Changes in Marine Bird Population Composition and Abundances Over Spatial and Temporal Scales in the San Juan islands.

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Marine Birds and Mammals 2011

Summer 2011

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Abstract:

The San Juan Archipelago has a population of 172 different bird species that utilizes the surrounding waters at one point or another during the year that. Of these bird species 149 of them are either heavily reliant or moderately reliant on the marine habitat. This population of birds' composition and abundance can differ on a spatial scale within the archipelago due to its varied environmental features. The data suggest largest factor that affects the variance of overall abundance and spatial distribution is most likely the direction of tidal flow, while population composition is most likely greatly affected by the seasonal availability of bird species and their relative population size.

Introduction:

Located between Washington State, on the eastern side, and Canada, on the western side, the San Juan Archipelago is a fertile ecosystem that is home to a wide variety of marine birds and mammals, ranging from the large and charismatic killer whale to the small, understudied, and endangered marbled murrelet. .

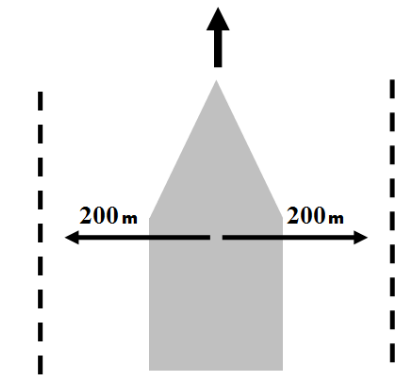
The San Juan Archipelago has a population of 172 different bird species that utilizes the surrounding waters at one point or another during the year that. Of these bird species 149 of them are either heavily reliant or moderately reliant on the marine habitat. (Gaydos 2011) This population of birds can change its species composition and abundance drastically over a seasonal scale, which was observed by Gaydos (2011) or over the shorter time scale of within day seen by Zamon (2003). Also population composition and abundance can differ on a spatial scale within the archipelago due to its varied environments available.

The San Juan Archipelago has many unique oceanographic and bathymetric features that are found in few other places around the world. For example cattle pass has a very complex bathymetric structure which interacts with the current in a way that congregates food in a small area. (Wang 2008) In addition to its bathymetric features the geographic set up of the archipelago causes currents to create strong tidal rips which circulate large amounts of water through the archipelago. These oceanographic and bathymetric features of the San Juan Archipelago, makes it a hot spot for resident and migratory populations of birds and mammals. With this high concentration of bird and mammal species the San Juan Archipelago is a prime destination for studying marine birds and mammals.

Specifically I focused this study on the channel that runs between San Juan Island and Lopez and Shaw Islands. (refer to figure 2) The overall objective of this study was to assess population composition and abundance of marine birds across multiple time scales and spatial scales. Specifically I present data on the abundance and distribution of marine bird species in summer 2011. I also compare my findings with data and findings from other studies in the same area. Finally I discuss the possible underlying factors leading to these trends.

Methods:

Site:



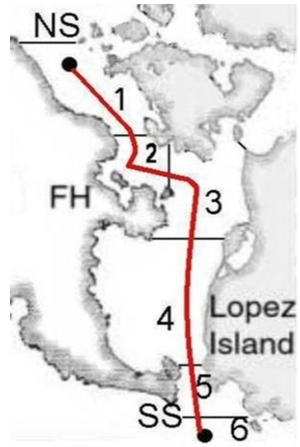


Figure 1 & 2

Figue illustrating the width of the transect zone and the map of the transect area.

(Hainey 2008)(Palmer 2010)

The data collection occurred between August 3rd and 18th within the San Juan channel. (refer to figure 2) Even though data was only collected from the 3rd to the 18th data from previous seasons and years were used in the analysis. The transect line begins at the north station (48° 35.00'N, 123°02.50'W) and continues south down the channel until it hit the south station (48° 25.20'N, 122°56.60'W). (refer to figure 2) This transect is divided up in to six distinct zones that represent unique habitats that are available for use by marine birds. To determine the shift in the zones on the water, the onboard GPS of the R/V Centennial was used.

Data Collection:

The data was collected using the strip transect method of surveying. According to Burnham et. al (1985) a strip transect is any long narrow plots or quadrants where elementary data sampling is taken. The data was taken by observers on the bow of the R/V Centennial.

Each side of the bow was manned by groups ranging in number from three to five people. With the use of binoculars the observers would record birds and mammals within 200 meter of their side of the boat resulting in a total transect width of 400 meters. (refer to figure 1) Although mammal data was taken for the sake of the long term study no mammal data was used in this specific study. Birds were only recorded under certain conditions: 1. Birds needed to be within 200 m of the bow of the boat. 2. Birds needed to be either on the water or flying over the water. 3. Birds that have been counted by one side of the boat should not be recorded by the other side to avoid double counting. When birds met these criteria their species and abundance were recorded. When a bird's species was unable to be ascertained due to diving, flying, etc., the bird was recorded under its representative family as "unidentified". While bird and species counts were taking place the time at which the birds were observed was also recorded. With time recordings tidal and weather conditions can be linked back to the survey. During the season of summer 2011 a total of three surveys were done, each including 2 transect, one going southbound and another going northbound. These transects were taken on the dates of 8/3/11, 8/10/11, 8/16/11.

Data Analysis:

Microsoft Excel was used for the data analysis which included; calculating the density of birds per km^2, average bird densities per seasons, and total counts of birds. The Program Mr.Tides 3.0 was used to find tidal predictions that corresponded to the times transects were taken.

Results:

Within Day Variation:

The first transect trip done on 8/3/11 showed little variation in overall # of birds recorded during the morning trip and the number recorded in the afternoon trip. (refer to figure 3) The total number of birds sighted in the morning and afternoon were 768 and 797 respectively. While there was little difference between the abundance of birds overall, the population composition had significant variance in the form of 14.4 California gulls/Km^2 recorded in the afternoon while 0 were recorded in the morning.

The second transect trip done on 8/10/11 had very high variation in overall # of birds between the morning and afternoon transects. (refer to figure 4) The number of birds recorded during the morning trip totaled 3032 while the afternoon trip had only 1707 birds recorded. As for population composition variance the morning trip had higher densities of Rhino Auklet (very large difference 175 individual/Km^2 or 100%), Common Murres, and Phalaropes, while the afternoon trip had higher densities of gulls overall. This transect was conducted on a flood tide while the other two were conducted on ebb tides. (refer to figures 14-16)

The third and final transect trip carried out on 8/16/11 had relatively small variation in overall abundance of birds of approximately 10-15% difference between the morning and afternoon trips. (refer to figure 5) The total number of birds recorded was 715 in the morning and 805 in the afternoon. Population composition variance wise there was a significantly large difference between morning numbers of phalaropes and afternoon numbers on the order of a 25 individuals per Km^2 more in the afternoon. There was also smaller variance in Glaucous Winged Gulls, California Gulls, and Rhino auklets, with higher densities in the morning and lower densities in the afternoon. This is the only transect where Rhinoceros Auklets were replaced by another species as most abundant.

Day to Day Variation/ Within Season:

Overall abundance in birds were relatively stable between trip one and trip three, with both trips recording overall abundance in the 1500-1600 range.(refer to figure 6) But the overall number of birds recorded on the second trip dwarfs that seen in the first and second. The second trip recorded approximately 4700 birds which is almost three times greater than that recorded in either the first or third trip. This overall greater number of birds transfers over to the density data where trip two had the highest or tied for the highest density of all birds except one, phalaropes. For the differences in population composition the top five species in each trip were; Trip1: Rhino Auklet, Glaucous Winged Gull, Common Murre, California Gull, and Heermann's Gull. Trip 2: Rhino Auklet, Common Murre, Glaucous Winged Gull, Heermans Gull, and Red Necked Phalaropes. Trip 3: Red Necked Phalaropes, Rhino Auklet, Glaucous Winged Gull, California Gull, Common Murre.

Seasonal Variation:

Birds were most abundant during the summertime where there was an average of 2254 birds per transect. Summer was followed by Spring which had an average of 1210 birds per transect followed by Fall with 800 and Winter with 230. (refer to figure 9) For population variance the top three species of each season are; Fall: Ducks, Glaucous Winged Gull, and Mew Gull. Winter: Common Murre, Glaucous Winged Gulls, and Mew Gull. Spring: Rhino Auklet, Common Murre, and Glaucous Winged Gull. Summer: Rhino Auklet, Phalaropes, and Glaucous Winged Gulls. Some important trends to notice is that Rhino Auklets are abundant during the spring and summer and make up the biggest part of the population during these times. But during the winter and the fall Rhino Auklets are almost completely absents. (refer to figure 8)

The Glaucous Winged Gull which ranks in the top three most abundant species in every season is prevalent in fall, summer, and spring but the population seems to drop in number during the winter. Another obvious trend is the seasonal abundance of ducks, ducks are the most abundant family during the fall and spring but are absent in the winter and the summer. Similar trends are also exhibited in many of the gull species and the marbled murrelet, although on a smaller scale.

Spatial Variance:

Trip one and trip two both had the highest densities of birds (mainly alcids, gulls and Phalaropes (trip 3)) in zone 6 followed by zone 5. (refer to figure 11&13) During the time that these transects were taken the tide was ebbing, which means that it was flowing out of the channel. On the other hand trip two had the highest densities of birds in transect zone 4 and then 5 for alcids and the reverse order for gulls.(refer to figure 12) This transect was taken during a flood tide, this means that water was flowing into the channel. In the combined graph (figure 10) it shows that zone six has the highest density of birds for all major groups of birds.

Disscussion:

Within Day and Within Season Variation:

The within day variance of trip one and trip 3 were relatively low the only factor that made a difference in the overall abundance in trip 3 was the phalaropes. According to Zamon 2003 tidal rips and jets can effect plankton distributions, abundance and incoming rates of plankton. In addition to the effects on plankton Zamon 2003 states that the accumulation of plankton causes congregations of planktivorous fish. With the accumulation of fish the likely conclusion would be that piscivorous birds would be attracted to the higher density of prey. (Vleistra 2005)

Trips 1 and 3 were both carried out during an ebb tide, this means that the tide was flowing out of the channel. This direction of flow would mean that the plankton would be pushed out of the channel and dispersed over a much wider area of the Salish Sea. By dispersing the plankton, the tide direction effectively disperses the planktivorous fish populations. This relatively low, but even density of prey over a large area gives birds no energetic incentive to actively seek prey since it is equally abundant everywhere. As a result the birds adopt a "sit and wait" approach to foraging which in turn means that they do not congregate. (Vleistra 2005) This is the reasoning behind why I think there was relatively low variance in overall abundance and densities due to the fact birds will be relatively evenly distributed and spread out over a large area. Also without high prey densities no new birds will be attracted into the transect area meaning relatively low change between morning and afternoon transects.

The large difference in phalarope densities was most likely either new individuals migrating in, since the archipelago is the home range for the phalaropes in the summer, or individual from off transect move to or through our transect zone. (Sibley 2003) The variance in trip one in the gull abundance most likely was also due to movement to or through the transect zone while migrating from the coast which is their winter habitat to inland which is their summer habitat. (Sibley 2003)

Trip 2 was conducted during a flood tide and showed great within day variation in general abundance and densities. In a flood tide event the water is moving into the channel so the plankton and the fish that prey on the plankton are concentrated at the mouth of the channel. This higher density of prey in a small area effectively attracts many different species of birds to feed. This large number of birds in a relatively small area makes density numbers shoot up drastically as seen in the data. (figure 5) The difference between the morning overall abundance counts and that of the afternoon was most likely due to the fact that the tidal shift started and grew in strength reaching its maximum force in the morning and then slowly died down into the afternoon. This seems to agree with Vliestra 2005 statement that when marine birds show "concordance" with their prey it is "temporally intermittent".

Overall the population composition for the second trip was similar to the first and third trip in individual density for most birds. The bulk of the difference in general abundance came from the huge increase in the number of Rhinoceros Auklets. Rhinoceros Auklets are diving piscivores so they are well suited for catching fish that have accumulated in the channel, meaning that they can reap the most benefits from the flow tide. The disproportional density between ebb and flow tide show that the Rhinoceros Auklets prefer flow tide events. This seems to agree with the findings of Wang 2008 that, "Some species selected for different current directions with significantly greater abundances."

The difference between the overall bird abundance population composition between first and third trip and the second trip is most likely due to the difference in tidal direction. Both trips 1 and 3 were done on an ebbing tide while trip 3 was done on a flooding tide. The reasoning behind these differences is explained above.

Seasonal Variation:

The overall abundance of birds over season data seems to conflict with some other studies of the area. According to Gaydos 2011 highest bird abundances in the Salish Sea should occur in the fall and the spring followed by winter and then summer. The only explanation I can offer is that the environment of the San Juan Archipelago is different from the general Salish Sea environment, resulting in the San Juan Archipelago having it own unique pattern of bird abundances. The overall difference in the abundance between seasons could be attributed to differential seasonal productivity, breeding seasons, or migratory patterns.

The difference in the population composition across seasons is most likely due to species of birds migrating in and out of the San Juan Archipelago. For example the Rhinoceros Auklet should be present in summer, fall, spring, and absent in the winter. (Gaydos 2011) For the most part this agrees with the data showing high abundance of Rhinoceros Auklets in every season that they should be present, except for the fall where very low densities of Rhinoceros Auklets were recorded. This low fall recordings could be due to the Rhinoceros Auklets leaving early for their wintering grounds. Another species the Glaucous Winged Gull is prevalent in all seasons, and is in the top three species for density in all four seasons. Although there was a drop off in Glaucous Winged Gull density in winter it could just be due to the fact that the winter data is represented by only one transect. This one transect could have been carried out on a day with unfavorable conditions for gulls resulting in a reduced number recorded.

The data suggest that there may be a weak correlation between seasonal availability and relative abundance in the bird population of the archipelago. This may not be true for all species of birds due to declines in their overall populations over the years. According to Bower 2009, 13 of the 20 bird species studied in the Salish Sea showed significant decreases in population size from 1975-2007. This could be the reason why some birds are not strongly represented in the population even when they are seasonally available.

<u>Spatial Variance:</u>

The trips 1 and 2 both had the highest bird densities in zone 6 and both were taken on an ebb tide. The ebb tide effectively moves the plankton out of the channel and disperses it over the larger open waters. The birds most likely pursued this movement of prey out towards the more open waters. With zone six being the most outer zone, reasonably it should have the highest density of birds during an ebb tide. Conversely trip two had the highest densities in zone 4 and 5, and was taken on a flood tide. The flood tide delivers and concentrates prey within the channel, which the birds pick up on and congregate within the channel. Zone 4 and 5 represent the inner channel and the mouth of the channel respectively, and are the most likely place that the prey and birds would congregate on a flood tide.

Looking at the data there seems to be a trend that where there are high densities of alcids there are high densities of gull. Gulls are surface feeders and cannot access food below approximately 2-3 feet of depth while alcids are diving birds and can access prey that is deep down. So the gulls use the alcids to either flush the prey up to the surface where the gulls can acces it, or steal the alcids' catch. This behavior is called klepto-parasitism and has been document in many species of gulls and alcids. (Watatnuki 1990) This is most likely why the two families' spatial distributions are so similar.

In conclusion the largest factor affecting variance of overall abundance and spatial distribution is most likely the direction of tidal flow. As for population composition, it is most likely greatly affected by the seasonal availability of bird species and their relative population size.

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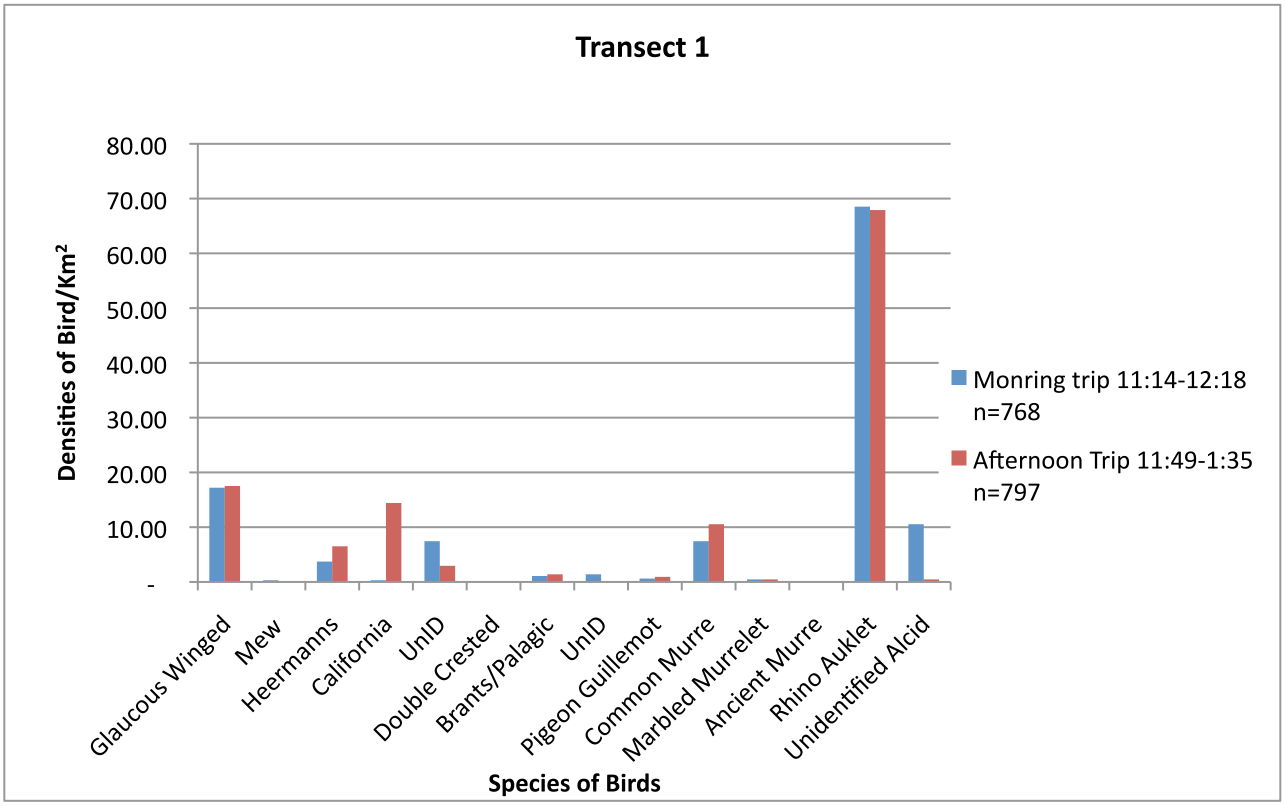

Figure 3

Figure showing the density of birds by species for the first transect.

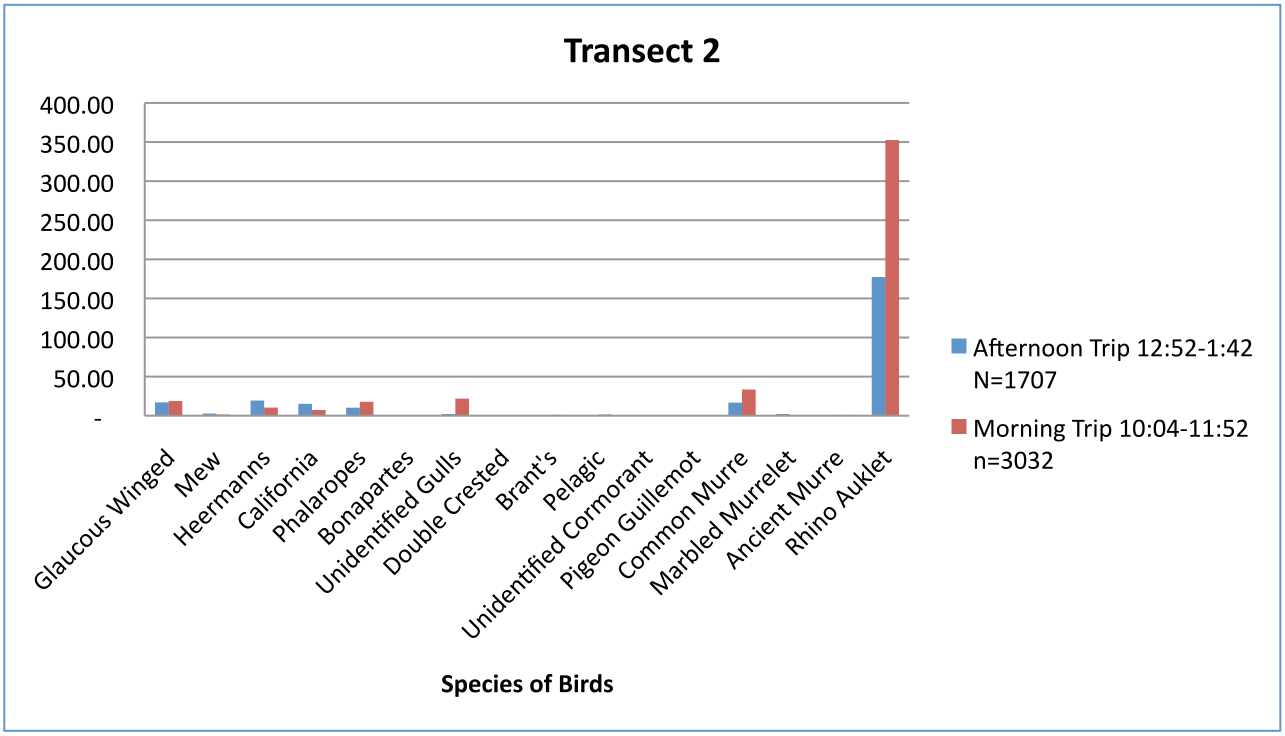

Figure 4

Figure showing the density of birds/Km^2 per bird species for the second transect.

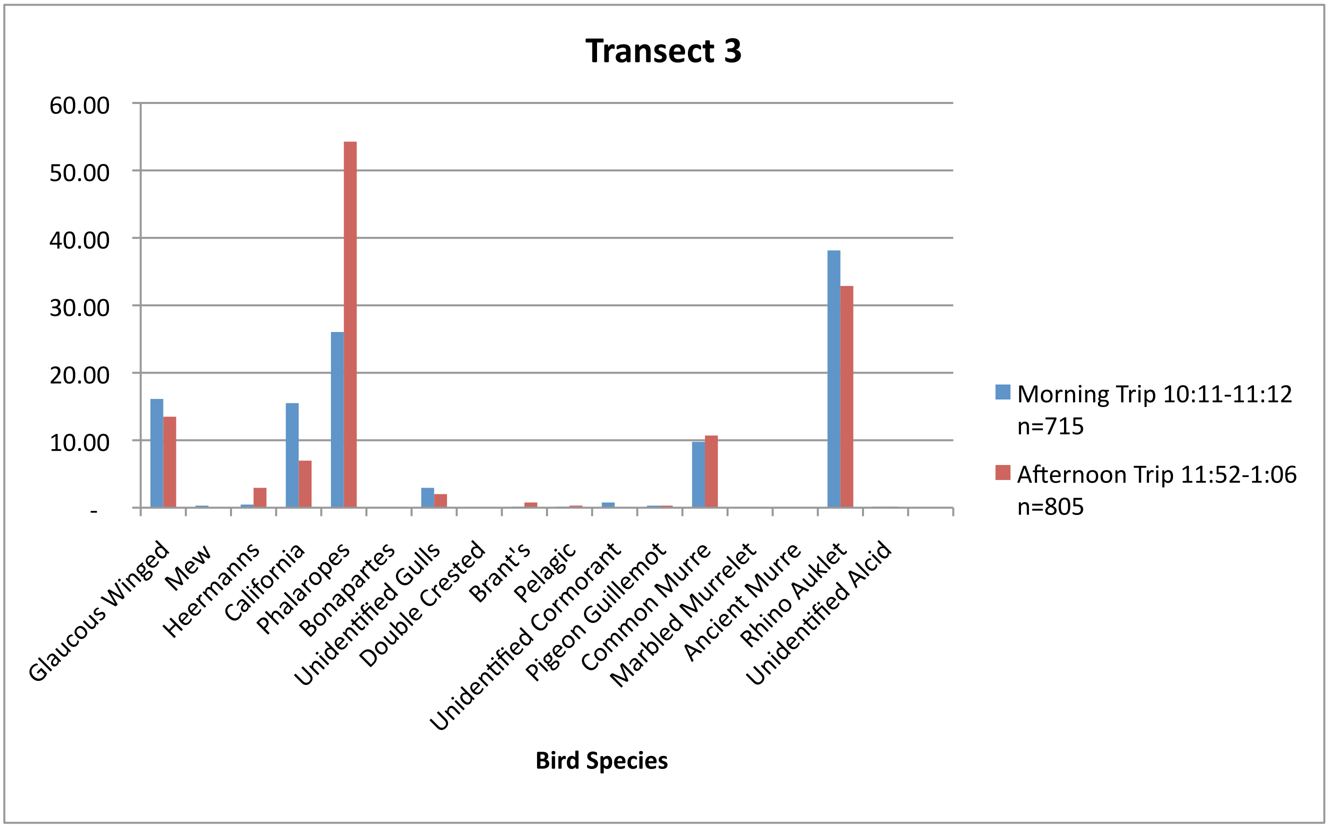

Figure 5

Figure showing the density of birds/Km^2 by species for transect three.

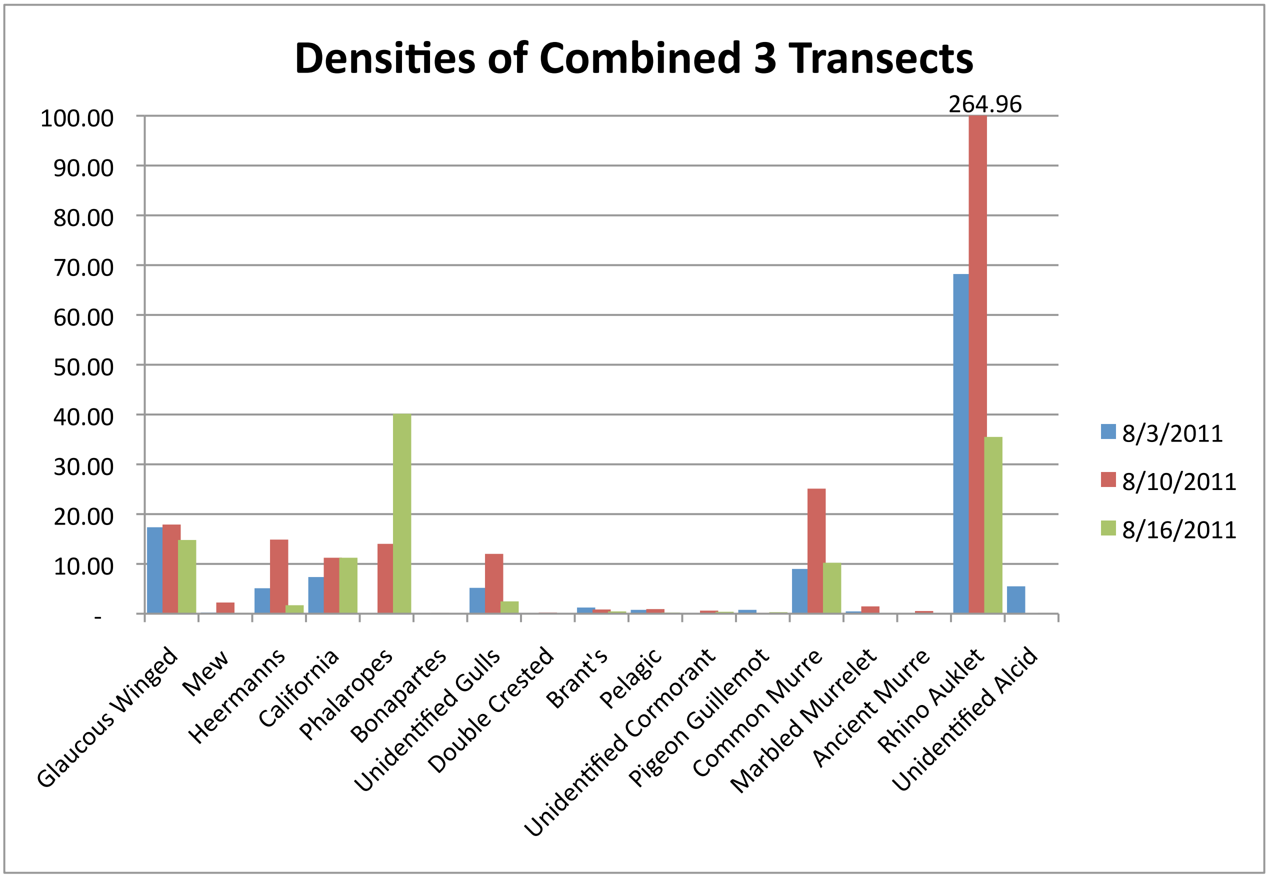

Figure 6 Density for birds/Km^2 by species for all three summer transects.

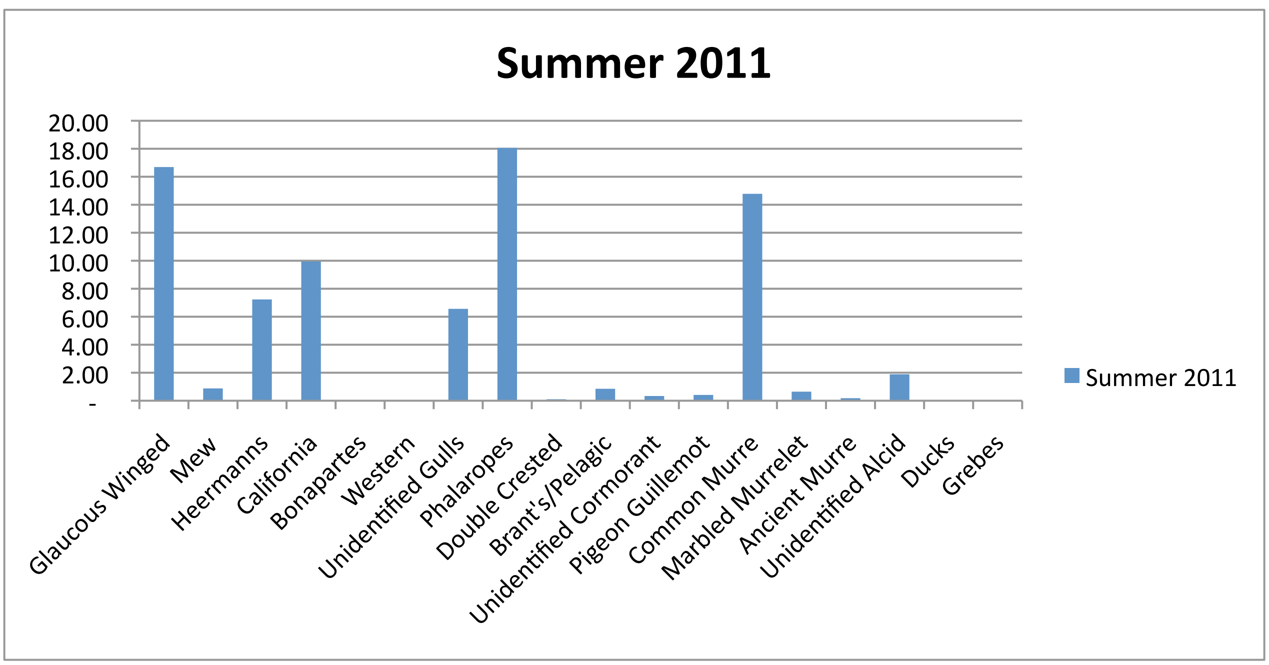

Figure 7 Average of density of birds/Km^2 for all three summer transects.

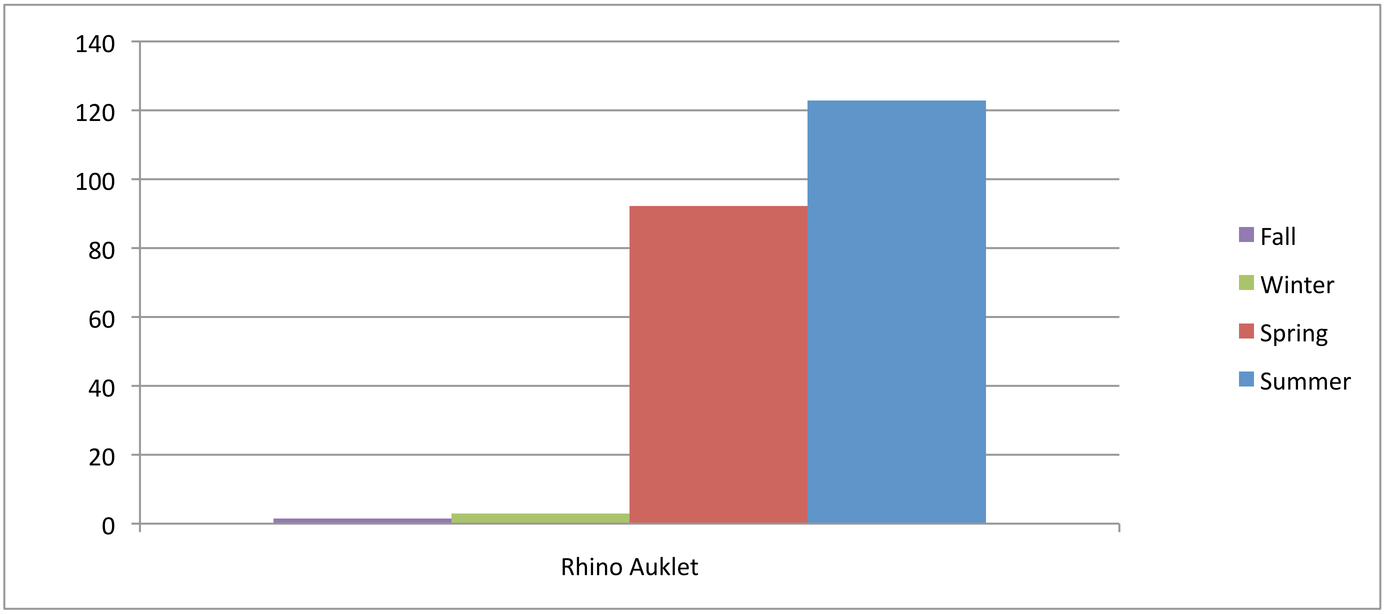

Figure 8 Rhinoceros Auklet density by season.

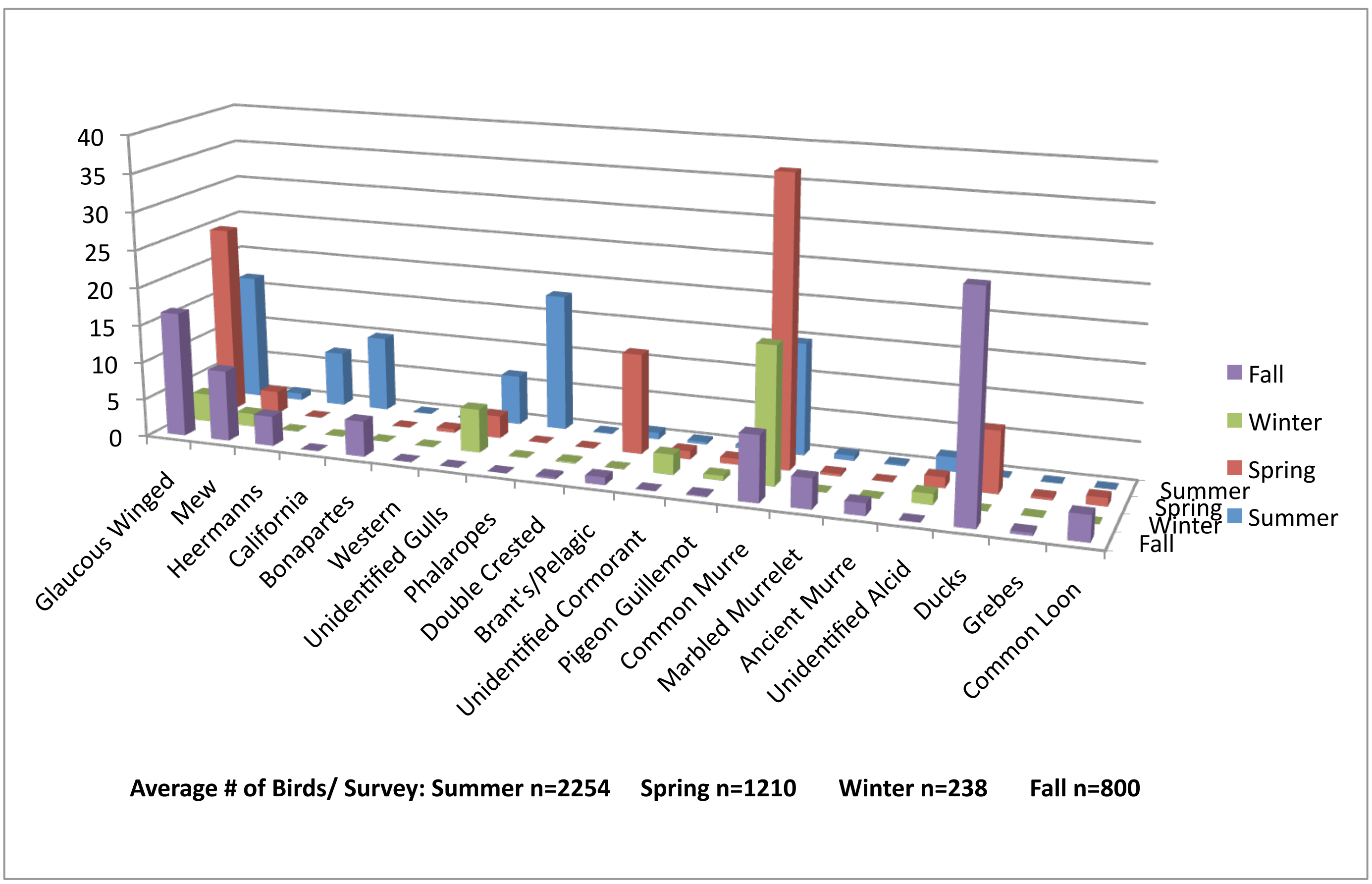

Figure 9 Density of all Birds for all seasons by species of family of birds.

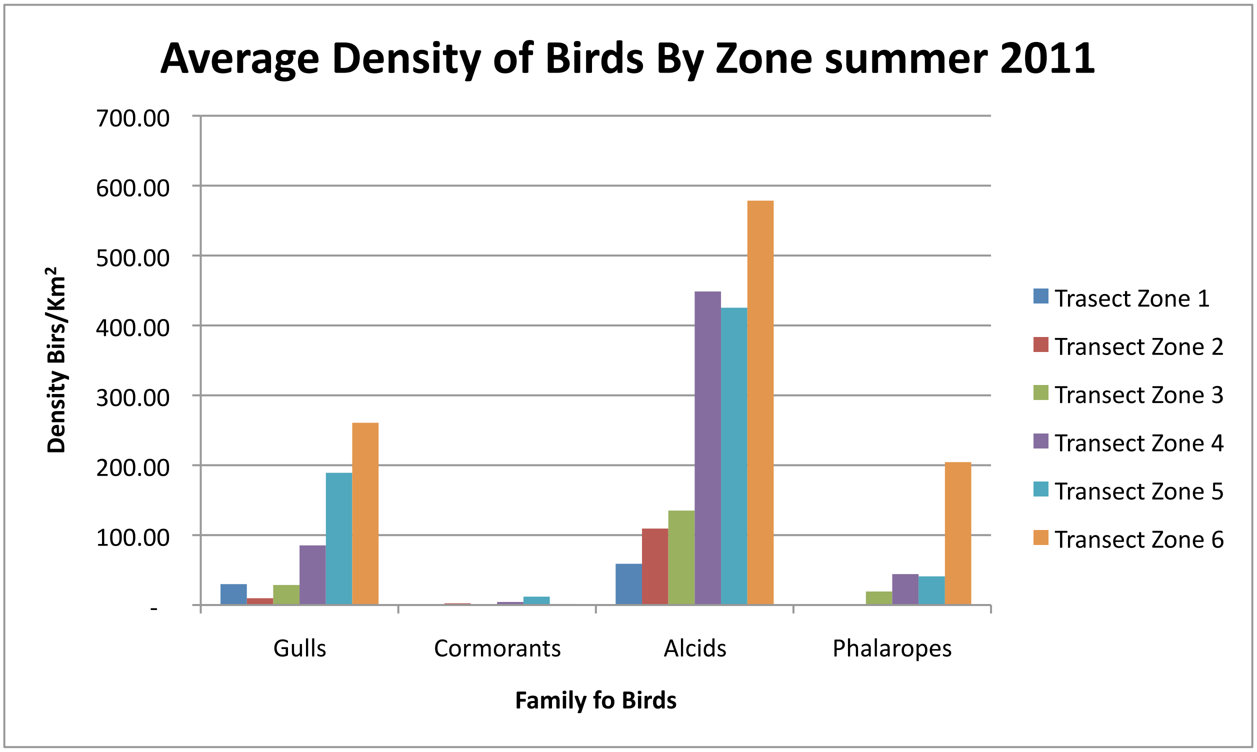

Figure 10 Figure showing average density by zone for summer 2011.

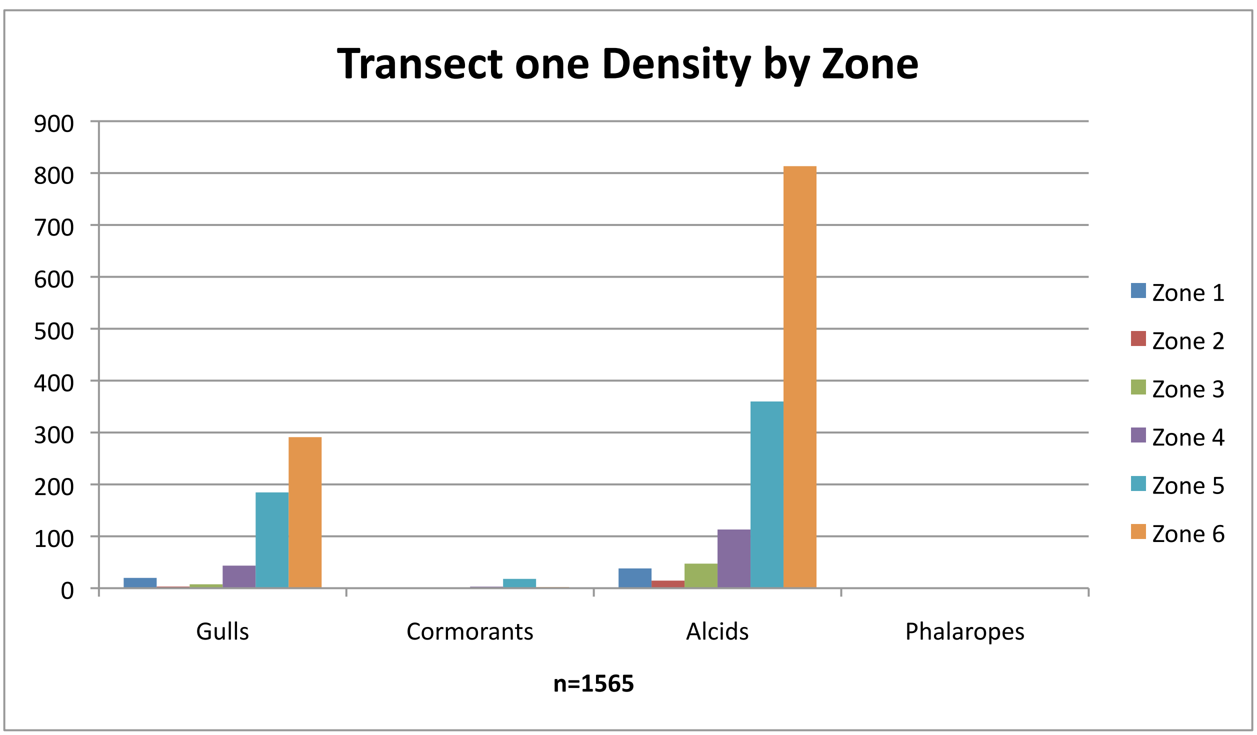

Figure 11   Figure showing density by zone for transect number one.

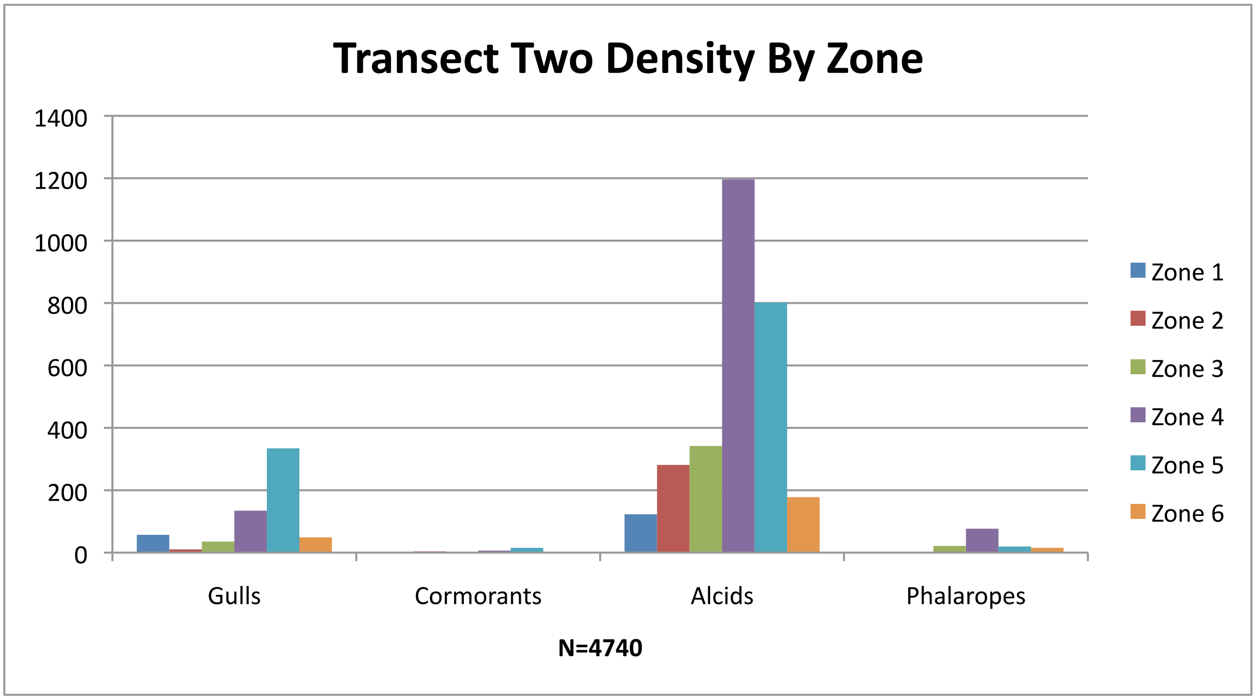

Figure 12 Figure showing density by zone for transect number two.

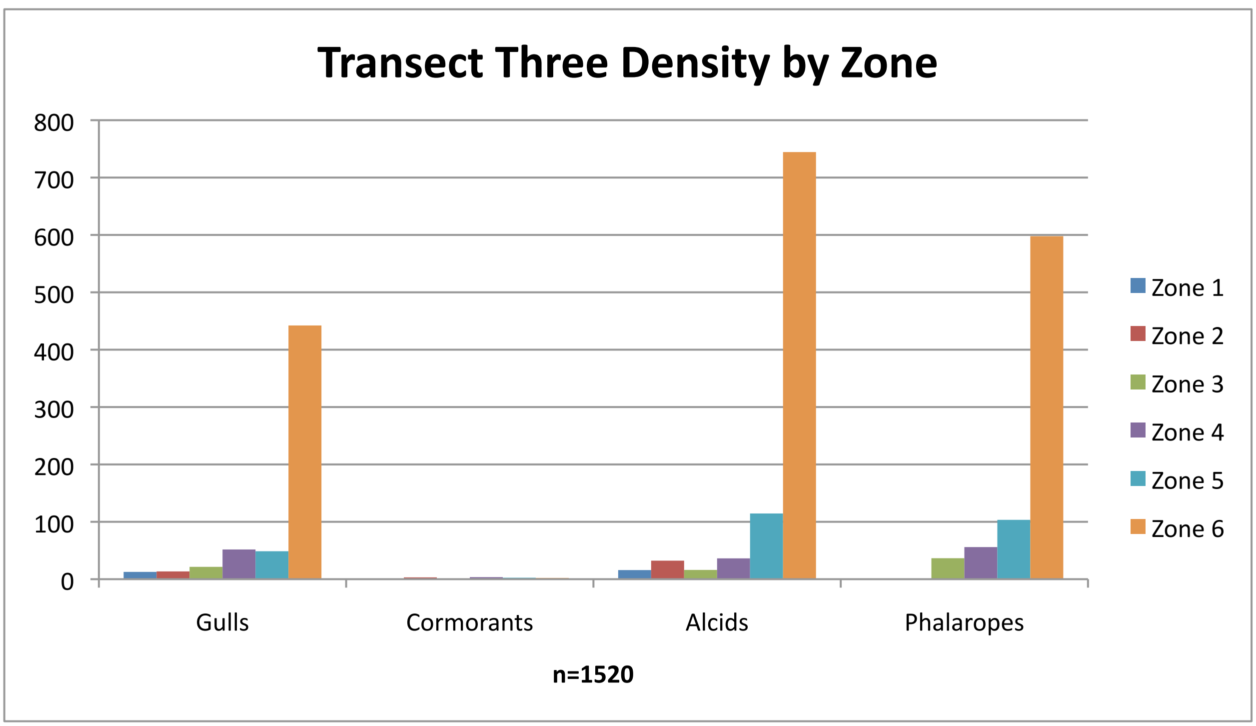

Figure 13 Figure showing density by zone for transect number three.

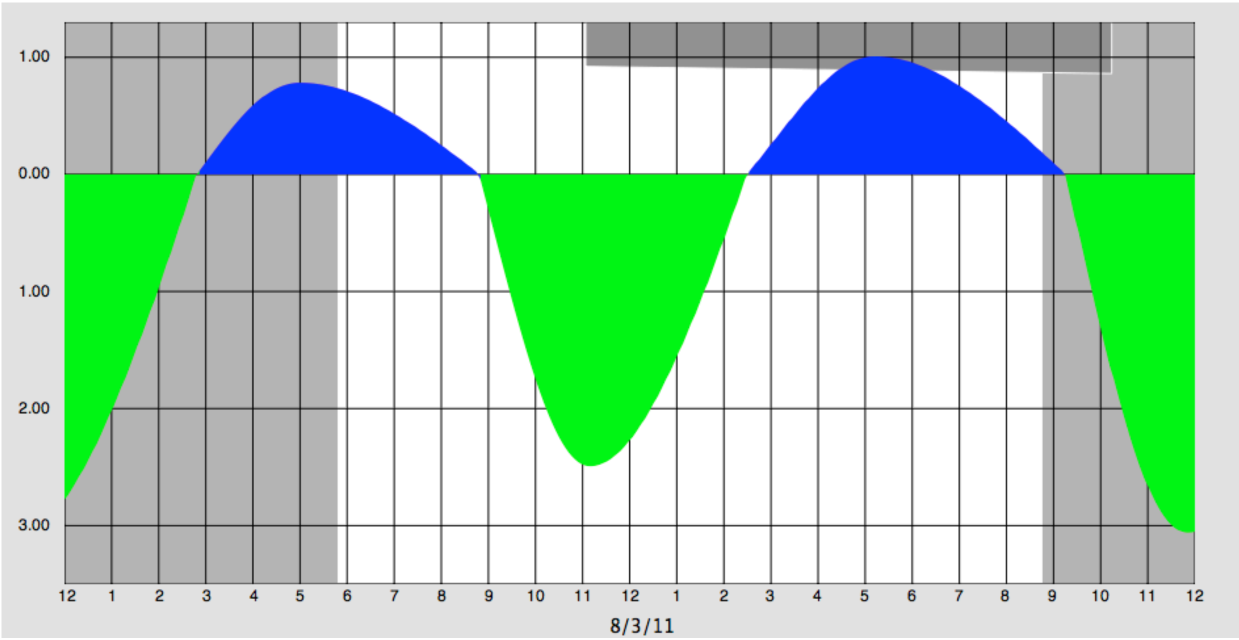

Figure1 4 Tidal chart from transect number one.

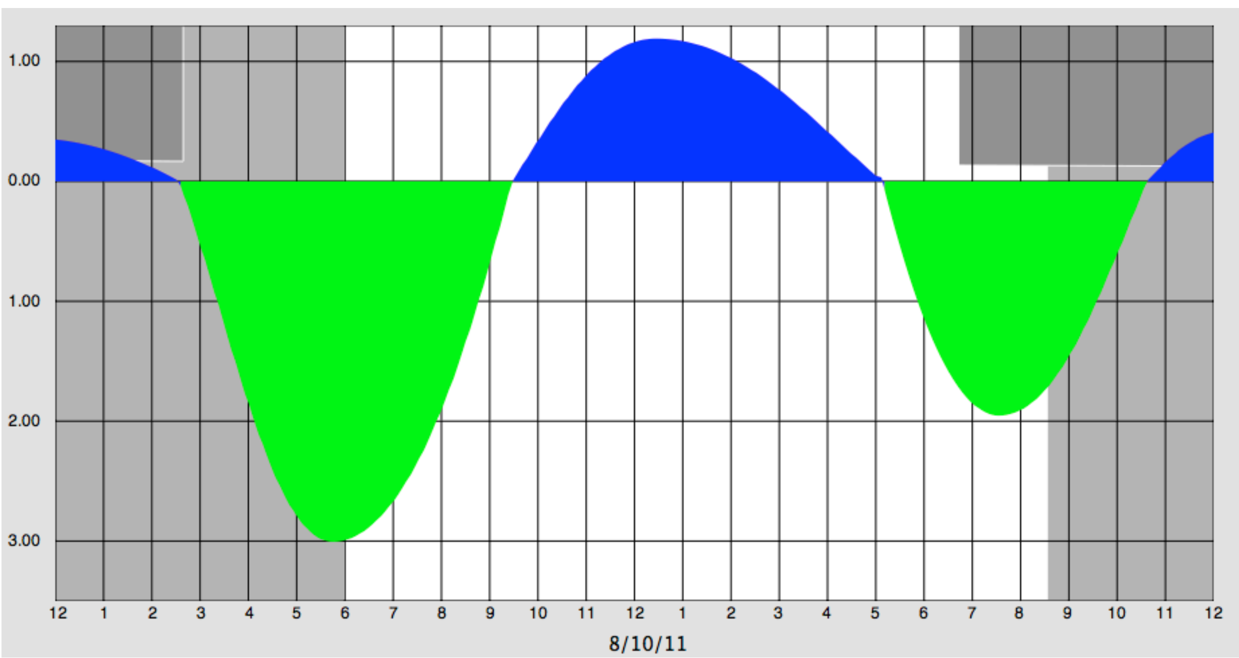

Figure1 5 Tidal chart from transect number two.

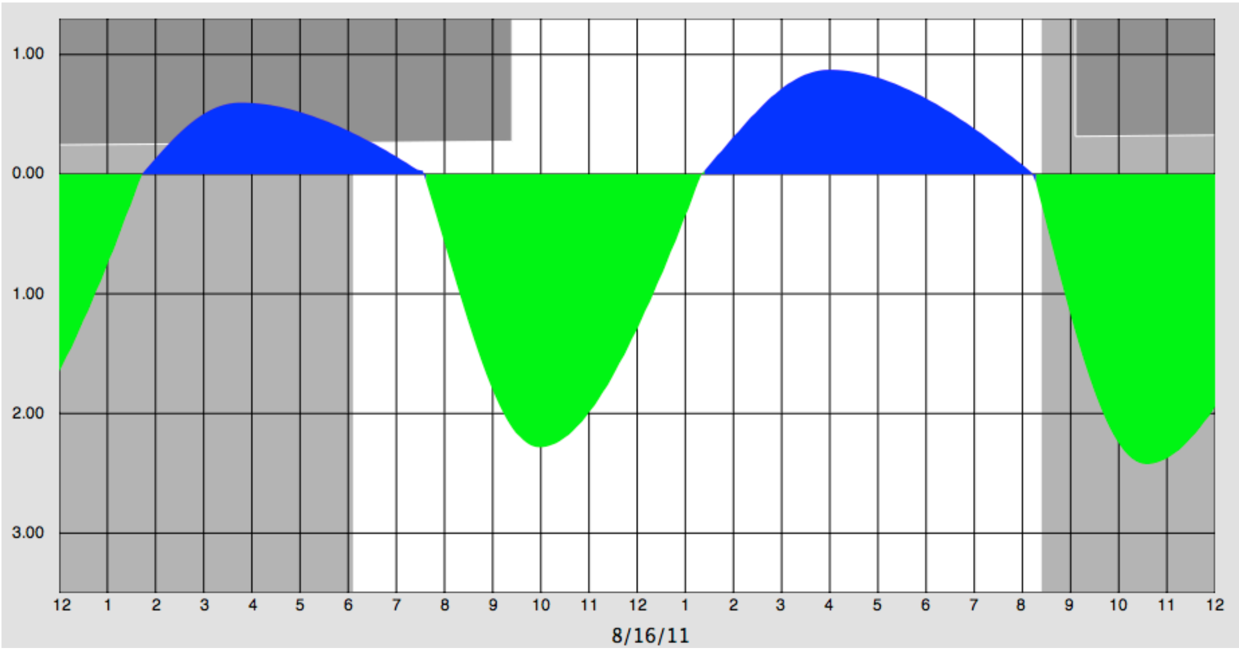

Figure 16 Tidal chart for transect number 3.