a three day period.

Data Analysis

We used DeepZoom.com to track tidal current speed in San Juan Channel. We planned our observation times according to this chart, with the intention of collecting data across a wide range of current speeds. We then categorized current speed into six groups, according to the current speeds observed over the six day study period (Table 1).

We analyzed our data to compare the abundance and behavior of alcids relative to tidal current, as well as the abundance and behavior of alcids relative to time of day. We categorized time of day into three categories, which include: Morning (7:00-12:00 hrs), Afternoon (12:00-16:00 hrs) and Evening (16:00-21:00 hrs). These categories were modified from a previous study (Davoren & Burger 1999).

We constructed our sectors randomly, without regard to the actual physical and environmental changes throughout the sectors. We sampled each sector several times, and combined all data from each sector to get an accurate representation of our study area.

Results

Abundance

We found that PIGUs were more abundant during fast ebb currents, RHAUs during slow ebb currents and slack high currents, and COMUs during slack high currents (Figure 2). Our study had a low sample size for MAMUs, but trends in data indicate a weak trend with higher abundance during ebb currents and slack high currents. Comparing abundance with time of day, we found that all species appeared to prefer the afternoon (12:00-16:00) to other times of day (Figure 3).

Behavior

We found that PIGUs dove most in slack low currents and slow flood currents, RHAUs dove equally in slow ebb, slack high, and slow flood currents, and that COMUs and MAMUs dove most often in slack high currents (Figure 4). We also found that PIGU dove most in the afternoon, while RHAU, COMU and MAMU all preferred evening (16:00-21:00) (Figure 5).

Rhinoceros Auklet Feeding

We found that there was a correlation between time of day and RHAU feeding patterns, where the amount of RHAUs recorded with food in their bills was significantly greater in the evening than in both the morning and afternoon (Figure 6). Alternatively, we did not see a significant correlation between the number of RHAUs seen with food in their bills and current speed (Figure 7).

Flight Direction

During a three day period, we found that 99% of PIGUs and RHAUs (*n* = 150) were flying north to south during flood currents, while 96% of individuals (*n* = 121) were flying north to south during ebb currents (Figure 8).

Discussion

Multiple factors could explain why our study found that PIGUs had different tidal current preferences than the other alcids we observed. RHAUs, COMUs, and MAMUs use their wings to propel themselves while diving, but PIGUs prefer to use their feet, which are not as strong as wings (National Audubon Society nd). Because of this, PIGUs most likely prefer to dive in slower currents that provide less resistance during dives. PIGUs also have a different diet than the other three species. PIGUs are piscivores and occasional benthic feeders, whereas RHAUs, COMUs, and MAMUs are piscivores and occasional surface feeders. All four alcid species feed on fish in the water column, but PIGUs also feed on invertebrates on the ocean floor while the other three species feed on small fish and plankton at the ocean surface. Because PIGUs have to dive all the way to the ocean floor, they most likely prefer to dive in the tidal currents that coincide with low tide heights and shallower water. These differing preferences are potentially an example of niche partitioning, which happens when competing species use a habitat's resource in different ways or different times to better coexist with each other.

Behavior patterns can also inform conservation and management of a species' known feeding areas. With knowledge of a species' diet and preferred feeding location, researchers can make inferences about the health of the community in this area and assess the various levels in the species' food chain. If a species shifts away from one of its established feeding locations, it could indicate that prey in the area is decreasing in abundance or nutritional value.

Due to our short study period, our data for tidal currents and time of day were somewhat confounded. However, we made observations of the different tidal current phases at most time of day categories. Based on this, we can confidently claim that tidal current phases had an influence on alcid diving patterns.

Our findings that RHAU feeding patterns shifted at 16:00 are consistent with a study by Davoren & Burger, 1999. This study shows that RHAU prefer to gather smaller fish before 16:00 to feed themselves. After 16:00, they gather larger fish to bring back to their young.

Additionally, we found that flight direction had a slight correlation to tidal current direction. In Cattle Pass, a flood current moves from the south to the north, whereas an ebb current moves from north to south. We would expect to observe birds swimming on the surface in the same direction as the current to feed, then fly in the opposite direction to reposition themselves. While this pattern was observed during flood currents, it was not as consistent with the ebb currents we observed. This may be due to the lack of data collected during fast ebb in the second half of our study period.

Study limitations

Sources of potential bias in our research include decreased visibility during overcast days or evening observations, and miscalculation of the estimated half-way point of the channel. Additionally, errors in data may have occurred due to the complexity of identifying species due to morphological similarities, as well as the likelihood of more birds being counted when flying than swimming or diving due to flight being a more visible activity.

Conservation Implications

Understanding the abundance and behaviors of these species relative to the tidal currents and time of day is critical in order to implement the necessary conservation measures that ensure healthy populations are maintained.

With climate change becoming more severe, global currents are increasingly susceptible to change. While our study was focused solely on tidal currents in San Juan Channel, the observed patterns of alcid abundance and behavior can be applied to these other kinds of currents elsewhere in the world.

Alcid behavior relative to time of day is another piece of information that is critical for understanding how they may respond to climate change. As climate change causes shifts in daylight availability, storm frequency, and temperature, alcids and other marine birds could shift their daily schedules to avoid unpleasant conditions. Knowing what times of the day alcids are performing different tasks can allow changes in behavioral patterns to be recognized early.

Our study was limited to a short period of time during the alcid nesting season. Because of this, it is possible our behavioral results could be representative of feeding patterns exclusive to the time of the year when mature birds are feeding themselves and their young. If we were able to repeat this study, we would like to do it again outside of nesting season so as to gather data for alcids' other feeding patterns.

Abundance patterns can be a useful tool to help inform conservation efforts for birds in the family alcidae. Some species of alcids, especially PIGUs, prefer to nest close to the areas they feed and rest in (Molina et al 2022). Knowing where a bird spends most of its time can inform interested parties about where these nesting sites may be. These patterns also help to designate specific areas as critical habitats, which are areas that are crucial to the health and recovery of a species. Knowledge of where a species' nesting sites and critical habitats are is vital to inform proper conservation and management strategies. This ensures these areas are maintained so populations remain healthy and declining populations have a better chance at recovery.

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Tables and Figures

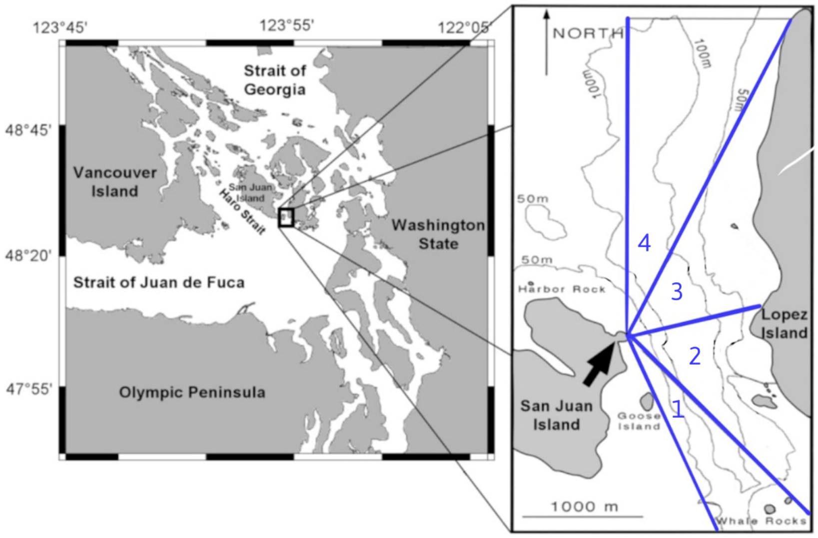

Figure 1 | Modified from Zamon (2003). Shows sectors used to divide San Juan Channel based on permanent geological markers.

Table 1 | Categories of current speed in knots. Positive values represent flood tide current speed and negative values represent ebb tide current speed. Categories and table by Braune & Gaskin (1982) and Zamon (2003).

Tidal phase	Predicted current velocity (knots)
Slack low	-0.5 to +0.5
Slow flood	+0.6 to +2.5
Fast flood	> +2.5
Slack high	+0.5 to -0.5
Slow ebb	-0.6 to -2.5
Fast ebb	< -2.5

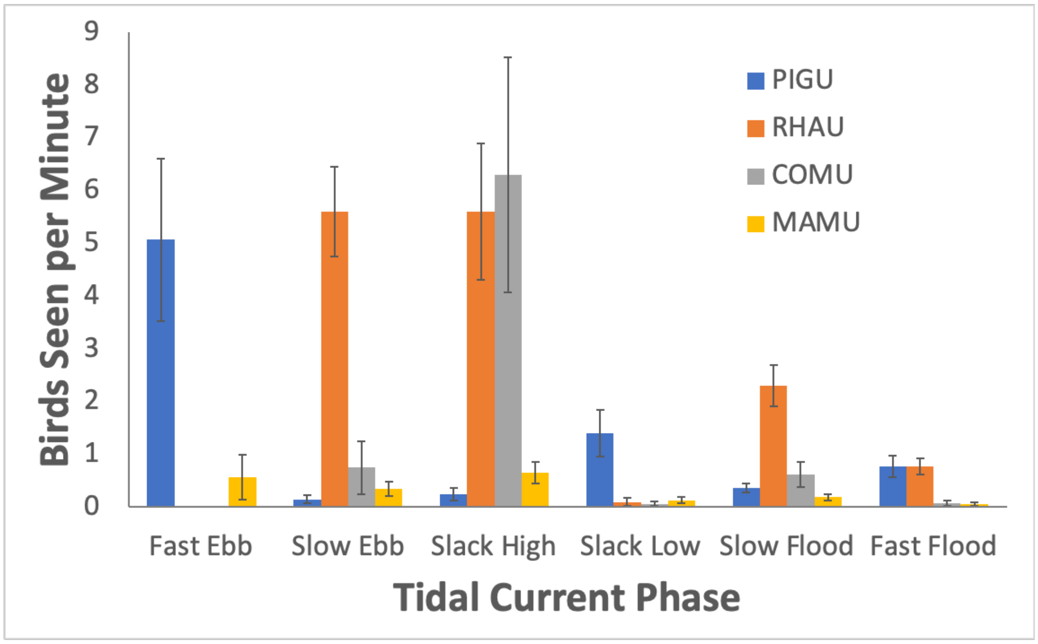

Figure 2 | Comparison of average number of alcids observed per minute during different tidal currents. Observations were made during 7-12 August, 2023 at Cattle Pass.

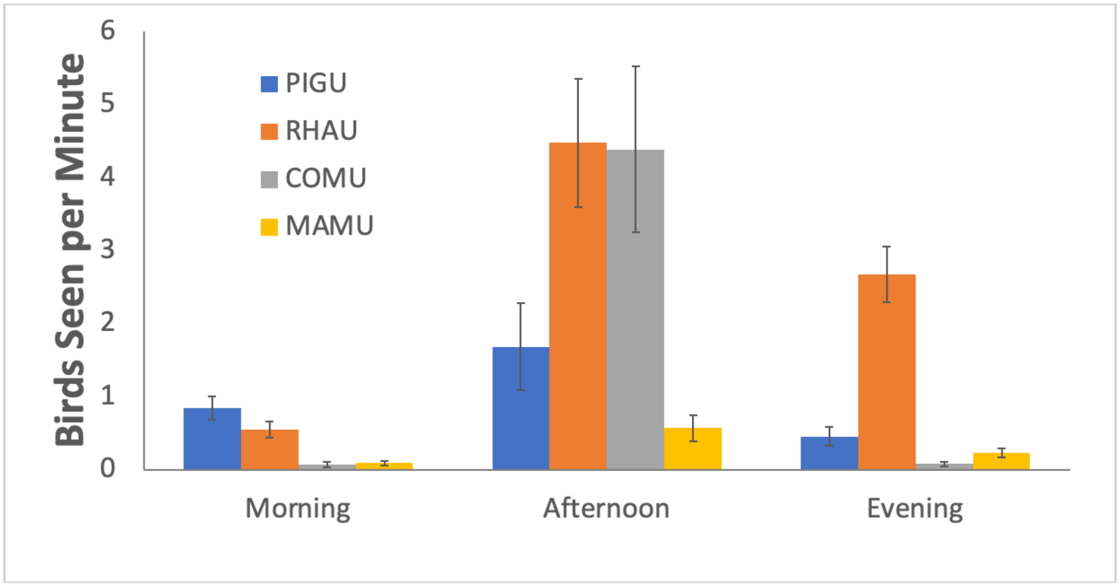

Figure 3 | Comparison of average number of alcids observed per minute during different times of day. Observations were made during 7-12 August, 2023 at Cattle Pass.

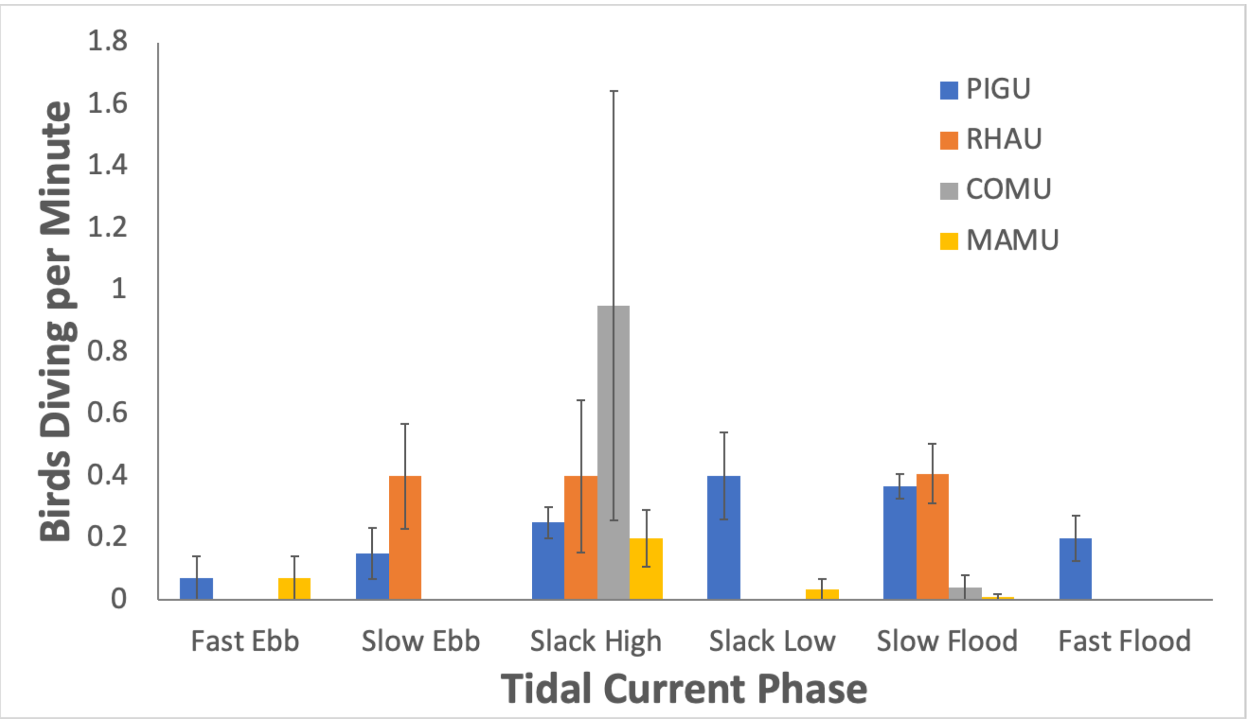

Figure 4 | Comparison of average number of alcids diving (±SE) relative to tidal current phase. Observations were made during 7-12 August, 2023 at Cattle Pass.

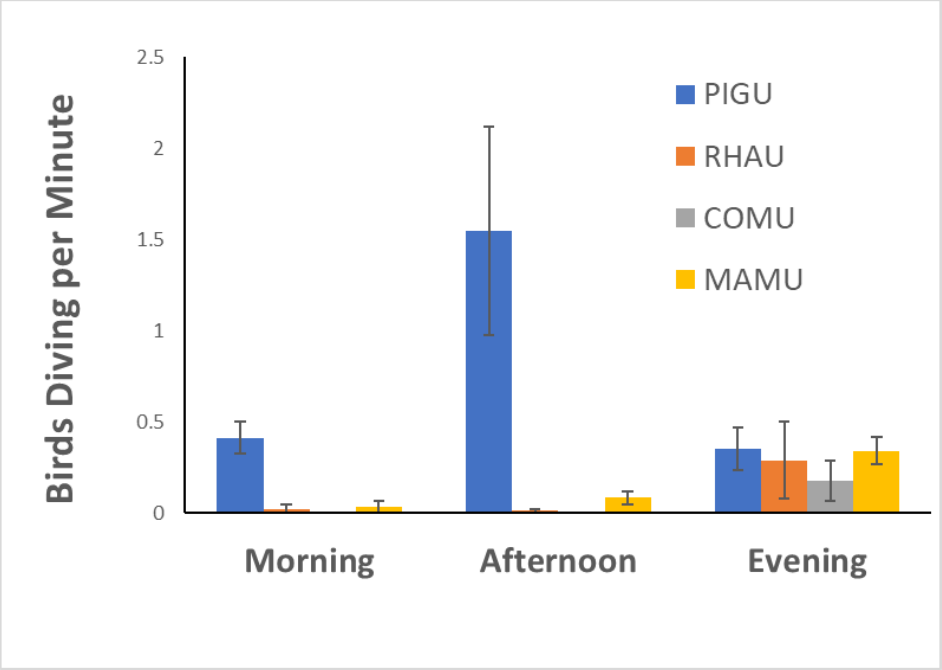

Figure 5 | Comparison of average number of alcids diving (±SE) relative to time of day. Observations were made during 7-12 August, 2023 at Cattle Pass.

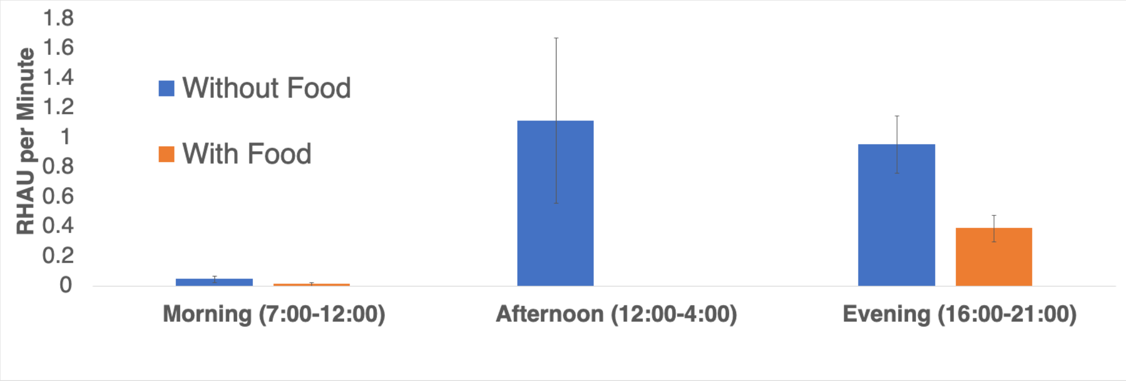

Figure 6 | Comparison of RHAU (*n* = 223) with and without food in their bills (±SE) relative to time of day. Observations were made during 7-12 August, 2023 at Cattle Pass.

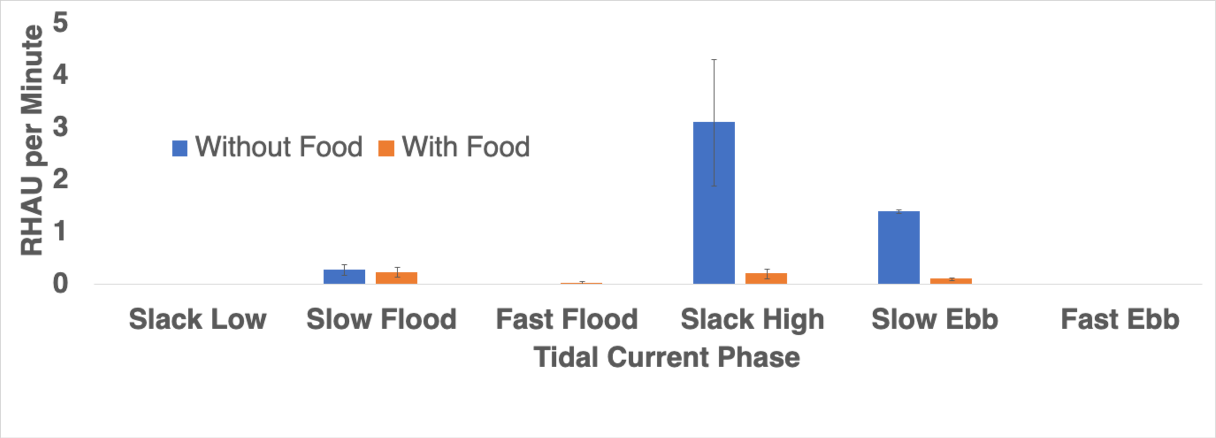

Figure 7 | Comparison of RHAU (*n* = 223) with and without food in their bills (±SE) relative to tidal currents. Observations were made 7-12 August, 2023 at Cattle Pass.

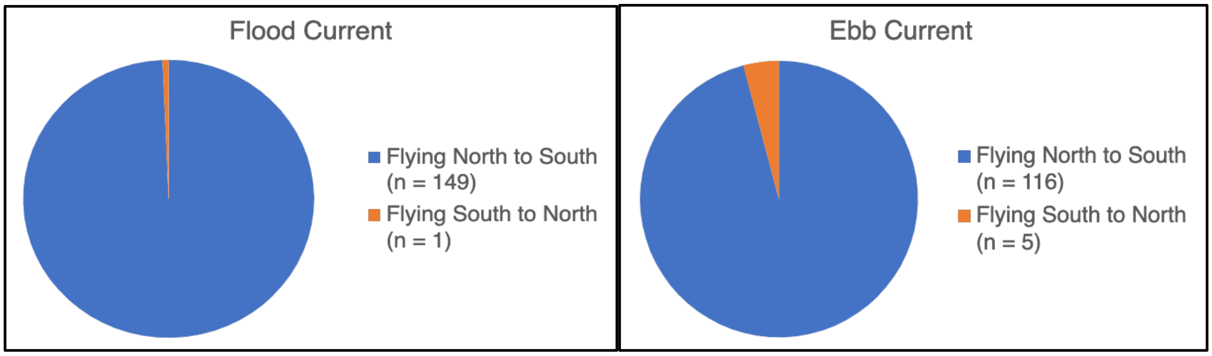

Figure 8 | Comparison of the flight direction of PIGU and RHAU during a flood current (*n* = 150) and during an ebb current (*n* = 121). Observations were made during 10-12 August, 2023 at Cattle Pass.8