

# Marine Mammals in the San Juan Channel, Autumn 2011

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## ABSTRACT

Since 2005, one site has been studied in the San Juan Channel, located just off San Juan Island, Washington in the United States. This research has been done by the Pelagic Ecosystem Function Apprenticeship at the Friday Harbor Labs on San Juan Island. Continuing this research and focusing on mammals in the San Juan Channel, individual mammal species were counted in autumn 2011. 2011 abundances were calculated based on these counts, compared to abundances from 2007-2010, and looked at by date of sailing, zone in the study, and tidal phase present during each sailing in each zone. The zones were predetermined by the apprenticeship. Mammal individuals were counted using visual identification taken on day trips in October and November 2011. All mammal species seen across the study site, or transect, were counted during these sailings. The four mammals seen in the San Juan Channel in 2011 were Harbor Seals (*Phoca vitulina*), Steller Sea Lions (*Eumatopias jubatus*), Harbor Porpoises (*Phocoena phocoena*), and Dall's Porpoises (*Phocoenoides dalli*). Abundance for Harbor Seals was higher in 2010 and 2011 compared to years 2007-2009. Abundance for Harbor Porpoise's in 2011 was significantly higher than years 2007 to 2010. Abundance for Steller Sea Lions and Dall's Porpoise's remained stable from 2007-2011. Harbor Seals were the most abundant mammal present in the study, and Dall's Porpoise's were the least abundant. For the pinniped species, Harbor Seals and Steller Sea Lions showed no net change across season, but showed variation date to date. By zone, Harbor Seals showed some preference for Zone 3 in the study, and Steller Sea Lions showed high preference for Zone 5. By tidal phase, Harbor Seals and Steller Sea Lions both showed

preferences that differed in each zone. Abundance in relation to date, zone, and tidal phase for both species are likely effected by two factors; the location of haul out sites, as well as presence of prey.

## **INTRODUCTION**

Throughout the Salish Sea, there is a lack of general consensus as to whether mammal species are increasing or decreasing. Populations vary based on different locations and species throughout the Salish Sea. Since 2005, one site has been studied in the San Juan Channel, located just off San Juan Island, Washington in the United States. The channel, to the east of San Juan Island, has been researched in regard to oceanographic and biological characteristics, under the Pelagic Ecosystem Function Apprenticeship at the Friday Harbor Labs run by the University of Washington. Continuing this research, focusing on mammals in the San Juan Channel, individual mammal species were counted in autumn 2011, and numbers compared to other counts gathered since 2007 across the same area. These counts and corresponding abundances were looked at to conclude any general stability, increase, or decreases in populations over the past 5 years. Interannual data was looked at from 2007 and compared to abundance in 2011, and the 2011 abundance data was then looked at more closely in three ways. These three ways considered the 2011 abundance data by date, by zone within the study, and by tidal phase. This allowed for relationships to be examined between abundance and different biological characteristics that may effect the abundance numbers. The transect, or study site, in the San Juan Channel was separated into 6 zones

based on the various zones geographical locations. The first zone was the northern most zone near the northern part of San Juan Island, and the sixth zone was the southern most zone past the southern point (Cattle Point) of San Juan Island.

Three questions were asked based on the abundance data for 2011. The first question was to look at general abundance data for all mammal species present in the San Juan Channel, and compare these abundances to abundance data from 2007. The second question was to ask what distribution exists for the pinniped species present throughout the transect, and throughout each zone. The third question was to examine what relationships exist between tidal phase and abundance of pinnipeds in the channel. These abundances may be an important indicator of the health of mammal populations, or health of the overall ecosystem which additionally includes plankton, fish, and birds. More research is needed to make clear any relationships between mammal abundance in 2011 and date of sailings, location within zones, or presence during specific tidal phases, however some conclusions can be drawn with the data in 2011 and comparisons to data from 2007 to 2011.

The four mammals seen in the San Juan Channel were Harbor Seals (*Phoca vitulina*), Steller Sea Lions (*Eumatopias jubatus*), Harbor Porpoises (*Phocoena phocoena*), and Dall's Porpoises (*Phocoenoides dalli*). The four species were counted and abundance data calculated based off these counts. Tidal phases were also considered for what was occurring in each zone during each sailing, to examine if there is a relationship between mammal abundance and tidal phase.

## **METHODS**

Mammal individuals were counted using visual identification taken on day trips in October and November 2011. Individuals sitting on the bow of the research vessel R/V Centennial counted bird and mammal species each minute, using binoculars and visual identification. The group of individuals counting ranged from 5 to 8 people, and considered a transect measuring 21.5 km in length, covered twice each day that a trip was taken. A counting boundary was set at 150 m (.15 km) on each side of the vessel as it traveled south in the early morning, and north in the late morning and afternoon. All mammal species seen in this area were counted by individuals present on the bow of the research vessel. Data was tabulated based on the numbers counted during these trips. Numbers were written on sheets with categories for the various birds and mammals. The R/V Centennial traveled at a speed of generally 5-10 knots.

A total of 6 zones were identified across the transect area, each measuring a different length. Data was tabulated not only for each day, but also for each trip (heading either north or south), and for each zone, and each tidal phase corresponding to each zone. Data from 2007 to 2010 was found by papers written by previous apprentices under this apprenticeship. Seven trips were taken total on the R/V Centennial over autumn 2011. Tidal phases were predicted using Mr. Tides 3, with a station located at Wasp Passage for Zones 1 and 2, Turn Rock for Zones 3 and 4, and Cattle Point for Zones 5 and 6. Time was categorized using current speed measurements at these various stations, assuming a 6 hour period for each tidal cycle (ebb/flood). These time categories

put the first 30 minutes of a cycle at slack (with slack low before flood stages and slack high before ebb stages), the next 2 hours at stage 1 of the cycle (flood 1 or ebb 1), the next 1 hour at max for the cycle (max flood or max ebb), the next 2 hours at stage 2 of the cycle (flood 2 or ebb 2), and the last 30 minutes at slack again. Using these categories, the tidal phase was predicted within each zone and compared to mammal species abundance. If a period of max or ebb lasted 8 hours rather than 6 hours, the time was altered accordingly (for example, 30 minutes for slack becomes 40 minutes for slack). The tidal phases were split into 8 groups, and abbreviated, to be Slack low (SL low), Flood 1 (F1), Max Flood (MF), Flood 2 (F2), Slack high (Sl High), Ebb1 (E1), Max Ebb (ME), and Ebb 2 (E2). The six zones were established by the apprenticeship and considered the 2010 data on zones (Vermiere 2010). The location of these zones can be seen in Figure 18 and is from Vermiere 2010. All abundance was calculated using Microsoft Excel. Error bars were calculated as 95% confidence intervals, with the confidence calculated based on the standard deviation of the data and number of data points within the data set.

## **RESULTS**

### Interannual Results 2007 – 2010 and Abundance in 2011

Density data was available for the four mammal species from 2007 to 2011. This is shown in Figure 1. Since 2007, density increased for both Harbor Seals (*Phoca vitulina*) and Harbor Porpoises (*Phocoena phocoena*), and remained stable for Steller Sea

Lions (*Eumatopias jubatus*) and Dall's Porpoises (*Phocoenoides dalli*). For Harbor Seals, there was a high number in 2011 and 2010 compared to years 2007-2009. 2011 and 2010 showed 4.88 and 4.72 individuals per km<sup>2</sup> respectively, whereas the previous high from 2007-2009 was 2.59 individuals per km<sup>2</sup> in 2008. In 2011, there was a higher number of Harbor Porpoise's than from 2007 to 2010. Whereas the highest number of Harbor Porpoise's previously was 1.11 individuals per km<sup>2</sup> in 2008, there were 1.49 individuals per km<sup>2</sup> in 2011. Both Steller Sea Lions and Dall's Porpoise's remained stable from 2007-2011. Steller Sea Lions had a density of 1.69 individuals per km<sup>2</sup> in 2011, the lowest number in the range from 2007-2011, and 2009 had the highest abundance of Steller Sea Lions in the 2007-2011 range at 2.21 individuals per km<sup>2</sup>. Dall's Porpoise's showed .06 individuals per km<sup>2</sup> in both 2011 and 2007, .02 individuals in 2010, and zero individuals in 2008 and 2009. The densities for the four species in only 2011 is shown in Figure 2 below, with error bars showing 95% confidence intervals.

#### Abundance in 2011 by date, zone and tidal phase

The abundances for Harbor Seals and Steller Sea Lions in 2011 were looked at more closely by date, zone, and tidal phase. By date, Harbor Seal density ranged from 2.09 individuals per km<sup>2</sup> on November 7<sup>th</sup> to 7.91 individuals per km<sup>2</sup> on October 7<sup>th</sup>. Across the autumn season, there was no net change in Harbor Seal abundance, although there was variation date to date. The sailing on October 7<sup>th</sup> showed an abundance of 7.91 individuals per km<sup>2</sup>, while the last sailing on November 15<sup>th</sup> showed an abundance of

6.28 individuals per km<sup>2</sup>, to show that there was no net change. It should be noted that on October 4<sup>th</sup> the abundance for Harbor Seals was 5.07 individuals per km<sup>2</sup>, but this sailing was not completed and, due to bad weather, ended after zone 4. For Steller Sea Lions, there was also no net change in density, with 1.94 individuals per km<sup>2</sup> on October 7<sup>th</sup> and 2.09 individuals per km<sup>2</sup> on November 15<sup>th</sup>. The first sailing showed only .72 individuals per km<sup>2</sup>, but as this sailing did not include zone 5 (which contains the highest numbers of Steller Sea Lions), this number should not be considered complete. There was little variation date to date in Steller Sea Lion density, with the lowest density at .72 individuals per km<sup>2</sup> on October 4<sup>th</sup> and the highest at 2.64 individuals per km<sup>2</sup> on October 18<sup>th</sup>. Excluding the incomplete sailing on October 4<sup>th</sup>, the next lowest was October 24<sup>th</sup>, Nov 1<sup>st</sup>, and Nov 7<sup>th</sup> which all had a density of 1.40 individual Steller Sea Lions per km<sup>2</sup>. The above numbers show the variation by net change, and date to date for both species. This is summarized in Figure 3 below.

By zone, looking at distribution, Harbor Seals had the highest density in Zone 3. For the autumn season 2011, Zone 1 had the lowest Harbor Seal density at 1.25 individuals per km<sup>2</sup>, followed by Zone 6 at 1.48 individuals per km<sup>2</sup>, and Zone 2 at 2.98 individuals per km<sup>2</sup>. Zone 3 at the highest density had 12.60 individuals per km<sup>2</sup>, with Zones 4 and 5 below it at 5.70 and 4.06 individuals per km<sup>2</sup> respectively. Steller Sea Lions in 2011 had the highest density clearly in Zone 5, with 7.55 individuals per km<sup>2</sup> in Zone 5. The lowest densities were in Zones 2, 6, and 1, with .15, .19, and .28 individuals per km<sup>2</sup> respectively. Zone 3 had a density of .54 individuals per km<sup>2</sup>, and Zone 4 had a density of 1.11 individuals per km<sup>2</sup>. Other than Zone 5 at 7.55 individuals per km<sup>2</sup>, the only density higher than 1 individual per km<sup>2</sup> was Zone 4. These results

for density by zone for both species is summarized in Figure 4 below, along with error bars as 95% confidence intervals which in some cases showed high variation. Zone 3 for example had a confidence interval of 7.76, which with a positive and negative range extends 15.52 individuals per km<sup>2</sup> total.

The results for Harbor Seal and Steller Sea Lion density by tidal phase showed different tidal phase preferences for each species in each zone. Overall, there is no trend for either species across the entire transect, or by a north/south zone distinction. Harbor Seals showed a more clear trend than Steller Sea Lions, though not across the entire transect. For Zones 1 through 3, Harbor Seals showed a slight preference for high tide, while in Zones 4 through 6 they showed no preference. Steller Sea Lions showed a slight preference for high tide in Zone 2, a slight preference for low tide in Zone 4, no preference in Zones 3 and 5, and there were too few animals to make a tidal preference distinction in Zones 1 and 6. These results are graphed in Figures 5 through 16 below, with a summary of the tidal preference for both species in Table 1. The number of times each tidal phase was present in each Zone is also listed on these figures below as “n” numbers, for both species. There were few times the sailings occurred during Max Ebbs, but the other tidal phases occurred more often throughout the sailings, which can be seen in the n numbers on Figures 4 through 15. This concludes the results for density interannually, and by date, zone, and tidal phase for autumn 2011.

## **DISCUSSION**

### Interannual Results 2007 – 2010 and Abundance in 2011

Considering the interannual abundance data from 2007-2011, it is clear that Harbor Seals had a substantial density increase in 2010 and 2011 compared to the previous 3 years, but it is less clear what caused this. Similarly, it is clear that Harbor Porpoises had a substantial density increase in 2011 when compared to the previous 4 years, but the cause may be unknown. It can be noted that the results these data show from the San Juan Channel are in line with results of what other researchers have found throughout the Salish Sea in 2011. For example, at the Salish Sea Conference in October 2011, Calambokidis reported that there are larger numbers of Harbor Porpoises in 2011 than in previous years. Over a longer time period, Osmek reported in 2007 that a substantial decline of Harbor Porpoise's has occurred in the past. However, Osmek also discusses numbers that show an increase in the San Juans in Harbor Porpoise's since 1991 overall. It may be true that Harbor Seals are at carrying capacity in the Salish Sea, though not confirmed, as discussed at the Salish Sea Conference in 2011 by Lance. If this claim is true, then Harbor Seal densities may remain at higher levels, similar to those found in 2010 and 2011, in the next few years. If other interannual trends continue, then numbers for Steller Sea Lions and Dall's Porpoises will likely remain stable in the next few years throughout the San Juan Channel. What remains completely unknown from the results of this data is how certain mammal densities have changed over longer periods of time. For example, local knowledge suggests that Dall's Porpoises used to be found in

higher numbers, but have decreased from 10 years ago or longer, though this is unconfirmed. If this is true, the data from 2007 to 2011 would show stable numbers in abundance for Dall's Porpoises, but would only show stability after a larger decline in previous years undetected in this data. Long term declines for all four species are not documented in this data, but the 5 year series of 2007 to 2011 documents short term changes in the San Juan Channel which show all populations to be either stable or increasing. In summary, Harbor Seal and Harbor Porpoise populations have increased from 2007, and Steller Sea Lion and Dall's Porpoise populations have remained stable. Considering the abundance data for just 2011, it is clear that Harbor Seals have the highest abundance of any mammal in the San Juan Channel, Steller Sea Lions and Harbor Porpoise's have lower but similar abundances, and Dall's Porpoise's have the lowest abundance with just a few individuals present during the study.

#### Abundance in 2011 by date, zone and tidal phase

Looking more closely to two species, Harbor Seals and Steller Sea Lions, and their abundance by date, zone, and tidal phase, there are a number of things to discuss. Abundance by date as discussed in the results shows no net change for either Harbor Seals or Steller Sea Lions across autumn 2011, but does show some notable variation date to date for Harbor Seals, and minimal variation date to date for Steller Sea Lions. To explain this date to date variation for Harbor Seals, there are two factors that may effect these numbers. One factor could be Harbor Seals swimming in and out of the area on the various dates. Another factor could be that Harbor Seals are swimming in and out

of the water from haul out sites located nearby. Considering the results and other evidence, it may be more likely that the pinnipeds are simply hauling out, or feeding a few kilometers from the haul out sites but not leaving the area altogether. For Steller Sea Lions, it may be similarly likely that the variation exists due to Steller Sea Lions swimming in and out of the water from haul out sites nearby. This may be true because of the minimal variation present in the data date to date, which may be otherwise more substantial if the Steller Sea Lions were in fact swimming in and out of the area. One major haul out site exists along the transect, known as Whale Rock, which Steller Sea Lions swim off and onto. With the minimal variation, it is likely that the number leaving this haul out site and swimming into the San Juan Channel is what causes the date to date variation. As Harbor Seals have many smaller haul out sites throughout the channel, the variation Harbor Seals show may be due to them hauling out along these different haul out sites, but a few could also be leaving the region, and without knowing more information, no concrete conclusions can be made in regard to this date to date variation for either species.

What evidence may be useful exists with the publication by Bjorge in 1995, Lyman in 1989, and Lance in 2007. Bjorge suggests that Harbor Seals primarily either return to the same foraging site to feed or travel a few kilometers away from haul out sites to feed. This would suggest that it is more likely Harbor Seals are simply hauling out or traveling a few kilometers to feed, which would place them out of the transect, but not out of the area. Lyman suggests that haul out sites are the central points of pinniped hunting, which would further decrease the likeliness that either Harbor Seals or Steller Sea Lions are leaving the area, but instead simply hauling in and out. Lance looks

specifically at the pinniped diets in the San Juan Channel to suggest that the primary haul out sites for Harbor Seals during the summer and fall is at Whale Rock and Goose Island. Whereas it is known by observation that Whale Rock is where Steller Sea Lions haul out, this may further contribute to the idea that the pinnipeds are hauling in and out of the water as opposed to leaving the area. Considering all this evidence, hauling out or traveling a few kilometers to feed seems most likely to explain variation in abundance numbers by date.

Considering abundance by zone, or distribution, there are two reasons why each pinniped species may be distributed as they are in specific zones. These reasons are the location of nearby haul out sites as discussed above, or the presence of prey. As Harbor Seals show more of a preference for Zones 3, 4, and 5, the location of haul out sites nearby may be an indicator of the higher abundances in these areas. Whether tidal phase or haul out sites, it seems likely that Steller Sea Lions prefer Zone 5 due to nearby haul out sites like Whale Rock. This would explain the much higher density in Zone 5 compared to the other 5 zones. With only knowing two haul out sites for Harbor Seals, Whale Rock and Goose Island, the presence of prey may be additionally important to consider, as it could be an additional indicator (Lance 2007). It is likely that haul out sites are one reason these two species are located and distributed primarily where they are, in combination with tidal phase. It is more clear to conclude that Harbor Seals are primarily in Zone 3 and Steller Sea Lions in Zone 5, even with a large error bar for Harbor Seals in Zone 3 based on the 95% confidence interval.

As we did not have data on prey in the area, we could only look at what effects the prey, primarily the tidal phases. Lance in 2007 offers a breakdown of pinniped diet in

the San Juans. Lance writes that Harbor Seals eat primarily pacific herring, adult salmonids, and walleye Pollock, dependent mostly on fish abundance and the timing of the salmon run. Steller Sea Lions eat primarily dogfish and skates, based on their waste. Knowing this, it is interesting to look at tidal phases not only for mammals but also for these fish species. Without fish data directly available, this relationship with fish and tidal phase would be interesting to consider for future study. As the presence of prey may effect the distribution of the two pinniped species, it is important to consider abundance in relation to tidal phase present in each zone. This is the main reason tidal phase was looked at in relation to mammal abundance.

For Harbor Seals, there was some trend in Zones 1-3 for high tide preferences. Considering Figures 6, 7, and 8, this pattern seems evident. Zones 4, 5, and 6 however, for Harbor Seals shows less of a pattern for any tide as seen in figures 8, 10, and 11. For Steller Sea Lions, Figures 12 and 17 show there are too few animals to make a tidal conclusion, Figures 14 and 16 show there is not a clear preference, and Figures 13 and 15 show a possible preference for high and low tidal phase respectively. This shows how it may depend on the zone, which tidal phase is preferred by each species. This is likely due to prey availability based on the tides, but may also be due to haul out sites. As Roen showed in 1995, tidal cycle showed a significant relationship with Harbor Seal haul out behavior. Furthermore, Roen claims most seals feed around high tide which may explain the preferences evident in Zones 1-3. If this is true, then both haul site location and prey availability may effect the abundances of pinnipeds present during each tidal phase. In conclusion, for abundances in relation to date, zone, and tidal phase, it is clear that both Harbor Seals and Steller Sea Lion densities are effected by the location of nearby haul

out sites, as well as prey availability, but the extent to which these effect each factor cannot be concisely concluded within the data presented in this study. This may be a good area for future research on pinnipeds in the San Juan Channel.

## **ACKNOWLEDGEMENTS**

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## LITERATURE CITED

Bjorge, Arne, Dave Thompson, Phillip Hammond, Michael Fedak, Edmund Bryan, Hilde Aarefjord, Randi Roen, and Marianne Olsen. "Habitat Use and Diving Behaviour of Harbour Seals in a Coastal Archipelago in Norway." *Developments in Marine Biology* 4 (1995): 211-23.

Calambokidis, John, Jessie Huggins, Dyanna Lambourn, Steve Jeffries, Bethany Diehl, and Josh Oliver. "Changes in cetacean occurrence in the Salish Sea: Anomalous sightings in S. Puget Sound." *Cascadia Research*. Salish Sea Conference. October 2011. Personal Communication.

Clemence, Ben. "Interannual Variability in Seabird and Marine Mammal Populations in the San Juan Archipelago." Pelagic Ecosystem Function Apprenticeship, Friday Harbor Labs, University of Washington. 2008.

Lance, M.M., and S.J. Jeffries. Temporal and spatial variability of harbor seal diet in the San Juan Island archipelago. Contract Report to SeaDoc Society Research Agreement No. K004431-25. Washington Department of Fish and Wildlife, Olympia WA. 2007. 21 pp.

Lance, Monique, Wan-Ying Chang, Steven J. Jeffries, Alejandro Acevedo-Gutierrez  
“Seasonal and spatial variation in harbor seal (*Phoca vitulina*) diet in the San Juan  
Islands, Washington.” *Washington Department of Fish and Wildlife*. Salish Sea  
Conference. October 2011. Personal communication.

Lyman, R. Lee. "Seal and Sea Lion Hunting: A Zooarchaeological Study from the  
Southern Northwest Coast of North America." *Journal of Anthropological Archaeology* 8  
(1989): 68-99.

Osmek, S., J. Calambokidis, J. Laake, P. Gearin, R. DeLong, J. Scordino, S. Jeffries, and  
R. Brown. Assessment of the status of harbor porpoise (*Phocoena phocoena*) in Oregon  
and Washington waters. U. S. Dep. Commer., NOAA Tech. Memo. 1997. NMFS- AFSC-  
76, 46.

Roen, Randi, and Arne Bjorge. "Haul out Behavior of the Norwegian Harbor Seal during  
Summer." *Developments in Marine Biology* 4 (1995): 61-67.

Rossini, Cyndi. “Marine Bird and Mammal Communities within the San Juan  
Archipelago during Fall - 2007” Pelagic Ecosystem Function Apprenticeship, Friday  
Harbor Labs, University of Washington. 2007.

Stombaugh, Rebecca. "Marine Bird and Mammal Composition in the San Juan Channel (WA) during Fall 2009." Pelagic Ecosystem Function Apprenticeship, Friday Harbor Labs, University of Washington. 2009.

Vermeire, Line. "Marine Mammals in San Juan Channel: Abundance, Distribution and Tidal Effects." Pelagic Ecosystem Function Apprenticeship, Friday Harbor Labs, University of Washington. 2010.

## FIGURES AND TABLES

### FIGURES

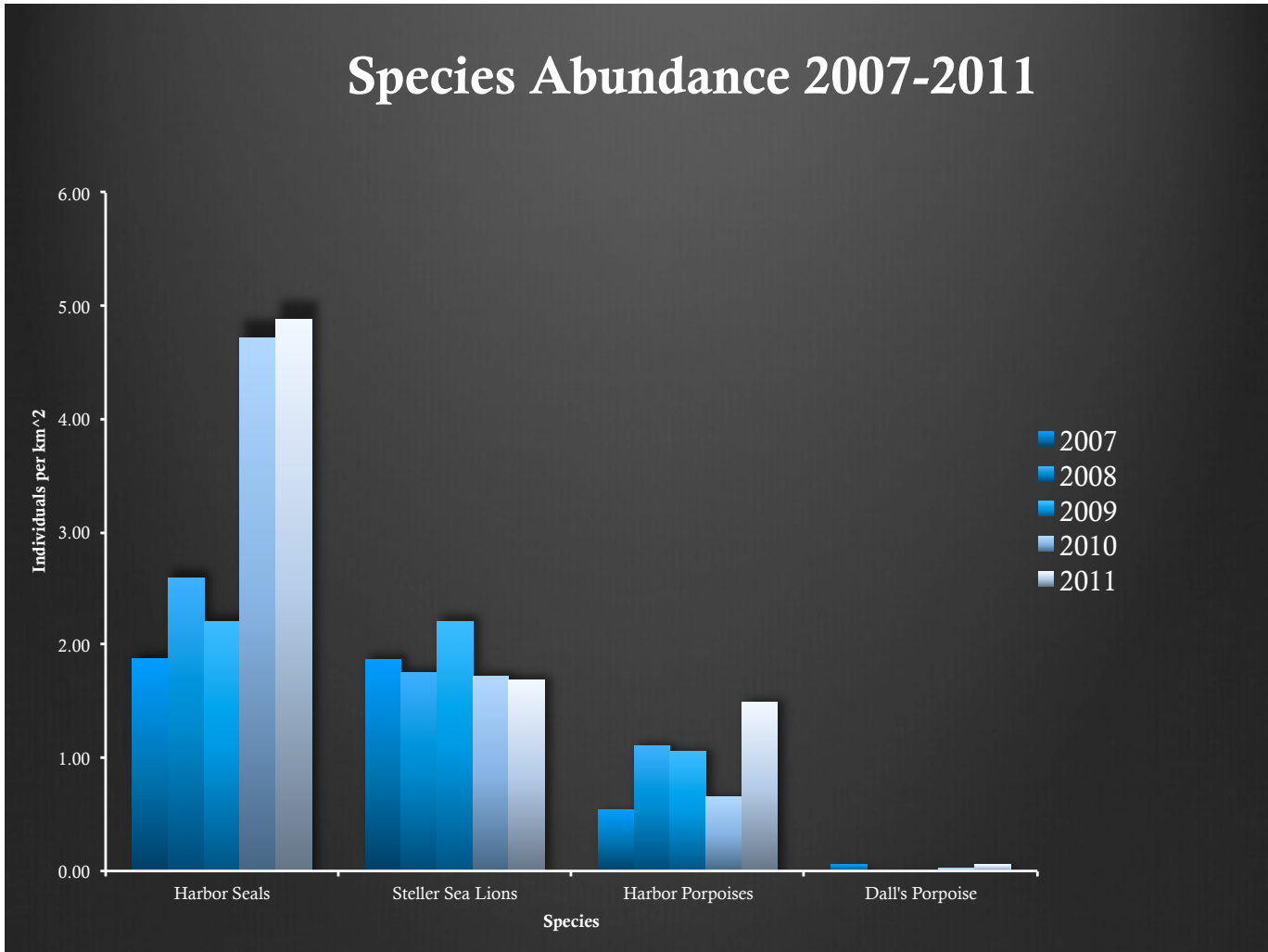


Figure 1: Species abundance for mammals in the San Juan Channel in autumn, 2007-2011

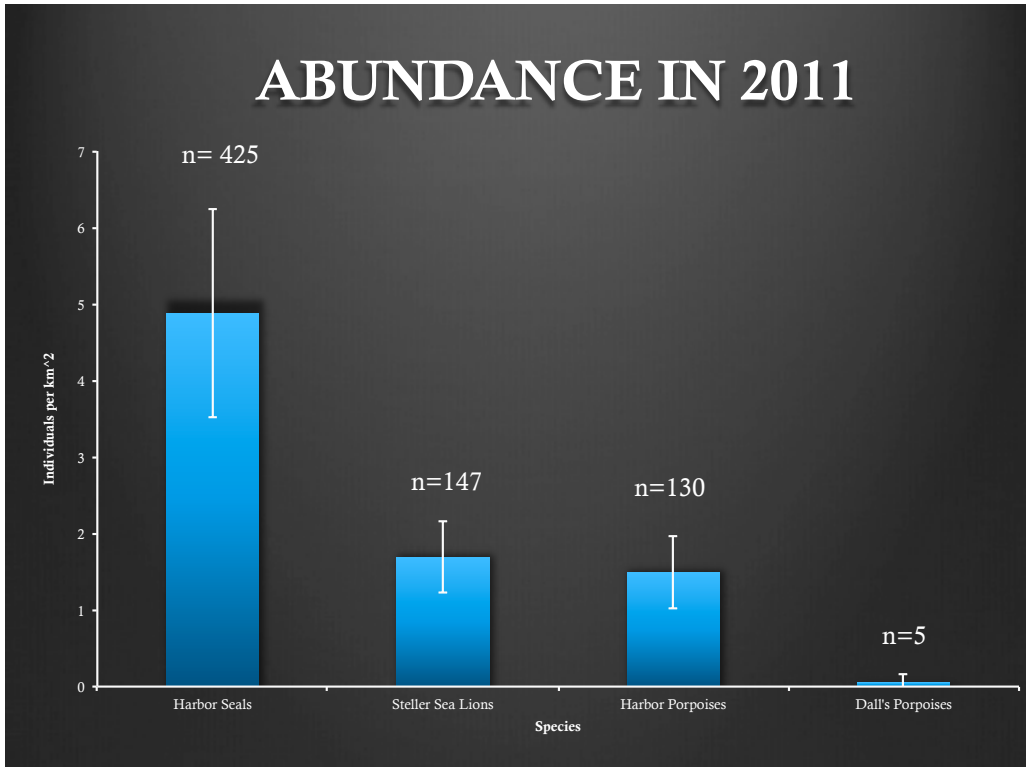


Figure 2: Species abundance for mammal species present, autumn 2011

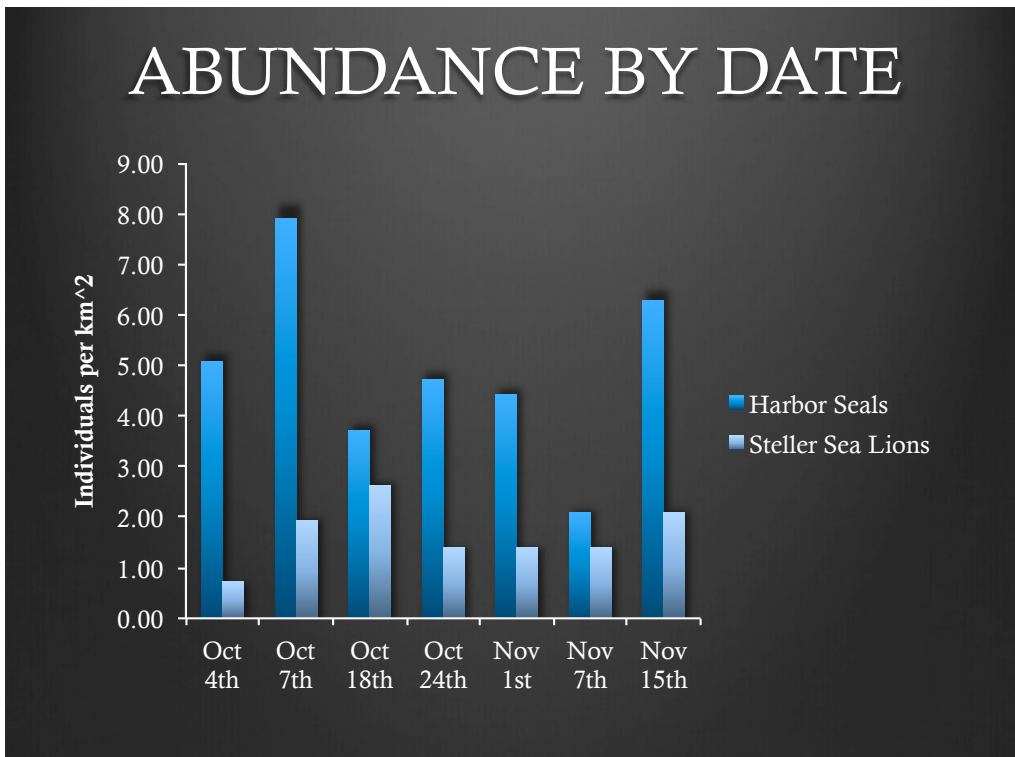


Figure 3: Harbor Seal and Steller Sea Lion abundance by date, autumn 2011

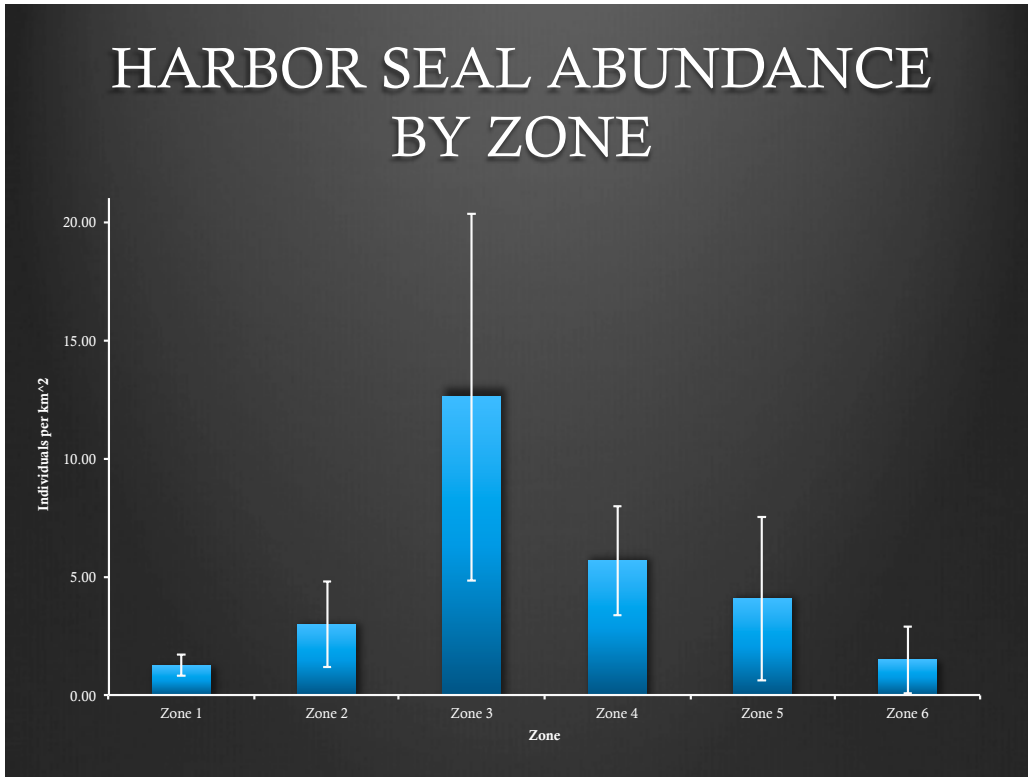


Figure 4: Harbor Seal abundance by zone, autumn 2011



Figure 5: Steller Sea Lion abundance by zone, autumn 2011

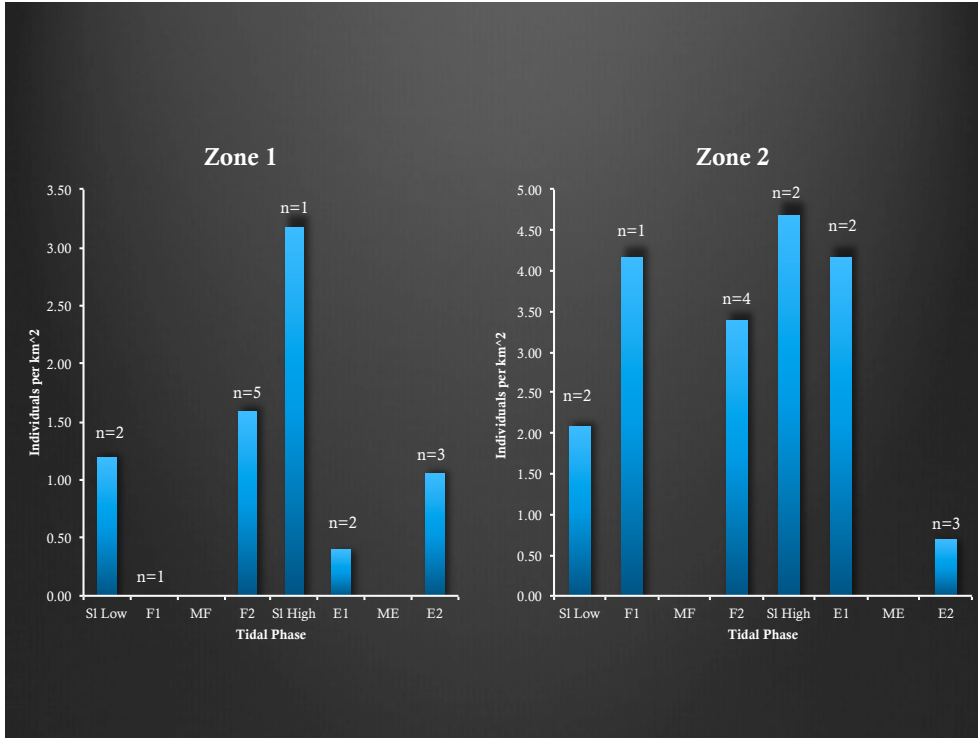


Figure 6: Harbor Seal abundance by tidal phase in zone 1

Figure 7: Harbor Seal abundance by tidal phase in zone 2

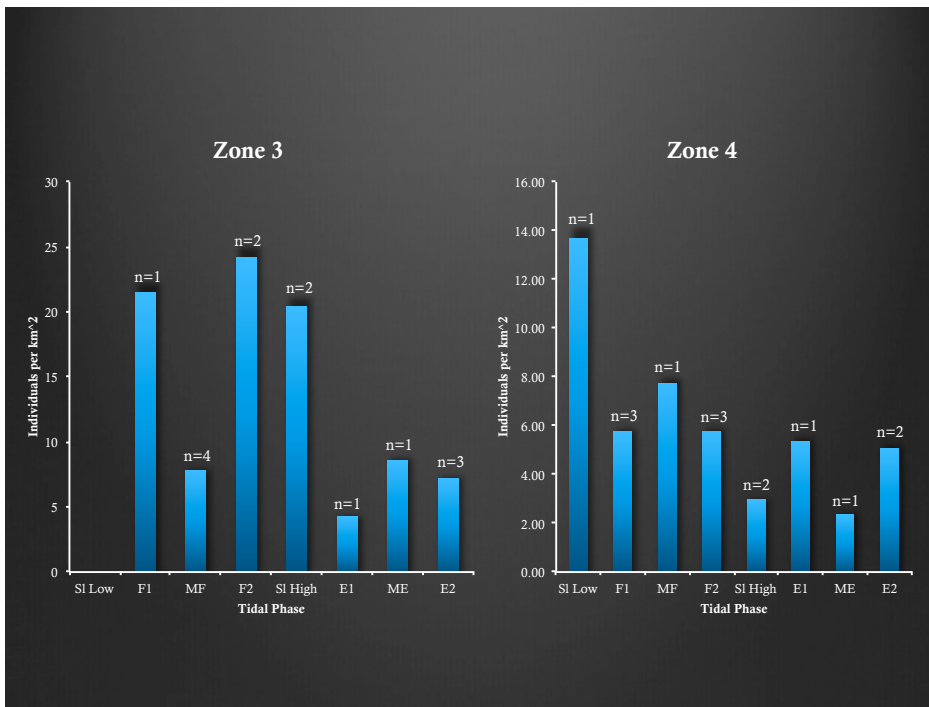


Figure 8: Harbor Seal abundance by tidal phase in zone 3

Figure 9: Harbor Seal abundance by tidal phase in zone 4

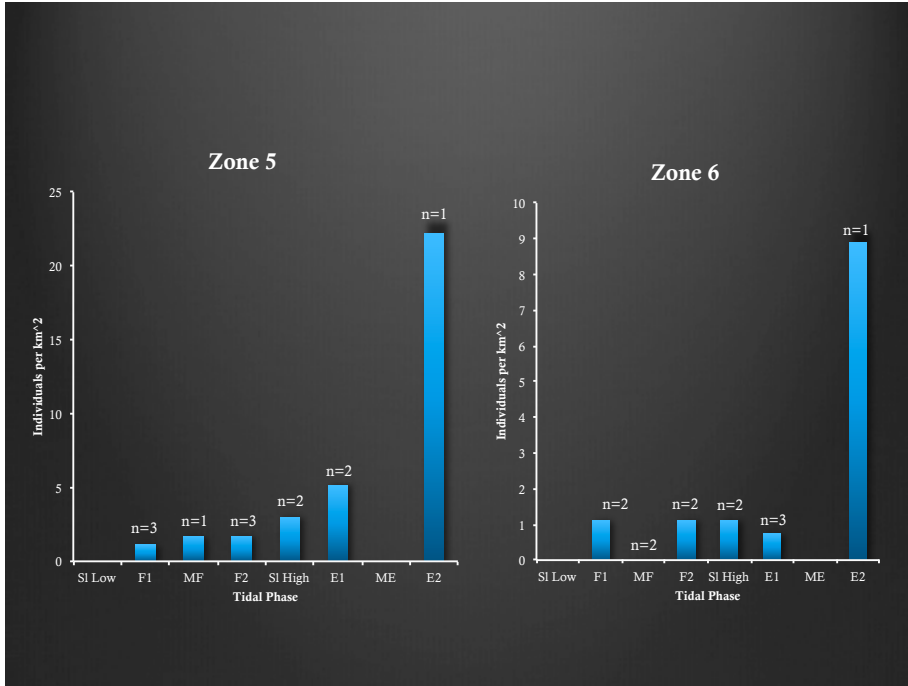


Figure 10: Harbor Seal abundance by tidal phase in zone 5

Figure 11: Harbor Seal abundance by tidal phase in zone 6

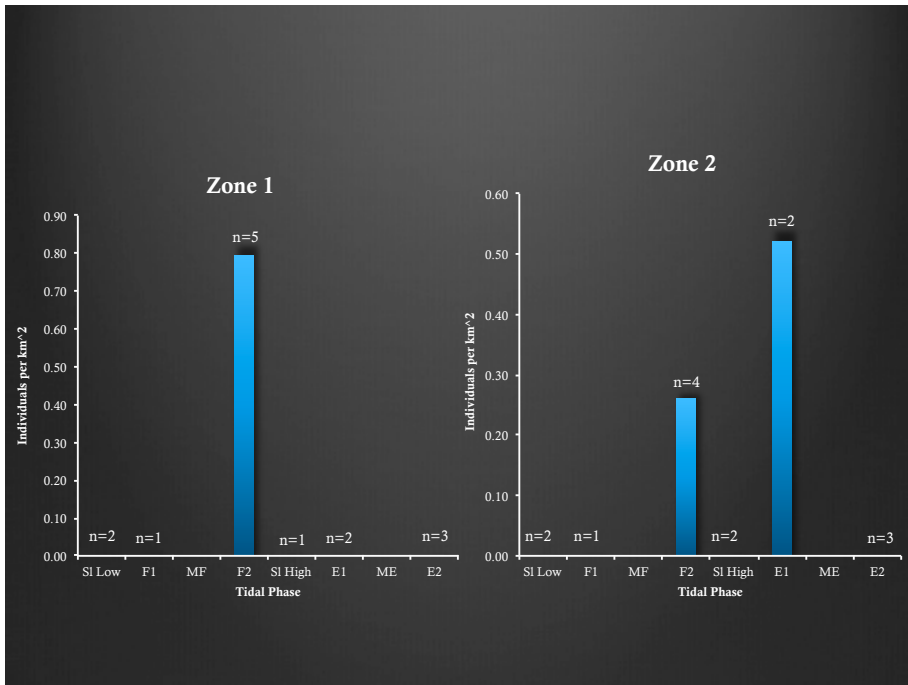


Figure 12: Steller Sea Lion abundance by tidal phase in zone 1

Figure 13: Steller Sea Lion abundance by tidal phase in zone 2

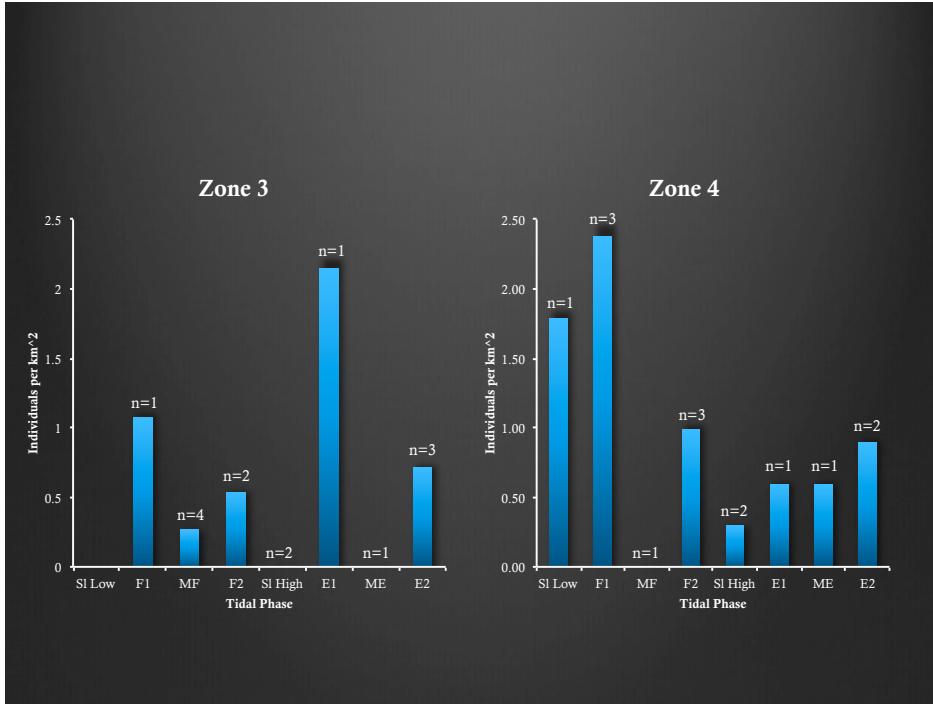


Figure 14: Steller Sea Lion abundance by tidal phase in zone 3

Figure 15: Steller Sea Lion abundance by tidal phase in zone 4

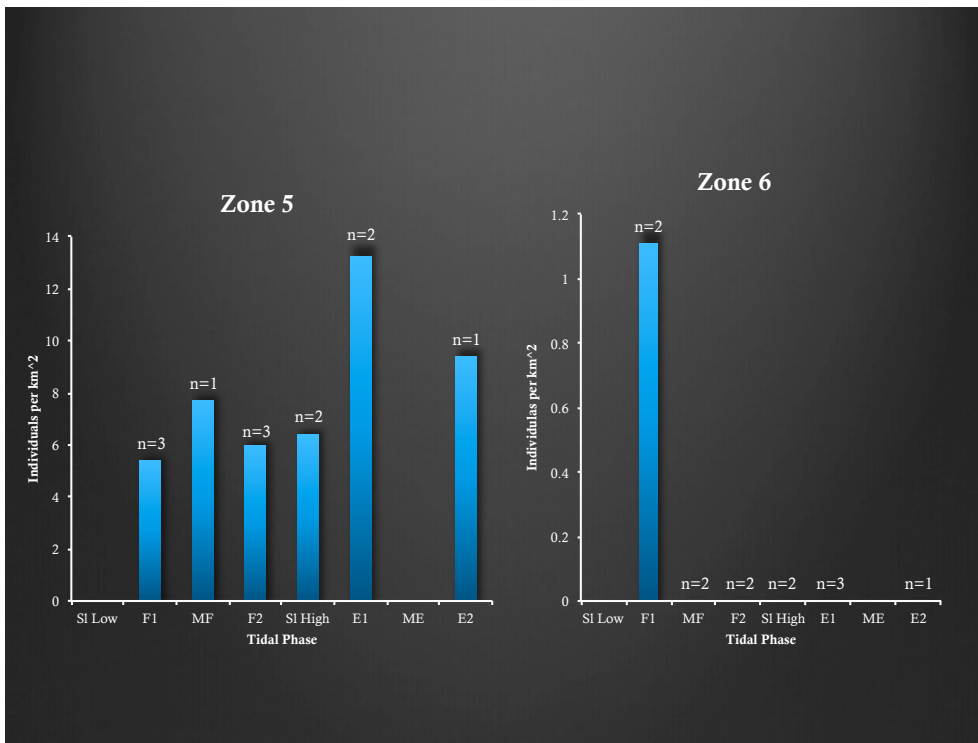


Figure 16: Steller Sea Lion abundance by tidal phase in zone 5

Figure 17: Steller Sea Lion abundance by tidal phase in zone 6

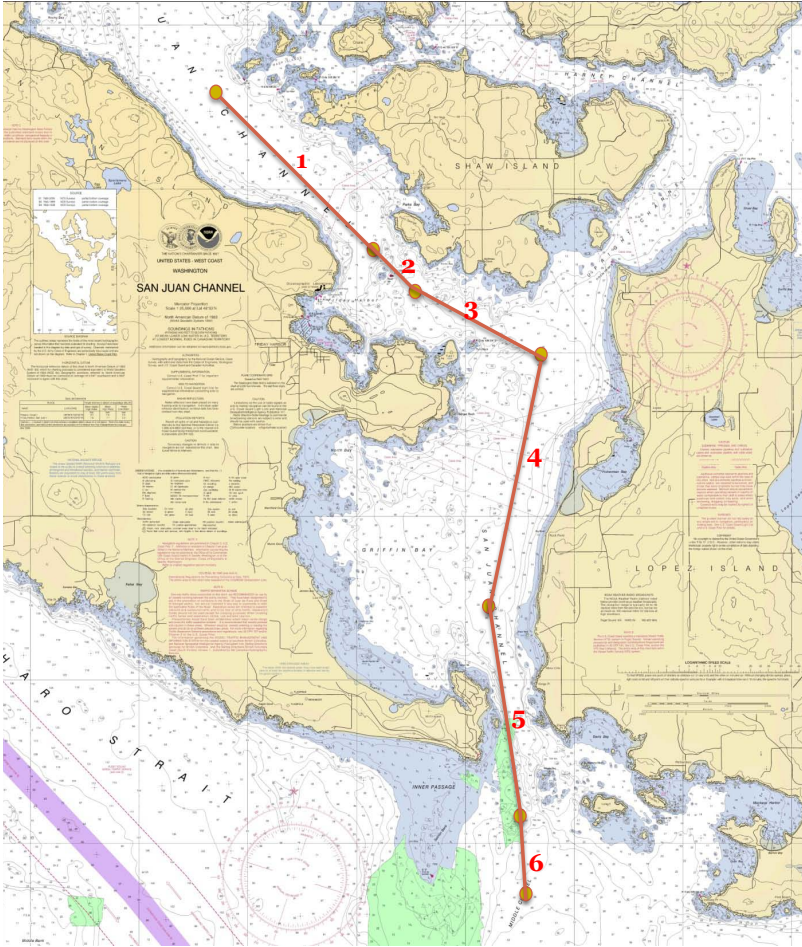


Figure 18: Map of San Juan Channel and location of six zones within the study site (Vermerie 2010)

TABLES

Table 1: Harbor Seal and Steller Sea Lion preference for tidal phase by zone in 2011

	<b>Harbor Seals</b>	<b>Steller Sea Lions</b>
<b>ZONE 1</b>	High	Too few animals
<b>ZONE 2</b>	High	High
<b>ZONE 3</b>	High	None
<b>ZONE 4</b>	None	Low
<b>ZONE 5</b>	None	None
<b>ZONE 6</b>	None	Too few animals