Spatial and Temporal Diversity and Abundance of Seabirds in the San Juan Channel, Washington during the summers of 2012-2014

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Abstract:

Marine birds are an excellent indicator of the health of the Salish Sea, located in between British Columbia, Canada and Washington State, United States. There have been research projects conducted in the 1970's and 1990's that revealed a significant decrease in seabird populations in the area. However, these projects only focused on the reduction of seabird populations during the winters. Friday Harbor Laboratories is currently attempting to gather data for the summers. During the summer of 2014, four surveys were conducted in one transect of the San Juan Channel. Results revealed an overwhelming majority of alcids, mainly rhinoceros auklets. Most of the seabirds aggregated near the northern and southern ends of the transect surveyed. Comparing the data to the survey results from 2012 and 2013, 2012 had a much higher density of seabirds than in 2013 and 2014. The community composition of the seabirds in the region remained steady over the three years. There is no apparent trend for the aggregation of birds in certain zones within the transect. There is also no apparent pattern with the number of birds seen in relation to tides or current speed. However, there could be a possible correlation with global weather patterns, suggesting that large number of seabirds can be associated with La Niña conditions. There is not enough data in the three years of the surveys to confirm any observations.

Keywords: San Juan Channel, Salish Sea, seabirds, abundance, diversity, density

Introduction:

The Salish Sea is an inland sea shared by the coasts of Washington, USA and British Columbia, Canada (Gaydos and Pearson 2011). There are 172 bird and 37 mammal species that depend on this marine ecosystem for habitat and food. 72 of these

bird species and 29 of these mammal species are highly dependent on the marine ecosystem (Gaydos and Pearson 2011).

Marine birds and mammals can be used as indicators of ecosystem health because some of these species and communities respond to changes in environmental conditions. They use a variety of habitat types and are easily surveyed with well-established methods (Piatt and Sydeman 2007). Data from these species is often used to estimate the population numbers (Montevecchi and Myers 1995) and sizes (Davoren and Montevecchi 2003) of the fish they use as prey.

From 1978 to 1979, a comprehensive study of non-breeding seabirds in the Salish Sea, the Marine Ecosystems Analysis (MESA) Puget Sound Project, was conducted. This study surveyed birds using shore-based point counts, ferry and small boat transects, and aerial transects. In the winters of 1992 to 1999, the Puget Sound Ambient Monitoring Program (PSAMP) was undertaken. This survey repeated the aerial surveys of the MESA project. Analyses from these two sets of surveys indicated significant declines in many seabirds, including the western grebe (*Aechmophorus occidentalis*) and common murre (*Uria aalge*) (Bower 2009).

However, the MESA and PSAMP surveys only accounted for seabird reduction numbers in the winter. Over the past few years, the Ecology and Conservation of Marine Birds and Mammals class and the Pelagic Ecosystem Function in the San Juan Archipelago Research Apprenticeship at the University of Washington's Friday Harbor Laboratories has been conducting surveys in the San Juan Channel in the summer and autumn, respectively, to obtain population details in other seasons for the local area.

This paper will examine the abundance and diversity of marine birds in the San Juan Channel during the summers of 2012, 2013, and 2014.

Methods:

Study Area

We conducted four surveys in the San Juan Channel of the Salish Sea in Washington State. The surveys were conducted on the R/V Centennial, a 58-foot research vessel. One survey was a cruise through one transect of the San Juan Channel, traveling from north to south along six zones. The other survey was the return trip, traveling from south to north. (Fig. 1)

Surveys

Two surveys were conducted on two different days – 31 July 2014 and 15 August 2014. Observers stood on both sides of the bow of the ship with binoculars and looked for any marine bird or mammal within 200 meters of the ship. This totaled a 400-meter perpendicular distance from the bow of the ship. Observers called out the number and identity of the animal(s) seen. Two recorders, one for the starboard and one for the port side of the ship, wrote down this information as well as the time at which those animals were spotted. The date, direction headed, and zones were also recorded. The weather on the first survey day was sunny and clear. However, the second survey day was cloudier and cooler; there were some sunbreaks.

Analysis

The data from the surveys were transferred over into Microsoft Excel spreadsheets. The number in each species and family were totaled by year, survey, and zone. The area of each zone was calculated by multiplying the length of that zone with

the 400-meter width. Abundance was calculated as density, the number of individuals per square kilometer. Error bars of 95% confidence intervals were calculated as well. We graphed results from only the 2014 surveys in relation to community composition, most abundant species, and density and composition by zone. We compared those results with the 2012 and 2013 data, also on Microsoft Excel spreadsheets, to assess the trends over the three years as well as to make predictions for future years. The surveys conducted in 2012 and 2013 were at very similar days as the surveys conducted in 2014. Dates were no more than 3 days different each year. We looked into tidal states and global weather patterns for further analysis of trends.

Results:

Over the four surveys conducted during the summer of 2014, a total number of 2377 marine birds were counted, resulting in an average density of 69±36 birds/km^2. These sightings came from five avian families and 12 species.

The vast majority of birds surveyed were alcids (72%) and gulls (25%), with low numbers of ducks, cormorants and shorebirds (Fig. 2). Rhinoceros auklets (*Cerorhinca monocerata*) were overwhelmingly 93% of all alcids seen. The rest of the family consisted of 4% common murres, 1% marbled murrelets (*Brachyramphus marmoratus*), and 1% unidentified alcids (Fig. 3). The gull species composition was more balanced with glaucous-winged gulls (*Larus glaucescens*) accounting for 55%, California gulls (*Larus californicus*) for 22%, Heermann's gulls (*Larus heermanni*) for 10%, and unidentified gulls for 13% (Fig. 4).

Rhinoceros auklets, glaucous-winged gulls, California gulls, common murres and Heermann's gulls were the top five species observed in 2014. Rhinoceros auklets were

once again the most numerous with an average density of 46.3 individuals/km^2. Glaucous-winged gulls were a distant second at just under 10 individuals/km^2, with California gulls, common murres and Heermann's gulls all under 5 individuals/km^2. These were the only five bird species in the 2014 surveys with a density over 1 individual/km^2 (Fig. 5).

Zone six had the largest density of total birds seen with over 100 individuals/km^2. Zone three was the least dense with under 40 individuals/km^2 (Fig. 6) Overall, the marine birds surveyed seemed to aggregate at the northern and southern ends of the transect. Zones one, two, five and six had the higher densities than zones three and four. All six zones were comprised of similar ratios of bird families (Fig. 7).

Discussion:

The number of seabirds surveyed in 2012, 107 individuals/km^2, was much larger than in 2013 and 2014, at 56 and 69 individuals/km^2, respectively (Fig. 8). However, the community composition remained fairly constant over the three years with the ratios of bird densities within families being fairly similar (Fig. 9).

The top five species observed in 2014 were also the same top five species seen in 2012 and 2013, with only slight variations in the order. Rhinoceros auklets were the most abundant birds seen every year. One anomaly is the large number of common murres seen in 2012 compared to subsequent years (Fig. 10).

The density of total birds by zone varied greatly from year to year. Zone three had the highest bird density in 2012, but the lowest in 2014. In 2012, bird density increased from zones one to three, dropped dramatically in zone 4, then increased again to zone 6. Bird densities in 2013 slowly increased in a southerly direction from zone one to zone

six. As previously mentioned, birds in 2014 seemed to aggregate in the northern (zones one and two) and southern ends (zones five and six) of the transect (Fig. 11).

No apparent correlation with bird density and tides was observed. The large numbers seen in 2012 all corresponded with flooding and end of ebb to flooding tides (792-1053 birds seen). High numbers were also seen in the first 2013 surveys with flooding tides (783-633 birds seen). However, high numbers were seen again in the first 2014 surveys (787-938) on an ebbing tide (Table 1).

Similarly, no apparent correlation was seen with bird density and current speed. High bird numbers were seen (>600) in currents from 0.5-1.8 knots. Low bird numbers were seen (<400) in currents from 0.3-1.03 knots. Both high and low numbers of birds were seen in currents ranging from 0.5-1.0 knots (Table 1). Similarly, no pattern between tides and bird abundance was observed in the fall surveys in San Juan Channel by the Pelagic Ecosystem Function Apprenticeship (Standish 2013).

However, global weather patterns may provide an answer for the greater abundance of birds seen in 2012 in the form of the El Niño Southern Oscillation. The Pelagic Ecosystem Function Apprenticeship found greater numbers of seabirds in years with La Niña conditions (Standish 2013). A La Niña episode occurred in the winter of 2011/2012 (National Oceanic and Atmospheric Administration 2014). The lasting effects of this weather event could have resulted in a large number of migratory birds, such as the common murre, coming to the Salish Sea in the subsequent summer.

Although we found few patterns in the distribution of seabirds across zones, strong correlations may yet be present. Our analysis focused on families of birds. Analyzing data at a species level may reveal trends we did not uncover.

We believe that three years of summer data is not enough to identify strong trends for seabird populations in the San Juan Channel, especially given the highly variable seabird numbers that have been recorded. Friday Harbor Laboratories will continue to conduct surveys to attempt to reveal these population dynamics.

Acknowledgements:

A very special thank you to the Ecology and Conservation of Marine Birds and Mammals 2014 class for conducting the surveys on board the R/V Centennial. An additional thanks to our excellent professors, Breck Tyler and Eric Anderson, as well as to our teaching assistant, Joshua Cummings, for their guidance and support throughout our research. We would also like to thank the University of Washington and Friday Harbor Laboratories for the use of their facilities and for the extraordinary opportunity to learn about marine ecology in a wonderful field setting.

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Tables and Figures:

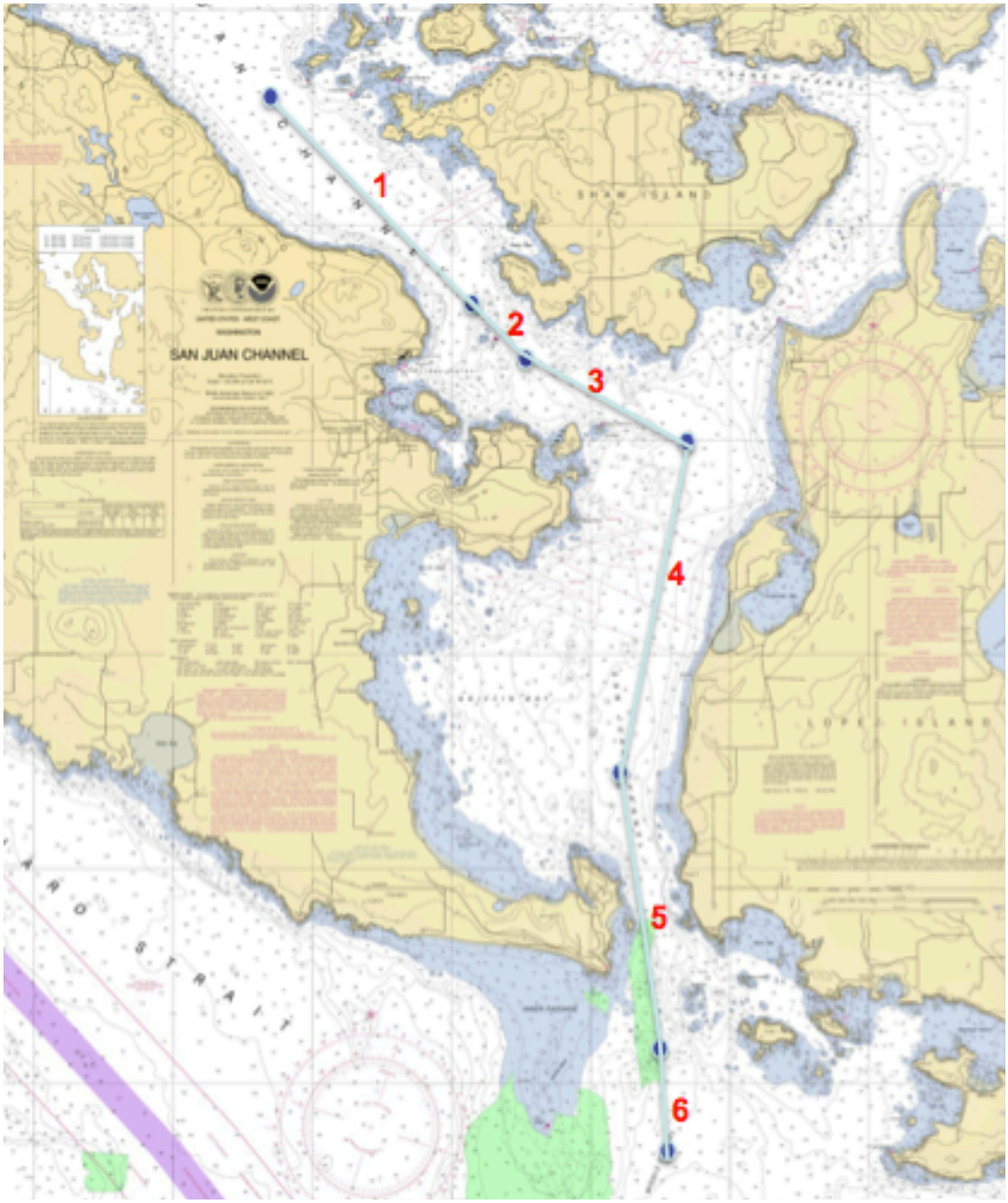

Figure 1: Map of survey area. Lines indicate cruise path. One transect include zones 1-6.

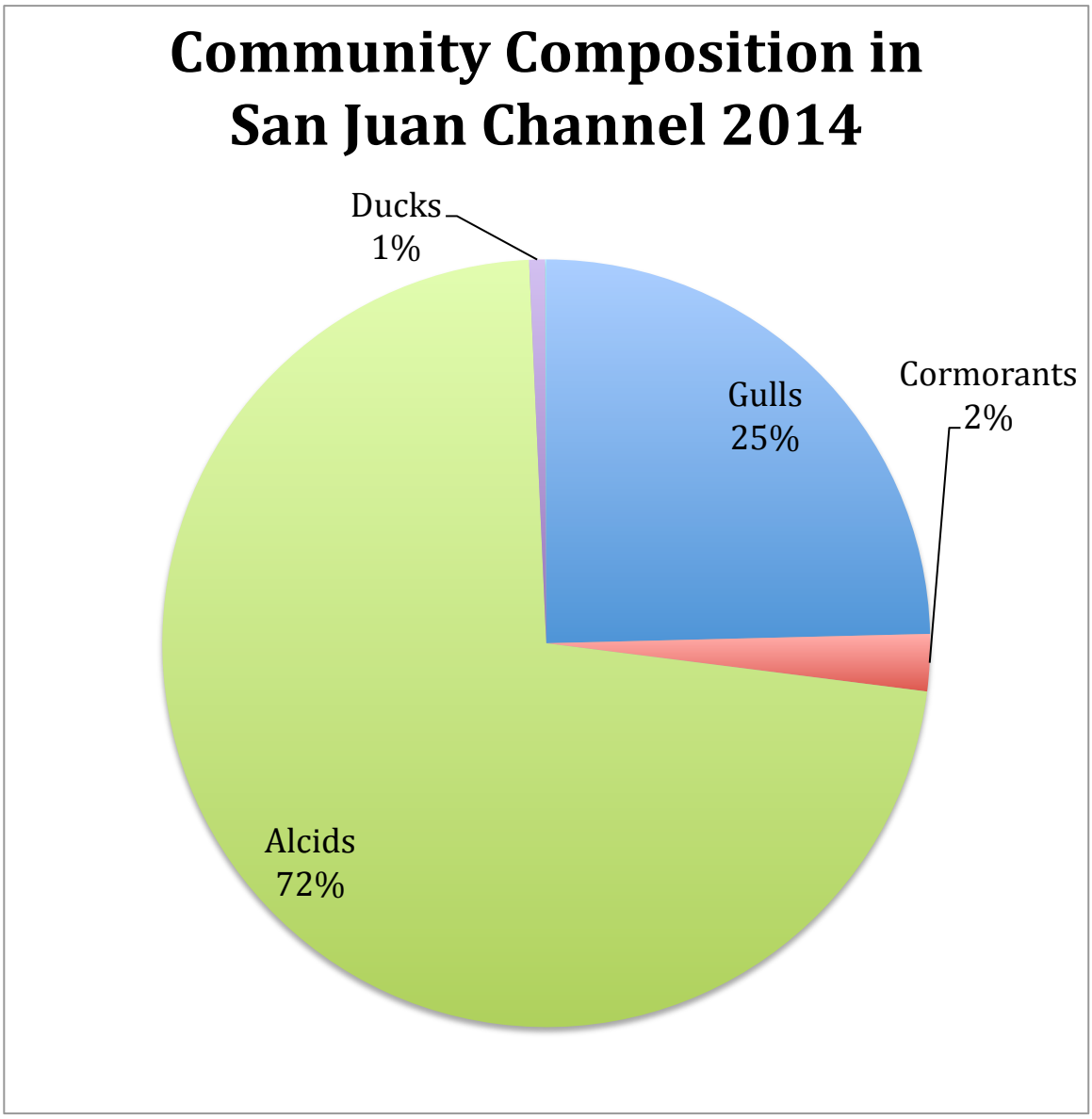

Figure 2: Pie chart of the Community Composition in San Juan Channel 2014. Numbers give the percentage that each family comprised of all birds identified during the 2014 surveys. Data collected on 31 July 2014 and 15 August 2014 in the San Juan Channel.

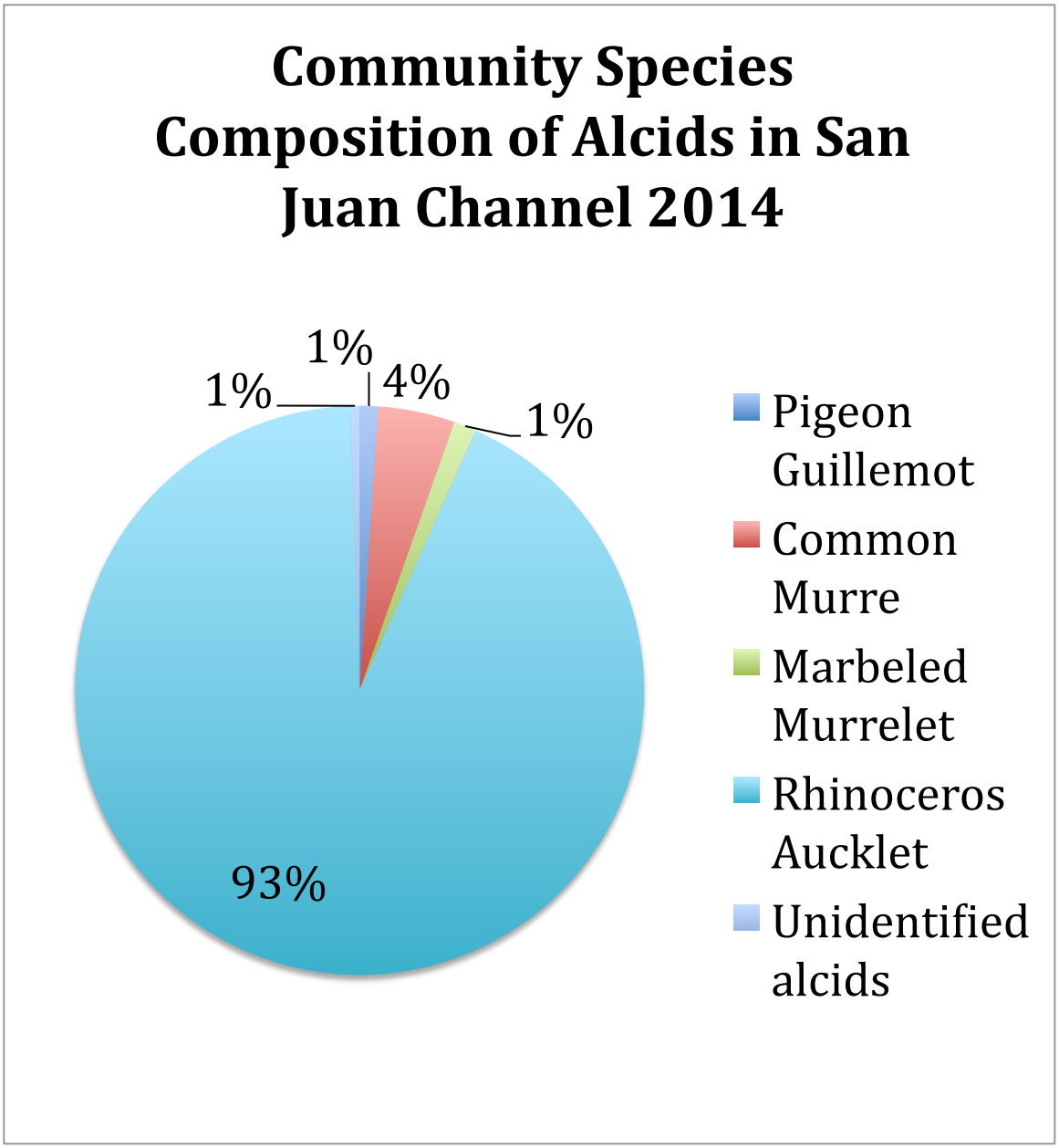

Figure 3: Pie chart of the Community Species Composition of Alcids in San Juan Channel 2014. Numbers give the percentage of each species comprised of all birds in the Alcidae families identified during the 2014 surveys. Data collected on 31 July 2014 and 15 August 2014 in the San Juan Channel.

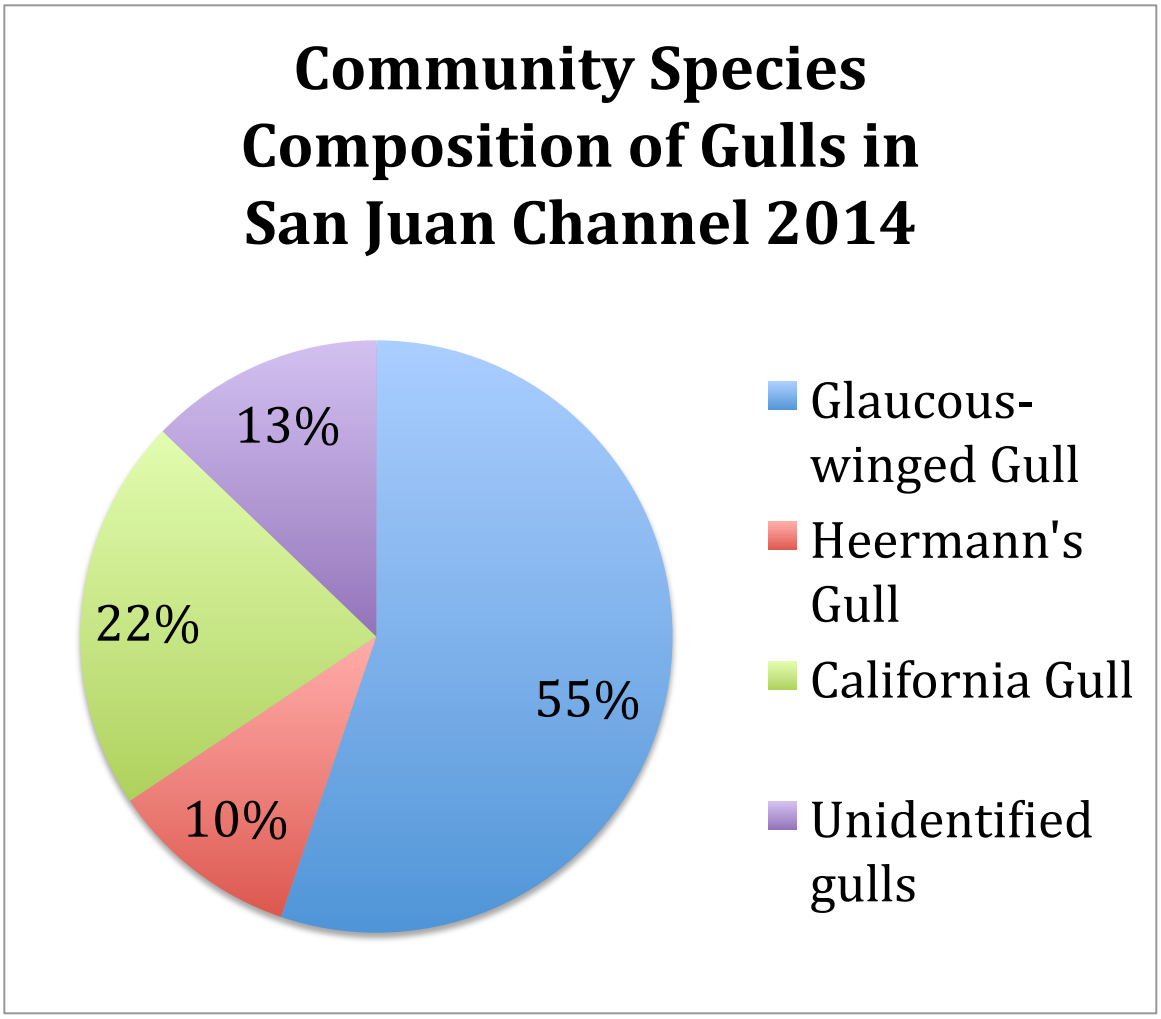

Figure 4: Pie chart of the Community Species Composition of Gulls in San Juan Channel 2014. Numbers give the percentage of each species comprised of all birds in the Laridae families identified during the 2014 surveys. Data collected on 31 July 2014 and 15 August 2014 in the San Juan Channel.

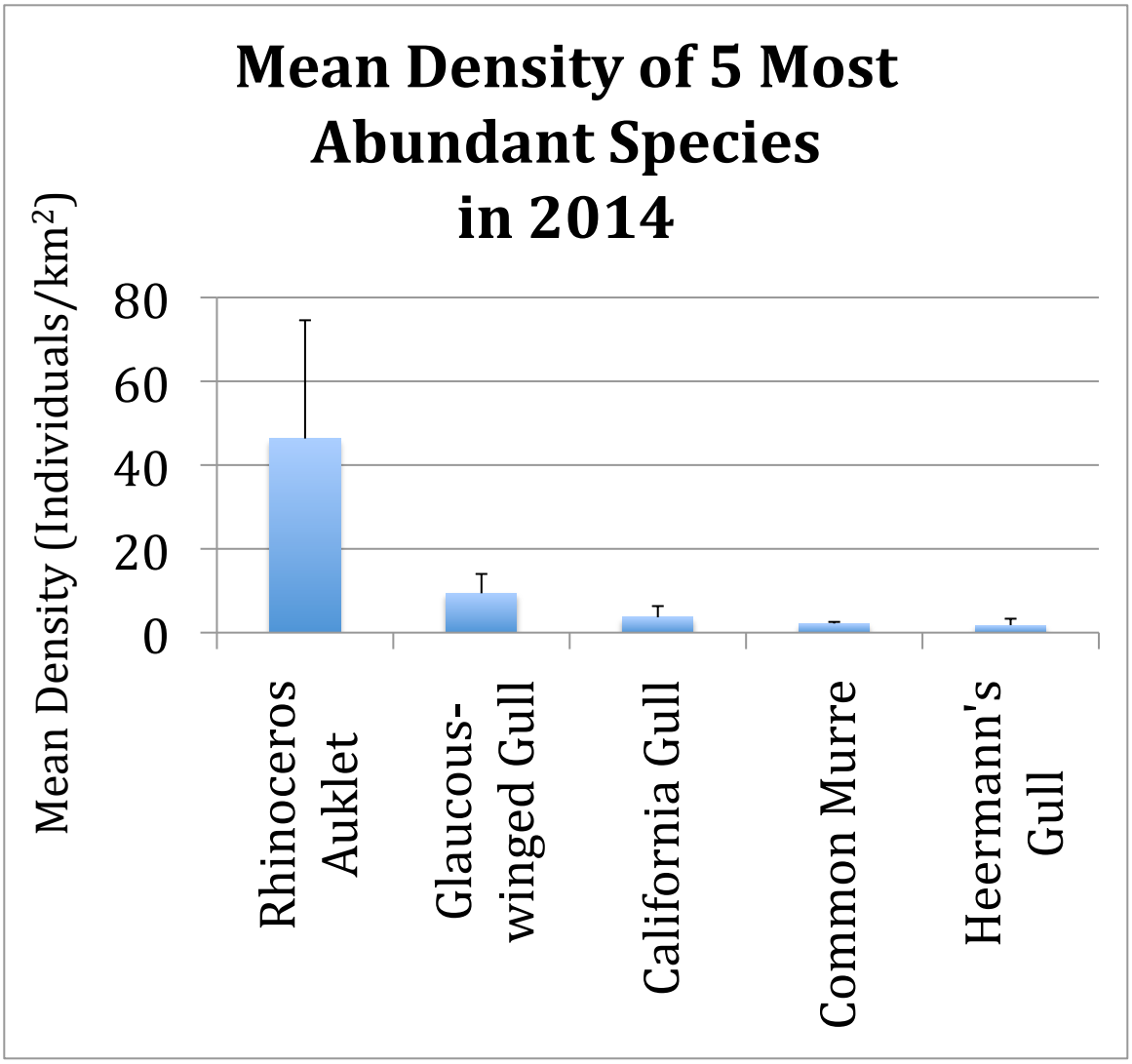

Figure 5: Bar graph of the Mean Density of the 5 Most Abundant Species in 2014. Bars are plotted as mean density (individuals/km^2) for each species. The lines represent 95% confidence intervals. Data collected on 31 July 2014 and 15 August 2014 in the San Juan Channel.

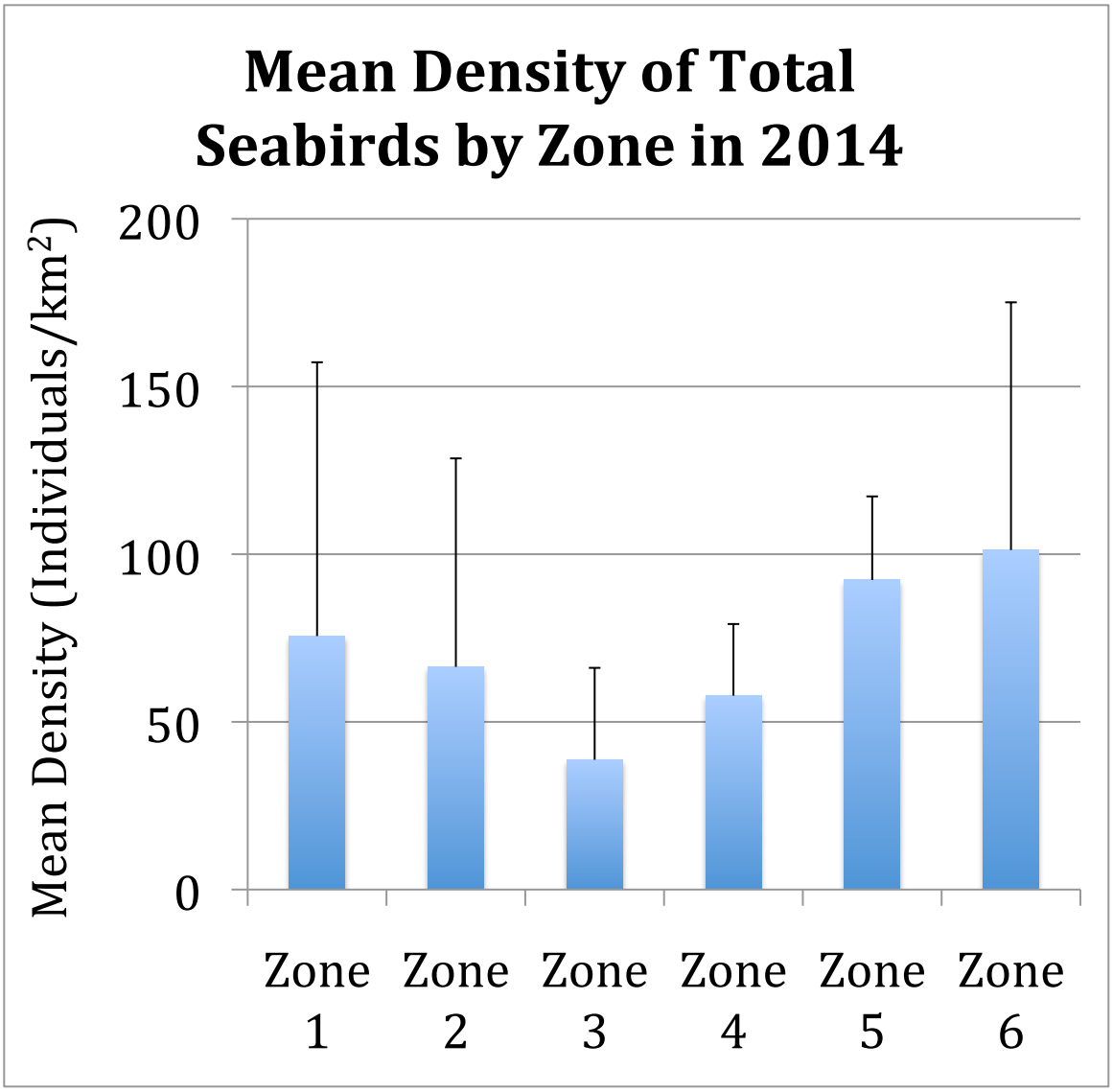

Figure 6: Bar graph of Mean Density of Total Seabirds by Zone in 2014. Bars are plotted as mean density (individuals/km^2) for each zone. The lines represent 95% confidence intervals. Data collected on 31 July 2014 and 15 August 2014 in the San Juan Channel.

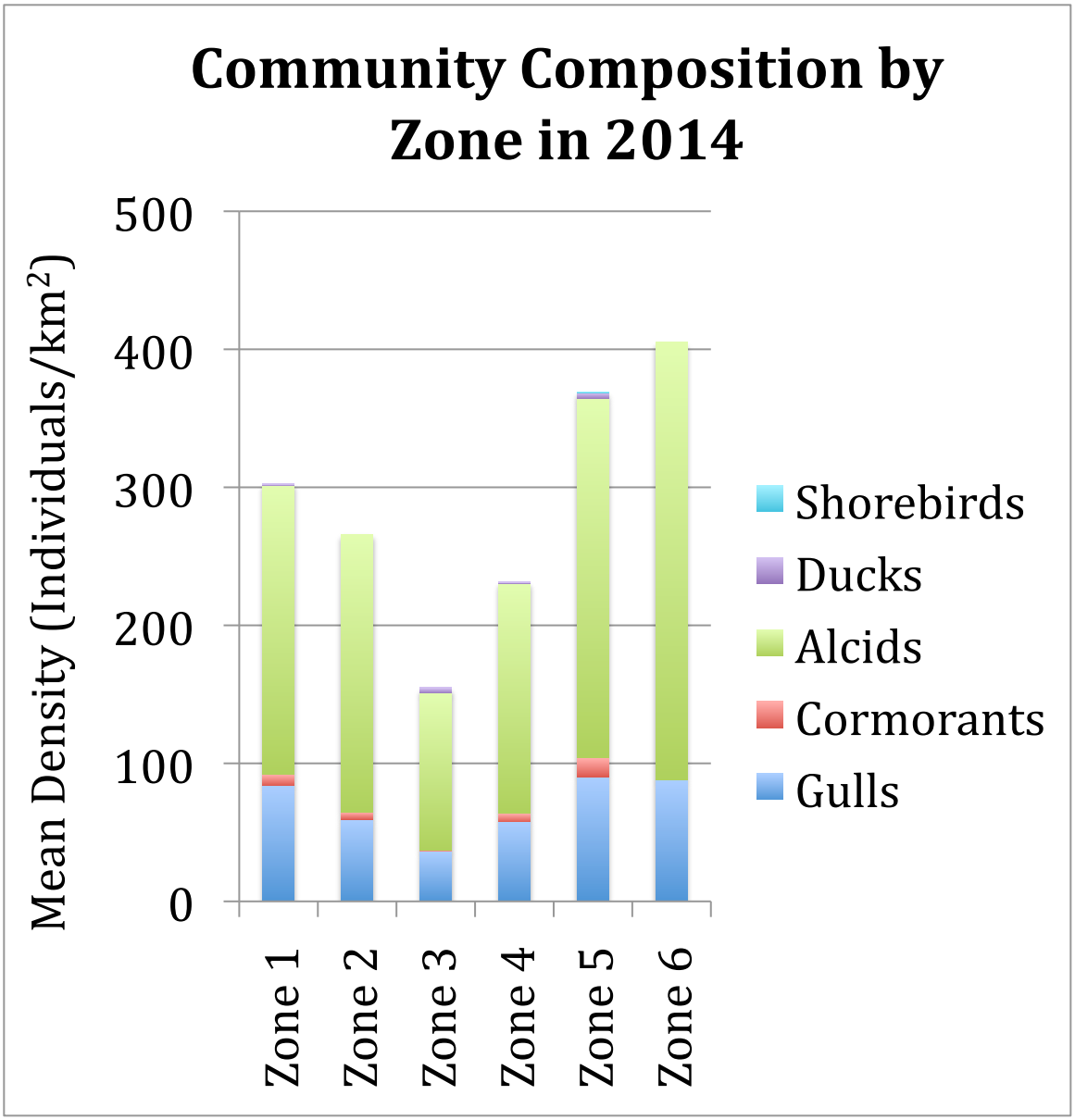

Figure 7: Bar graph of Community Composition by Zone in 2014. Bars are plotted as mean density (individuals/km^2) for each zone. Each bar contains the percentage of each family comprised of all birds identified in that zone. Data collected on 31 July 2014 and 15 August 2014 in the San Juan Channel.

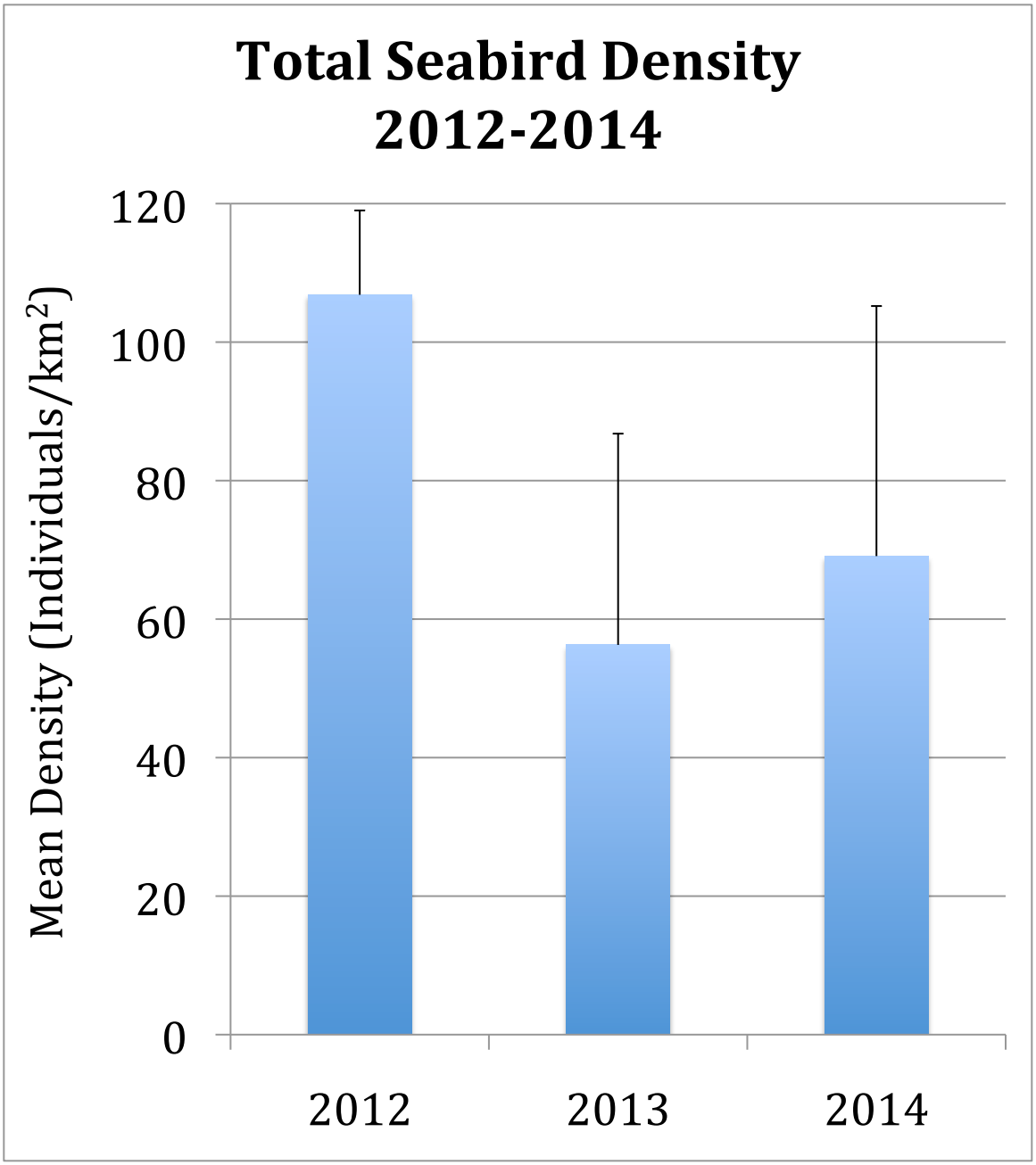

Figure 8: Bar graph of the Total Seabird Density 2012-2014. Bars are plotted as mean density (individuals/km^2) for each year. The lines represent 95% confidence intervals. Data collected during the summers of 2012, 2013, and 2014 in the San Juan Channel.

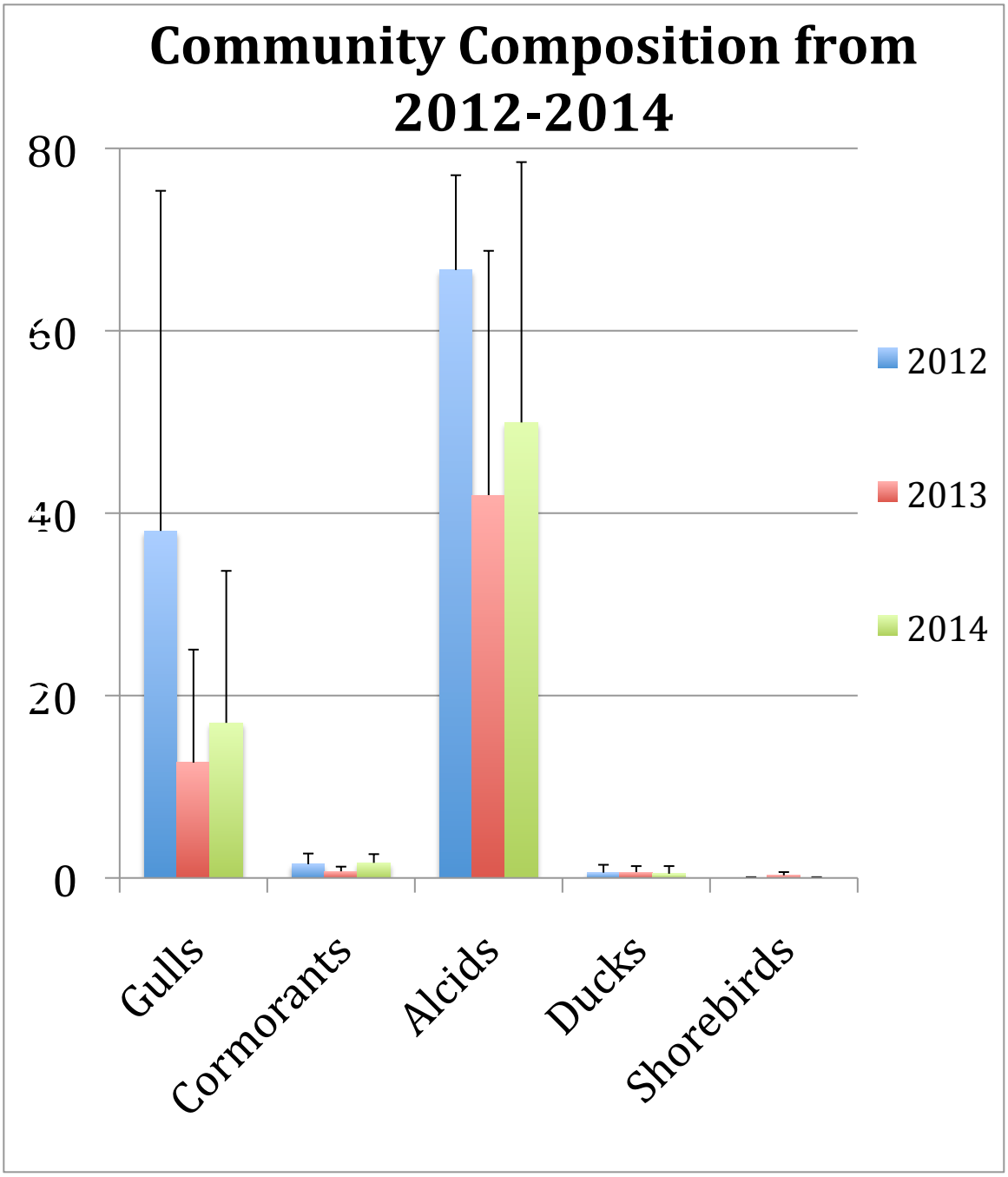

Figure 9: Bar graph of the Community Composition from 2012-2014. Bars are plotted as mean density (individuals/km^2) for families identified per year. The lines represent 95% confidence intervals. Data collected during the summers of 2012, 2013, and 2014 in the San Juan Channel.

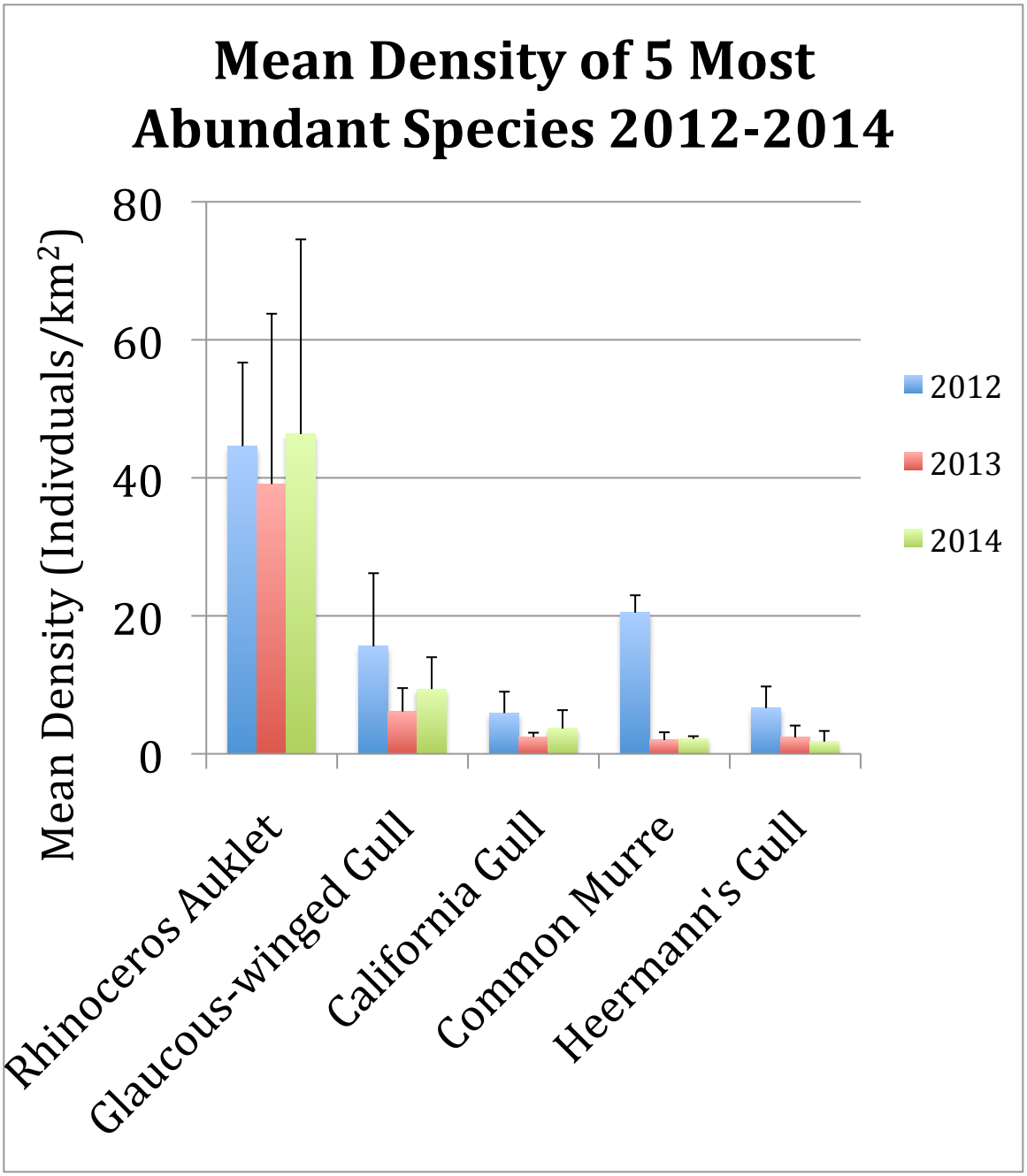

Figure 10: Bar graph of the Mean Density of the 5 Most Abundant Species in 2014. Bars are plotted as mean density (individuals/km^2) for each species identified per year. The lines represent 95% confidence intervals. Data collected during the summers of 2012, 2013, and 2014 in the San Juan Channel.

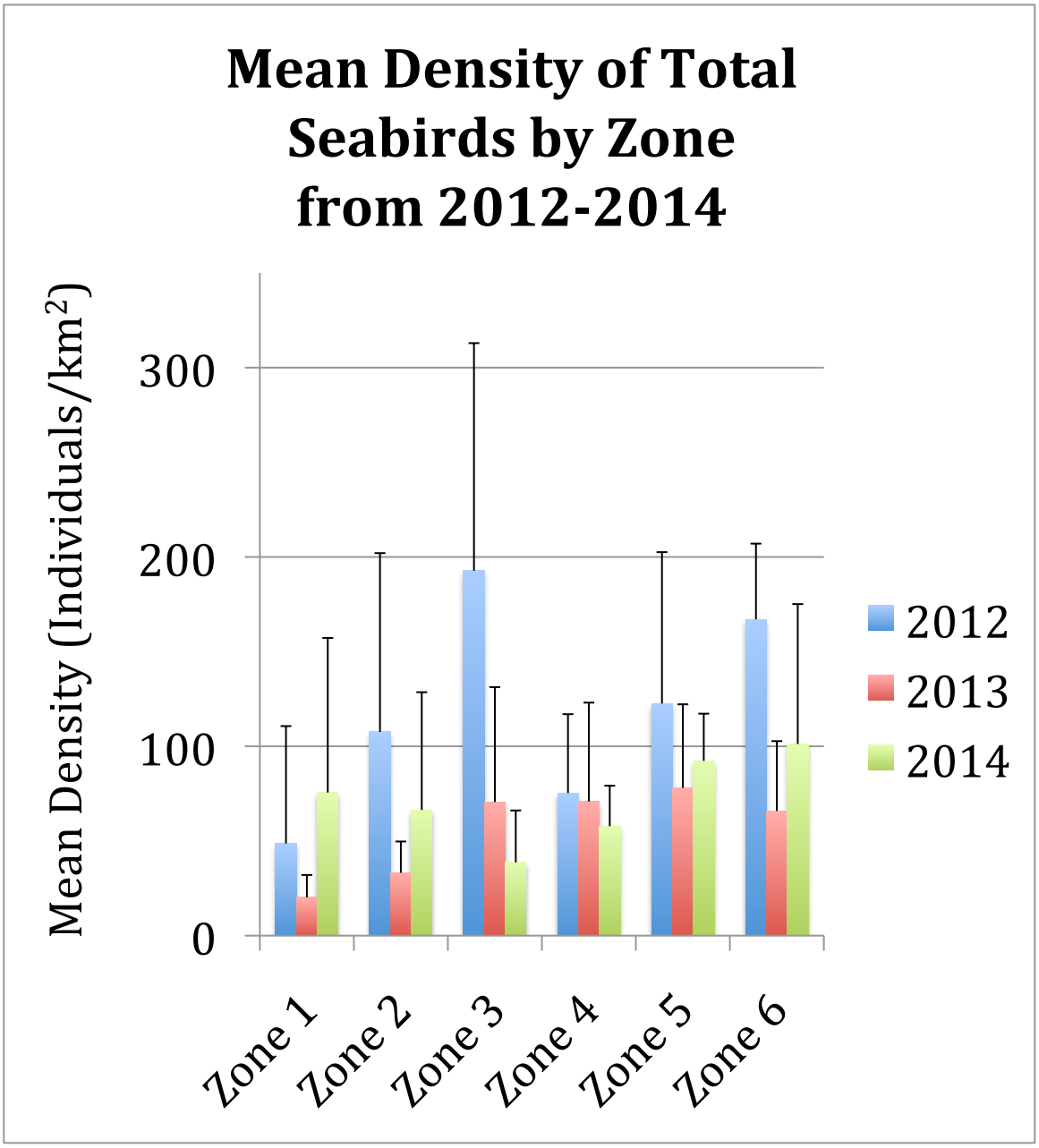

Figure 11: Bar graph of the Mean Density of Total Seabirds by Zone from 2012-2014. Bars are plotted as mean density (individuals/km^2) for each zone per year. The lines represent 95% confidence intervals. Data collected during the summers of 2012, 2013, and 2014 in the San Juan Channel.

Date	Tide State	Current Speed (knots)	Total Birds Seen
Aug. 1, 2012	Ebb–flood	-0.5→+1	1053
Aug. 1, 2012	Flood	+1.2→+1.8	906
Aug. 15, 2012	Ebb–flood	-0.33→+0.8	924
Aug. 15, 2012	Flood	+1.1→+1.44	792
Aug, 1, 2013	Flood	+0.5→+1.12	783
Aug. 1, 2013	Flood	+1.09→+0.83	633
Aug. 13, 2013	Ebb	-0.33→-0.56	299
Aug. 13, 2013	Ebb	-0.71→-0.30	221
July 31, 2014	Ebb	-0.68→-0.98	787
July 31, 2014	Ebb	-1.04→-0.7	938
Aug. 15, 2014	Ebb	-0.84→-1.03	294
Aug. 15, 2014	Ebb	-1.07→-0.8	358

Table 1: Table of the tide state, current speed in knots, and total birds seen on the days the surveys were conducted in 2012, 2013, and 2014 in the San Juan Channel.