Tidal Phase Effects on Marine Bird Abundance & Distribution in San Juan Channel

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Ecology and Conservation of Marine Birds and Mammals
Summer 2017

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Abstract

Understanding the factors that influence marine bird distribution and abundance is key in furthering conservation efforts. Moreover, because these species feed at high trophic levels, changes in their distribution and abundance may help track the condition of nearshore marine ecosystems. During August 2017, we surveyed the distribution and abundance of Laridae and Alcidae relative to tidal phase and current within a 2-km section of San Juan Channel in Washington State. Surveys were conducted during flood tides, from slack to just before fastest flood. Both bird families followed a trend of remaining on the water surface at low current speeds. As current speed increased and approached fastest flood tide, larids and alcids were observed in flight more than on the water. As tidal phase approached the fastest flood tide, larids moved south, presumably to join feeding flocks near the channel constriction at Cattle Pass. Conversely, alcids mainly flew north as tidal phase approached fastest flood tide, presumably to forage solitarily for non-schooling fish for their young. Further surveys of our transect beyond breeding season are needed to confirm this trend. Expanding our research beyond the flood tidal phase could also improve the accuracy of our trends regarding both Laridae and Alcidae.

Keywords

Marine birds, distribution, seabirds, abundance, Alcidae, Laridae, tidal currents, San Juan Islands, tidal coupling, tidal phase

Introduction

Marine bird populations have declined globally over recent decades (Boersma et al. 2001). This decline can be attributed to numerous anthropogenic factors (Bower, 2009). Monitoring and understanding marine bird distribution and habitat is not only important in monitoring the health of the species but also the health of marine ecosystems (Piatt et al. 2007b). Marine birds are easily observed indicators of the health of the pelagic ecosystem because they live on land, and spend most of their time on the surface or out of the water.

The San Juan Islands, in northern Washington State, are a collection of islands separated by narrow channels (Graham, 2014). The San Juan Channel divides San Juan Island from Lopez, Shaw, and Orcas islands and was the location of our study. This network of narrow channels results in strong tidal currents that influence the coastal ecosystem due to their effect on food web dynamics through a process called tidal coupling (Zamon 2003). Tidal coupling is when fast tidal currents work in conjunction with bathymetry to aggregate prey, which are consumed by several species of marine birds in San Juan Channel (Eisenlord, 2012).

In this study we measured marine bird abundance and distribution in relation to tidal phase and current speed in order to evaluate how these factors impact marine bird activity. We accomplished this by contrasting the two families, looking at their density in the water and in flight in comparison to tidal phase. We also compared the density and proportions flying north and south to determine habitat use. The Laridae and Alcidae families were the focus of our study due to their high abundance relative to other marine bird families.

Methods

Data Collection:

We conducted transect surveys of marine bird abundance from 7-10 of August 2017 for three hours per day aboard the Bufflehead, a 5.5 meter runabout with a 90 horsepower outboard motor. To assess changes in bird distribution and abundance related to tidal phase but not time of day, we conducted all surveys during similar times (start times ranged from 13:00 to 14:00). All surveys were conducted during flood tides, from low current speed to almost peak current speed (0 - 1.46 knots). There was no precipitation during surveys, although wildfire smoke reduced light somewhat. However, visibility of birds was not impeded within our survey transect. For three of the four survey days, Beaufort Sea Scale was $<$ 3. However, on 9 August there were large wind-driven swells and greater boat traffic, which forced us to diverge slightly from the survey path and likely caused bird flushing. Although we observed fewer birds on this day, we maintained these data in all analyses because this inclusion did not appreciably alter results.

We collected data in Zone 3, travelling south to north (Fig. 1). Friday Harbor Labs conducts at-sea surveys in six zones of the San Juan Channel. We chose Zone 3 because of its close proximity to Friday Harbor Labs which allowed us to complete more surveys over the duration of our study. Also, past student work focused on Zone 4, and we hoped to build upon the wealth of knowledge in the San Juan Channel as a whole. Total covered survey area was 0.80 km^2. Each survey took an average of 10 minutes to complete, at a mean speed of 8 knots (6-10 knots). We used the phone application "Navionics" to measure speed and navigate the transect. On occasion, we slowed our speed to count especially large flocks of birds. We conducted all surveys on the same transect route, with an average return time between surveys of 8 minutes from the end of the transect, to the beginning. When returning to the beginning of our transect we made sure to drive the boat along the edge of the channel, so that we were not flushing birds within our survey area. An average of 7 (6-8) surveys were taken every day. Counts of marine birds were taken simultaneously on both port and starboard then combined for a total abundance number. There were two observers who recorded their own observations, each equipped with a pair of 8xbinoculars. We placed each bird observation in one of three categories: flying south, flying north, or on the water.

Data Summary and Analysis:

We analyzed correlations between tidal phase and bird abundance and distribution. Seabirds were split between two families Laridae, and Alcidae. We focused our analysis on the Laridae and Alcidae because these two families comprised greater than 99% of our total observations. Across all surveys, total observations were comprised of 38% larids, and 62% alcids (Fig. 2). All survey times were divided into eight categories of tidal phase, in increments of 30 minutes before fastest flood tide (-240 to -30 minutes). These increments were established by previous student work (Eisenlord 2012).

We then created graphs comparing mean density of birds in the water and in flight over the 8 tidal phase categories for both alcids and larids. We also evaluated the percent of larids and alcids that were flying north, and flying south.

Results

More Alcidae were in the water than in flight before three hours from peak flood (Fig. 4). However, at 3 hours from peak flood to just before peak flood, there were more alcids in flight than in the water.

There is a similar trend of more Laridae in the water, and fewer flying, at low current speeds, near the end of ebb tide and slack tide (Fig. 4). Density of Laridae increased during low current speeds. However, as current speeds increased, after three hours from peak flood, the density of Laridae flying increased. There is a loose trend of more Laridae taking flight as current approaches peak flood. At 30 minutes from peak flood, larids flew less and were in the water more in response to a Steller sea lion feeding nearby.

As tidal phase changed from slack to peak flood, Laridae showed a trend of increasingly flying south, against the current (Fig. 3). The relatively low fraction of larids flying south 30 minutes before peak flood was likely due to their flocking near the feeding Steller sea lion. Mean density of larids flying south peaked at about two and a half hours before peak flood.

Alcidae showed a different trend as current speed increased. At low current speeds, 3 to 2.5 hours before peak flood, the density of alcids flying south was greater than the density flying north (Fig. 3). After 2.5 hours, however, Alcidae flew almost completely north, against the incoming tide. Higher current speeds, closer to peak flood, resulted in Alcidae flying north rather than south.

Discussion

Most Laridae rested during slow tidal phases, suggesting they may have been conserving energy during periods of low prey availability. In flood tidal phases with stronger currents Laridae were observed mainly in flight, and in particular flying in a southern direction. The Laridae were most likely flying in the southern direction to reach Cattle Pass, which is the most narrow part of the San Juan Channel and exhibits the fastest tidal currents (Eisenlord 2012). The relationship between tidal currents and changes in bathymetry result in tidal coupling; this process causes prey to aggregate in specific areas (Zamon 2002). These tidal coupling events are most likely why we saw a majority of Laridae flying south. Laridae, at 30 minutes from peak flood, did not follow the previous trend due to a Steller sea lion feeding. Larids are opportunistic and were likely using feeding cues to take advantage of smaller scale feeding opportunities.

Laridae and Alcidae showed similar tidal responses, although Alcidae did not follow some previously reported trends. Past research has suggested that Alcidae will fly south towards Cattle Pass, where food is aggregating, and float with the flood currents northward (Zamon 2003, Eisenlord 2012). Our results contradicted this hypothesis. Alcidae in our study were observed flying in the northern direction which could be contributed to their known habit of foraging for larger fish alone in the afternoon in order to avoid kleptoparasitism and feed their young (Davoren 2003).

When comparing mean density of marine birds in water and air (cross-reference Figure 4) we observed more Alcidae in the water than Laridae. This may be because energy expenditure by alcids is high during flight in comparison to other marine birds (Davoren 2003). Alcidae are more dense and have high wing loading caused by their evolutionary need to dive to deep depths. Overall, Laridae were observed flying more often than Alcidae because their high-aspect ratio wings allow them to glide at a lower energy cost. This lower cost of flight may also explain the weaker correlation between flight direction and current phase. Prospecting for food becomes more energetically favorable when the cost of flight is low.

The discrepancies between our work and past work can be further explained and investigated through continued research in Zone 3. We suggest more time spent observing the behavior of Alcidae in order to confirm our hypothesis as to why they fly north during fast flood currents. It would also be beneficial to conduct this study over complete tidal phases and during the nonbreeding season. Observing more tidal phases would increase our understanding of how tidal currents directly influence marine bird behaviors in the San Juan Channel.

Acknowledgements

We would like to thank our advisor, Eric Anderson, for his support and guidance through the entire research process. Thank you to Breck Tyler for helping us develop our research question. We would also like to thank our dedicated TA, Dave Slager, for answering questions and helping us identify birds in his free time. Lastly, we would like to thank the Friday Harbor Labs staff for providing us with the facilities that made this research possible, and our supportive classmates of the Marine Birds and Mammals Class of Summer 2017.

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Figures

Figure 1. Locations of the Zone 3 survey transect for marine birds in the San Juan Channel and the Turn Rock Light Tidal Station used for estimates of current speed. Surveys were conducted during 7-10 August 2017.

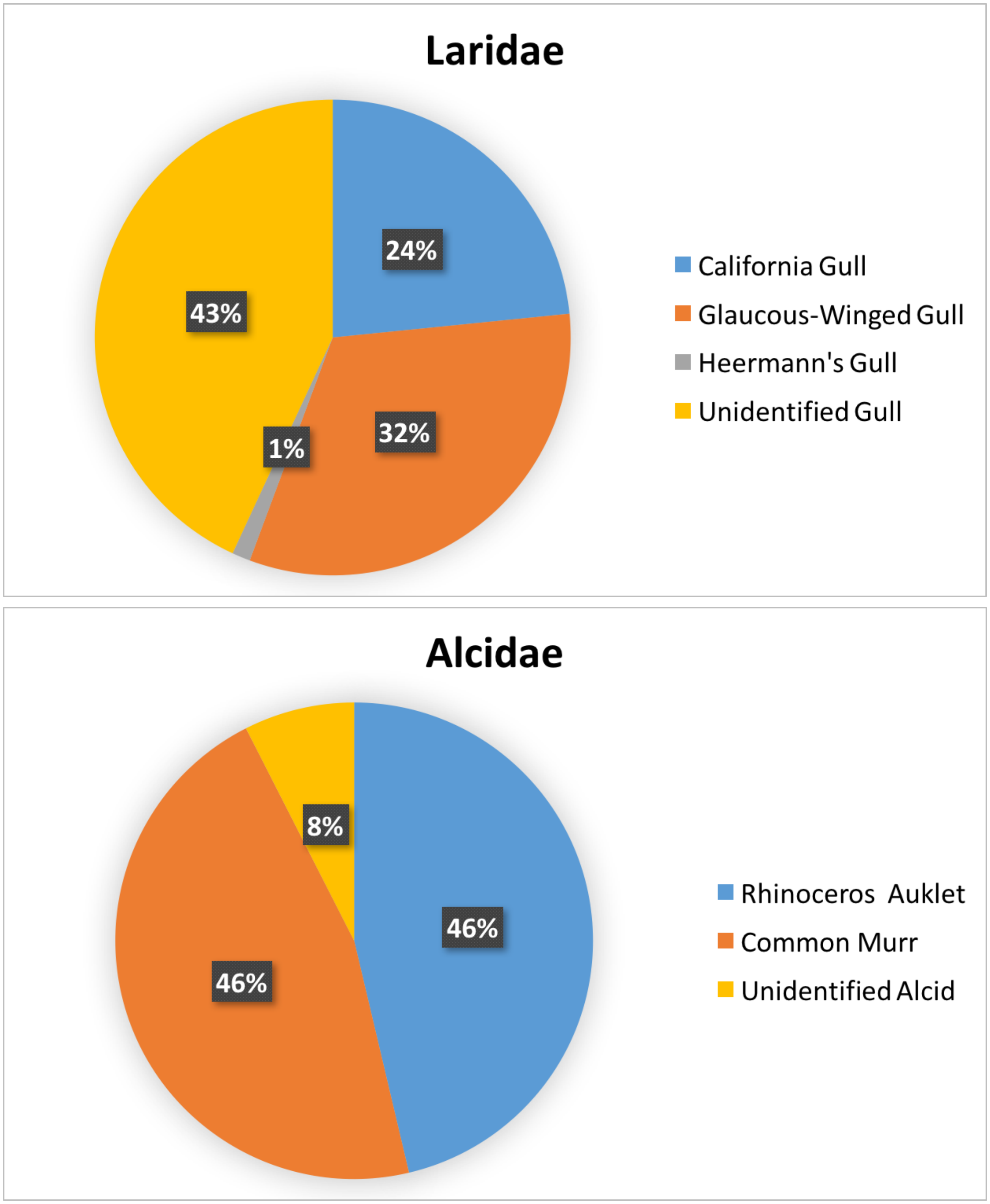

Figure 2. Species composition for Laridae (top panel) and Alcidae (bottom panel), the two main families observed along the Zone 3 survey transect in San Juan Channel between 7-10 August, 2017. Percentage of total observations.

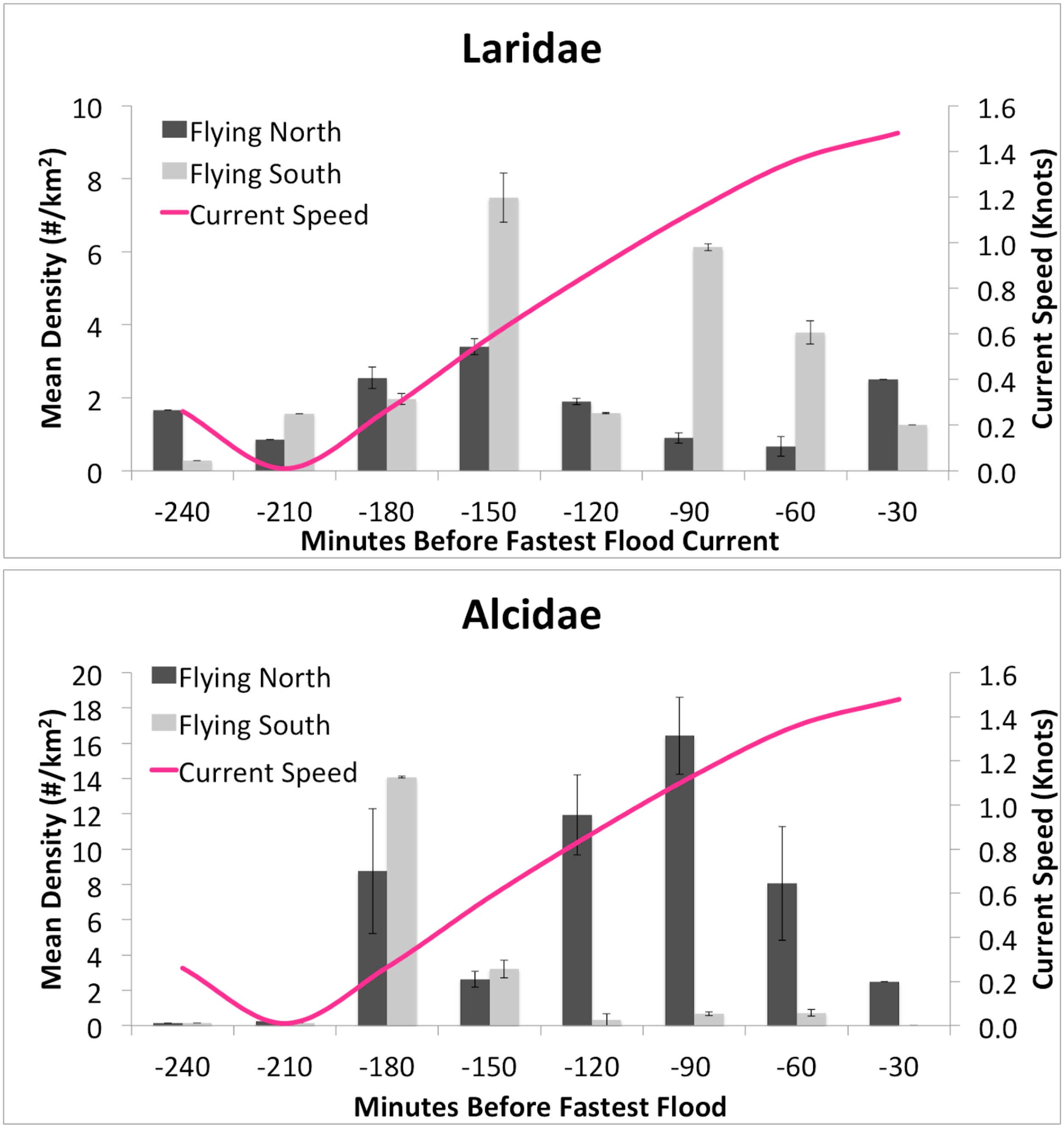

Figure 3. Mean density (±SE) of Laridae (top panel) and Alcidae (bottom panel) flying north vs. flying south during each half-hour increment before fastest flood. Means are based on all surveys conducted during 7-10 August 2017 along the Zone 3 survey transect in the San Juan Channel (for each category: n=1,1,3,4,3,2,1 respectively.)

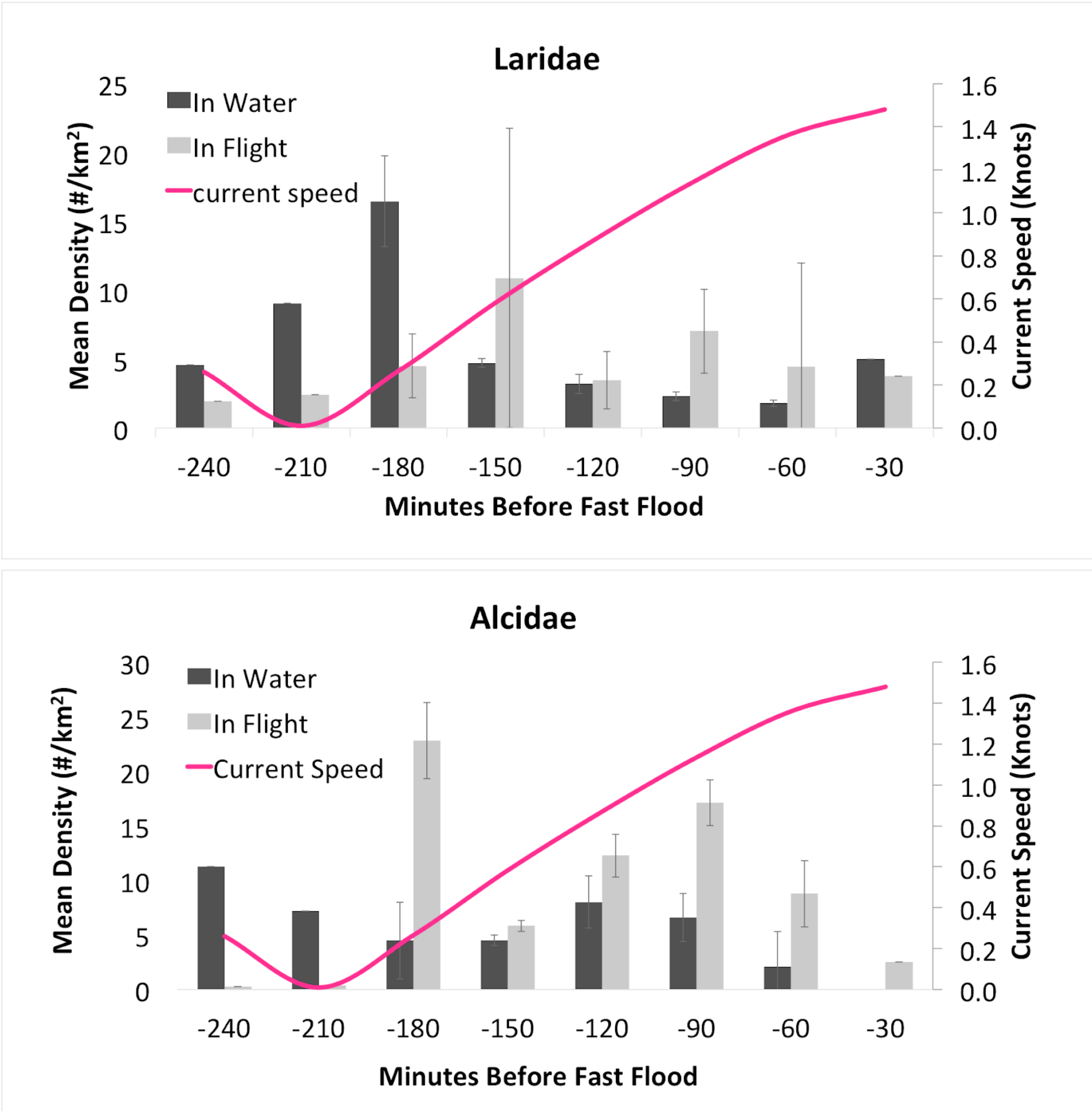

Figure 4. Mean density (±SE) of Laridae (top panel) and Alcidae (bottom panel) in water vs. flying during each half-hour increment before fastest flood current. Mean density is based on all surveys conducted during 7-10 August 2017 along the Zone 3 survey transect in the San Juan Channel (for each category: n=1,1,3,4,3,2,1 respectively).