

Haul-out Behavior of Harbor Seals (*Phoca vitulina*) in Summer on Yellow Island: Diel Patterns Contrasting Females with Pups and Solitary Seals

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Abstract:

Knowledge of harbor seal distribution, abundance, and site fidelity is essential for conservation, as is knowledge of female-pup behavior. I focused on these elements in this study by assessing haul-out tendencies of a local population of harbor seals on Yellow Island, Washington, and contrasting these characteristics between female-pup pairs and solitary seals. I found that seal abundance varied with temperature, tidal height, and time of day, although these factors were not independent and worked simultaneously to determine haul-out abundance. Female-pup pairs hauled out in proportion to the number of female-pup pairs at the study site, suggesting these pairs were not more likely to haul-out than solitary seals under any conditions. It is possible that due to the unique adaptations of harbor seals during the pupping season, including a maternal foraging cycle and comparatively precocial pups, females and their young did not have different haul-out needs than other seals. However, females with young remained in the study site for a longer period of time, even as haul-out sites decreased. This finding was consistent with other studies demonstrating the increased site fidelity and decreased length of foraging trips of females with pups during the pupping season. Aggregating in haul-out areas may also be a predator avoidance mechanism.

Keywords: Behavior, Harbor Seals, Haul-out, Maternal Foraging Cycle, Pupping Season, San Juan Islands, Site Fidelity, Temperature, Tides, Washington, Yellow Island

Introduction:

Harbor seals are the most numerous pinniped species in the inland waters of Washington State, with a population of 15,000 individuals that is in a state of expansion (Jeffries et al. 2003). Censuses to judge growth and distribution occur on haul-out sites, where abundance of seals varies with time of day, tidal height, temperature, and other factors (Patterson & Acevedo-Gutierrez 2008; Stewart 1984; Schneider 1983). It is likely that several variables work jointly to determine haul-out abundance at each site, although the effects of these variables may differ among sites (Schneider 1983; Simpkins et al. 2003).

Haul-out abundance varies across seasons as well as with age and sex classes (Harkonen & Harding 2001). The highest numbers of hauled-out seals each year occur during the pupping season, which in Washington lasts from June to late September (Patterson 2008; Huber et al. 2001; Cunningham et al. 2009). Mature females give birth to a single pup each year (Bowen et al. 1992). Evidence suggests that female harbor seals have a maternal foraging cycle, common among otariids yet rare among phocids (Bowen 1999). Due to their relatively small body mass, female harbor seals are unable to fast for the full 24-day lactation period (Thompson 1994; Bowen 1996). Pups are therefore precocial; with a larger percentage of blubber than other seals and a fully molted coat, they are able to follow their mothers into the water within a few hours of birth without thermal stress (Thompson 1994).

Because harbor seal pups are able to forage with their mothers soon after birth, females with young may show similar diurnal foraging and haul-out patterns compared to the rest of the population. However, the behavioral characteristics of lactating females

may diverge from other seals in other respects, such as increased site fidelity and decreased travel distance from haul-out sites (Cunningham 2009; Thompson 1994). Since females are responsible for the behavioral development of their offspring, they may remain in shallow, calm waters for longer periods than other seals.

Clearly, knowledge of harbor seal distribution, abundance, and site fidelity is essential for conservation, as is knowledge of female-pup behavior (Cunningham 2009; Patterson 2008). Therefore, I focused on these elements in this study. Specifically, I assessed haul-out tendencies of a local population of harbor seals in relation to temperature, tidal height, and time of day, and contrasted these characteristics between female-pup pairs and solitary seals.

Methods:

Location

This study was conducted at Yellow Island, in the north San Juan Channel adjacent to the west end of Wasp Passage, or roughly 20 minutes by boat north of Friday Harbor, San Juan Island, WA. I conducted all surveys on a commonly used haul-out site on the west side of the island (Fig. 1). The site consists of three separate areas: 1) a series of large rocks parallel to the shoreline and less than 200 m out, the tallest of which is exposed up to a water level of 4.40 ft, 2) a sandy beach perpendicular to the shoreline exposed during all surveys, and 3) the rocky coastline of the island.

Surveys

From August 9th to 17th, 2011, between the hours of 0830 and 1730, I recorded weather (sunny, cloudy, windy, etc) as well as the number of solitary seals and female-

pup pairs hauled-out and in the surrounding waters. The counts continued every 10 minutes for 1 to 2 hours.

I distinguished female-pup pairs on land by the obvious size difference between pups and older seals, as well as the comparably close proximity of the pup to its mother. In addition, the female and pup interacted through activities such as nursing and other tactile functions, as well as through visual recognition. Female-pup pairs were visible in the water by size, by the frequent touching of vibrissae, and by the characteristics of the pair swimming. The pups swam along the mothers back so that the two heads were almost touching.

At times one member of the pair was hauled-out while the other was very close by in the water. To avoid double counting I always counted the pair as hauled-out. I observed other seals lying partially in very shallow water with their heads and tails pointed upwards. I counted this “basking” behavior as hauled-out. I continuously observed the water between counts in order to better judge the number of total seals, the amount of female-pup pairs, and their movements.

In this paper, “seals” refers to all seals (both female-pup pairs and others) in a specified location, “total seals” or “total female-pup pairs” includes individuals both in the water and on haul-out sites, and “female-pup pairs” denotes a mother with its pup.

Temperature and tidal height

I obtained temperature and tidal height readings post-survey using data from the Friday Harbor Laboratory weather station and tidal prediction software (*Mr. Tides 3*) respectively. Though using data from this weather station is not ideal due to its distance from the study site (5.3 km), measuring temperature in the field proved to be difficult and

unreliable. Tidal prediction software is a generally accurate prediction of tidal height, as demonstrated by NOAA's tides and currents website for Friday Harbor, Washington. I recorded temperature readings in half hour increments beginning at the hour, and tidal height every ten minutes in keeping with the increments used during the surveys. Tidal heights for surveys ranged from -0.83 ft to 7.12 ft with some overlap in heights between days, as summarized in Fig. 2.

Results:

During my surveys the total number of seals in the study site ranged from 5–84 individuals while the mean number of total seals per day was 44 (Table 1). The number of individuals in female-pup pairs ranged from 0–48 while the mean number of individuals in female-pup pairs per day was 23. Female-pup pairs represented 0-100% of the local population, though most frequently they accounted for 30-70%.

Across time, haul-out patterns were not significantly different between female-pup pairs and the rest of the population. The proportion of female-pup pairs hauled-out to seals hauled-out closely paralleled the proportion of total female-pup pairs to total seals (Fig. 3). This suggests that female-pup pairs haul-out in proportion to the number of female-pup pairs in the local population (Fig. 4), and that female-pup pairs are not more likely to haul-out than the rest of the population under any conditions.

Numbers of total seals and total individuals in female-pup pairs varied with time of day. Air temperature and tidal height also varied with time of day, and surveys did not cover all combinations of temperature, time of day, and tidal height. However, in two cases I was able to discern trends by fixing the tidal variable. Firstly, for all morning

surveys, regardless of temperature, the total number of seals in the study site spiked upwards between 1045 and 1200 hrs (Fig. 5), an interval corresponding with the last hour of low tide and the first hour of flood tide.

Secondly, since I surveyed multiple times at the same tidal height, I was able to fix tidal height for both morning and afternoon hours, and focus only on the effect of temperature on haul-out patterns. On two morning surveys, tides were similarly low but the average air temperature varied by 0.73°C , and the sun was much more prominent on the warmer morning, causing a discernable difference in temperature. About twice the mean number of seals and individuals in female-pup pairs hauled-out on the warmer morning (Fig. 6a).

Numbers of seals and individuals in female-pup pairs hauled-out increased with higher temperatures in the morning but not in the afternoon. On three dates with similar tidal heights, the average afternoon temperature varied by 7.73°C . The average number of seals and individuals in female-pup pairs hauled-out did not show a clear trend; the lowest mean number of seals hauled-out corresponded to the warmest afternoon (Fig. 6b).

Although the number of seals hauled-out varied, the average number of individuals in female-pup pairs hauled-out remained more stable across all temperatures in the afternoon hours. Total number of female-pup pairs remained more constant throughout the afternoon, while the rest of the population at the site declined, even as tidal height submerged most haul-out areas (Fig. 7). The steeper decline in the total population of seals compared to the less pronounced decline in total female-pup pairs caused larger percentages of total female-pup pairs in the population in the afternoons than in the mornings.

Discussion

Variability in Harbor Seal Numbers Among Days

The observed variability in numbers of total seals among days may have been due to differences in temperature, tidal height, and time of day (Patterson & Acevedo-Gutierrez 2008; Stewart 1984; Schneider 1983). Peak numbers of seals were observed from late morning to mid-day. When tidal heights were high, the offshore rocks were submerged, and correspondingly fewer seals were hauled-out. For mornings when tide height was similar, the numbers of seals hauled-out increased with increasing temperature. Since these factors are not independent, it was difficult to decipher which factor explained the most variation. My findings are consistent with multiple studies from different regions that demonstrate that the maximum number of seals hauls-out at low tide and mid-day (Everitt & Braham 1980; Schneider 1983; Huber et al. 2001; Patterson 2008). Schneider and Payne (1983) also found that sky cover explained 16% of haul-out variation, which could explain the differences in seal numbers during morning hours.

Mid-morning Spike in Harbor Seal Numbers

A combination of diurnal and tidal cycles may best explain haul-out behavior. For all morning surveys, regardless of temperature, the total number of seals in the study site spiked upwards between 1045 and 1200 hrs, an interval corresponding with the last hour of low tide and the first hour of flood tide. This could be related to foraging patterns, or simply due to the fact that at the maximum level of exposure of haul-out sites, the number of seals aggregating over time increases. Stewart (2004) found that the number of seals hauled-out throughout the year increased in morning hours with a spike

between 1300 and 1600 hrs regardless of tidal level. His findings suggested that tidal height alone did not determine the timing of peak haul-out, but may have had an effect on the absolute number of seals present during the daily peak.

Female-pup Behavior

Female-pup pairs hauled-out in proportion with the amount of total female-pup pairs in the study site, suggesting that female-pup pairs are not more likely to haul-out than other seals under any conditions. Harbor seals have smaller body sizes in relation to other seals, and females are unable to fast throughout lactation (Bowen 1999). They resort to foraging trips and often bring their pups (Thompson 1994; Bowen 1996). Harbor seal pups have a higher percentage of blubber at birth than other seals, as well as a fully molted coat. They can therefore accompany their mothers without thermal stress (Thompson, 1994). Because of these adaptations, females-pup pairs may not show different haul-out patterns than other seals. Skinner (2006) found that increasing the distance that pups traveled by two orders of magnitude did not result in apparent changes in mass gain rates, and that pup mass gain rates were positively associated with increased water activity. The amount of energy a pup uses by remaining in the water is insignificant compared to the amount of energy it obtains from nursing (Skinner 2006).

As tide height increased, declines in total female-pup pairs were less pronounced than declines in total seals. This meant that as tides increased (which also corresponded to time of day during my study) the percentage of total female-pup pairs in the study site also increased. It must be more important for females with pups not to leave the area as quickly, even as haul-out space decreases. Silva & Terhune (1988) suggest that haul-out groupings occur as a predator avoidance mechanism. In addition, harbor seal pups may

prefer shallow waters and kelp forests for safety and predator avoidance (Bjorge et al. 2002). Thompson et al. (1994) and Skinner (2006) found that females with pups demonstrated increased site fidelity. They decreased the length of their foraging trips as well as the distance between the haul-out sites that they frequented (Thompson et al. 1994). It is possible that females take advantage of the shallow calm waters and kelp forests of this haul-out site on Yellow Island to rest, teach pups how to dive and forage, and avoid predators simultaneously. Other sites should be studied to see if female-pup pairs use all haul-out sites similarly, or if female-pup pairs only remain around haul-out sites with similar conditions to Yellow Island.

Bias in Counts

Female-pup pairs are often the first to flush in response to a disturbance. A team of three researchers and I conducted our observations from an exposed hill about 150 meters from the offshore rocks. Approaching, we did not notice any flushing occur. However, the beach, a known haul-out site (P.Green pers. comm.) was within 50-70 meters, and at times we observed female-pup pairs swimming very close to shore and viewing us without hauling-out. Twice during surveys groups of kayakers passed within 50 meters of the rocks, and seals flushed. Disturbance could have affected the proportions of female-pup pairs hauled-out to seals hauled-out, and the proportions of seals hauled-out out of the total population.

Data may be biased towards hauled-out seals, as seals are much more difficult to spot in the water. Huber et al. (2001) present a correction factor for use in the San Juan Islands during pupping season, where the total population of harbor seals is approximately 1.53 times the number of visible seals hauled-out. Using this correction

factor at the study site could result in more accurate population numbers as well as proportions of seals hauled-out.

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Tables and Figures:

Table 1: Numbers of total harbor seals and of female-pup pairs observed by date and by time of day on Yellow Island, Washington.

Date	Number of Total Seals Per Day				Number of Total Individuals in F/P Pairs Per Day			
	Max	Min	Mean	Std Dev.	Max	Min	Mean	Std Dev.
8/9/11	45	5	29.65	16.54	22	0	13.50	7.04
8/10/11	84	32	61.38	15.75	40	12	27.54	8.80
8/11/11	74	54	63.15	7.35	46	24	34.31	7.06
8/12/11	54	27	40.54	8.36	32	18	23.54	4.41
8/16/11	37	16	28.15	6.40	20	12	17.08	2.78
8/17/11	72	26	42.30	13.28	48	10	24.80	10.42
Morning	84	32	56.88	14.30	46	14	27.47	9.73
Afternoon	72	5	33.21	14.60	48	0	19.08	8.58

Figure 1: Study site on Yellow Island, Washington.



Figure 2: Predicted tidal heights during each survey for Friday Harbor, San Juan Channel, Washington (accessed from *Mr. Tides 3*).

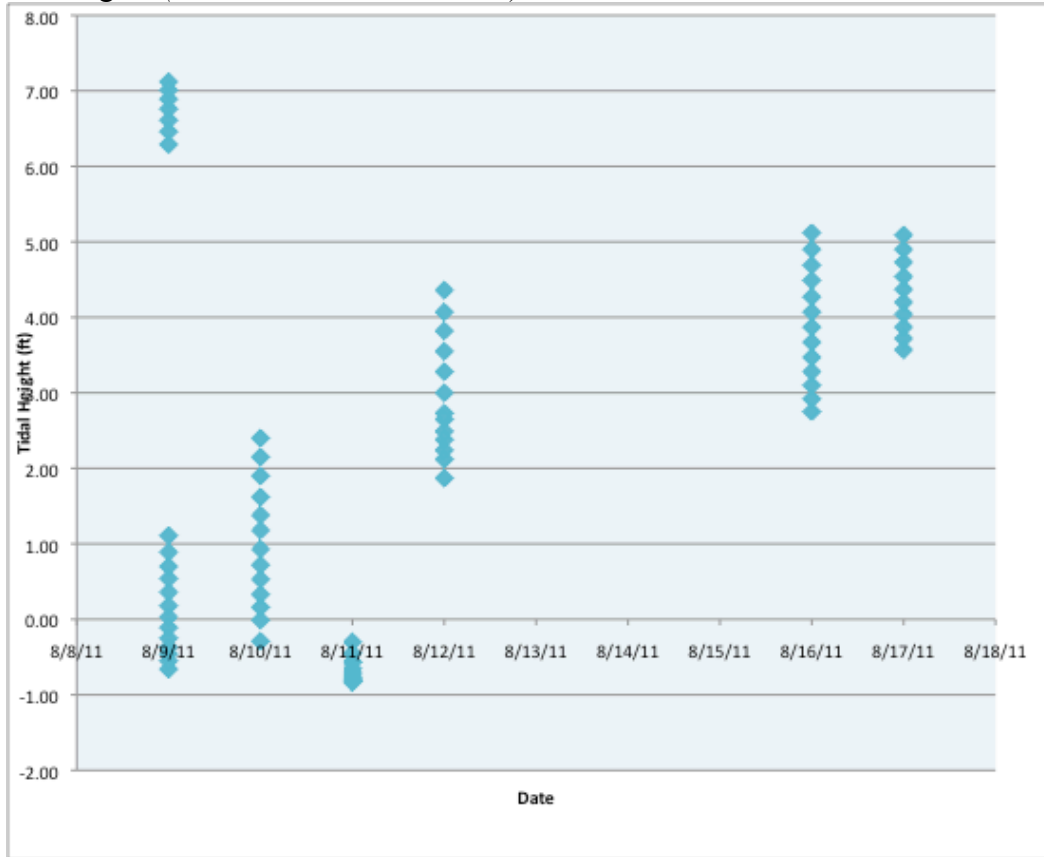


Figure 3: Percent of harbor seals hauled-out that were female-pup pairs, and percent of total seals that were female-pup pairs on Yellow Island, Washington.

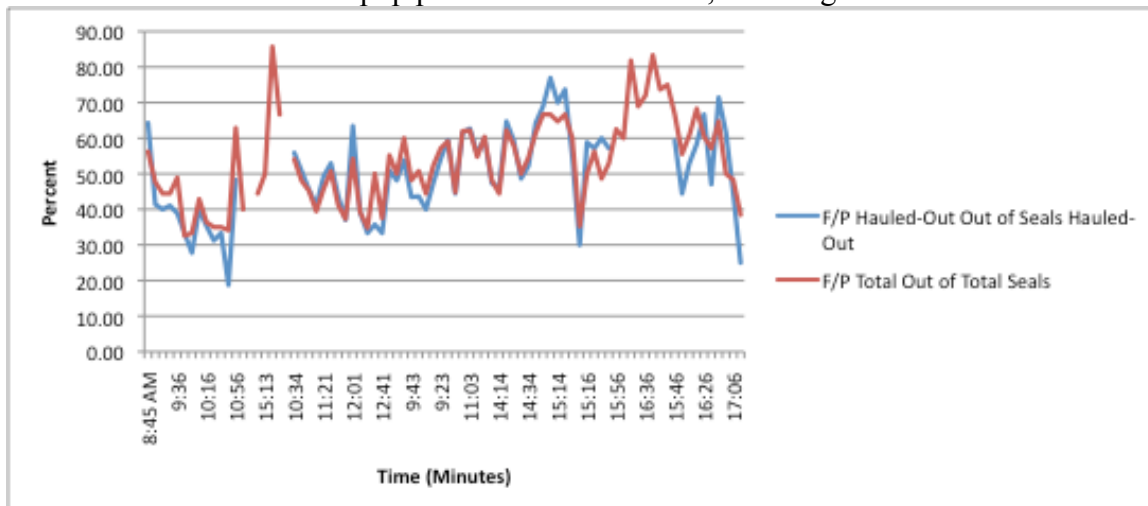


Figure 4: Percent of seals hauled-out that were female-pup pairs relative to percent of total seals that were female-pup pairs, on Yellow Island, Washington.

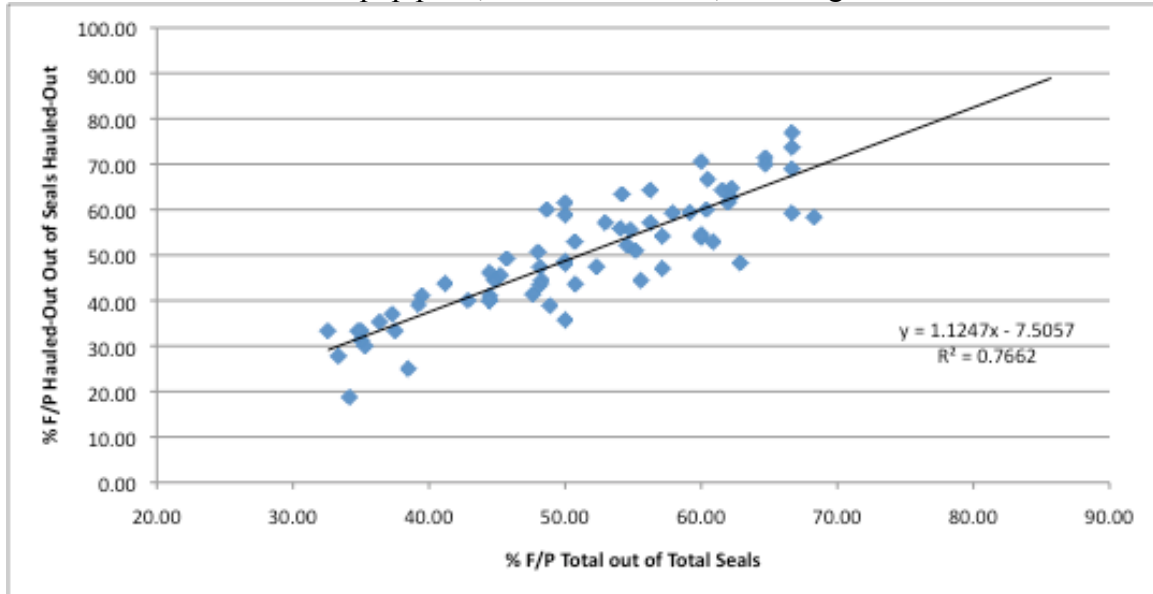


Figure 5: Number of harbor seals observed by time of day on Yellow Island, Washington during August 9th–17th, 2011.

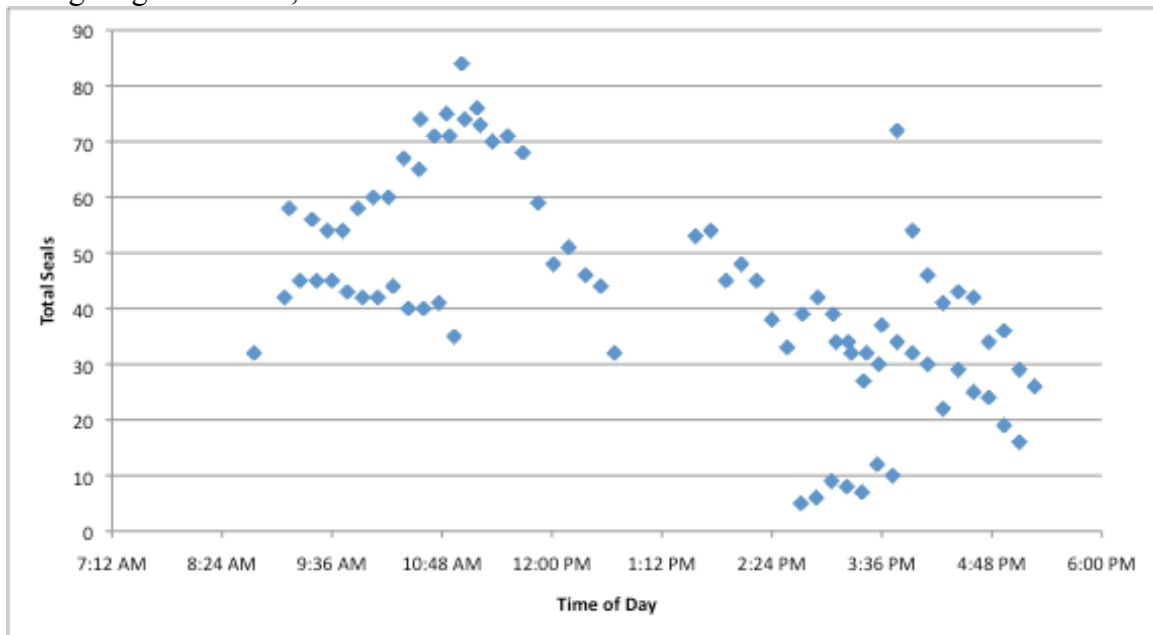
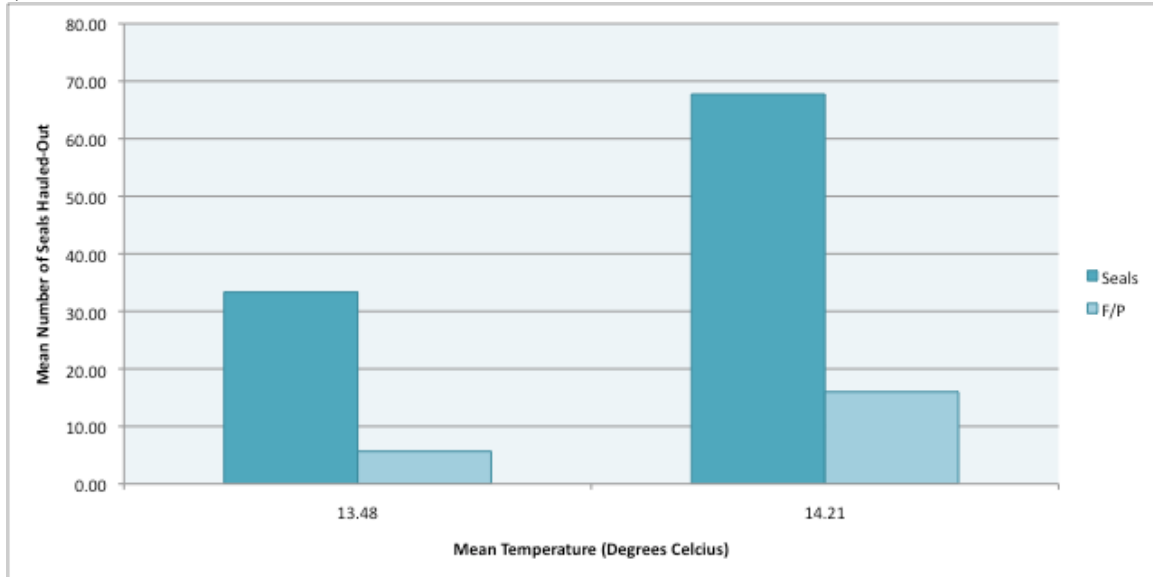


Figure 6: Mean number of seals hauled-out and individuals in female-pup pairs hauled-out by mean temperature for (a) morning hours (0830-1200) at fixed tidal height (-0.25-1.18 ft) and (b) afternoon hours (1200-1730) at fixed tidal height (2.95-4.37 ft) on Yellow Island, Washington.

a)



b)

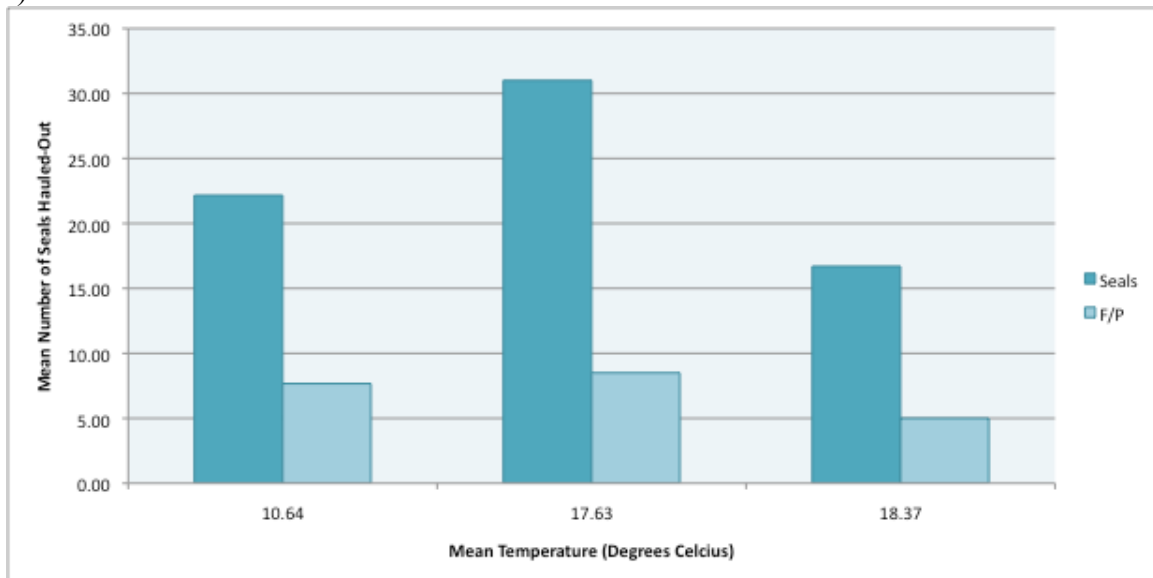
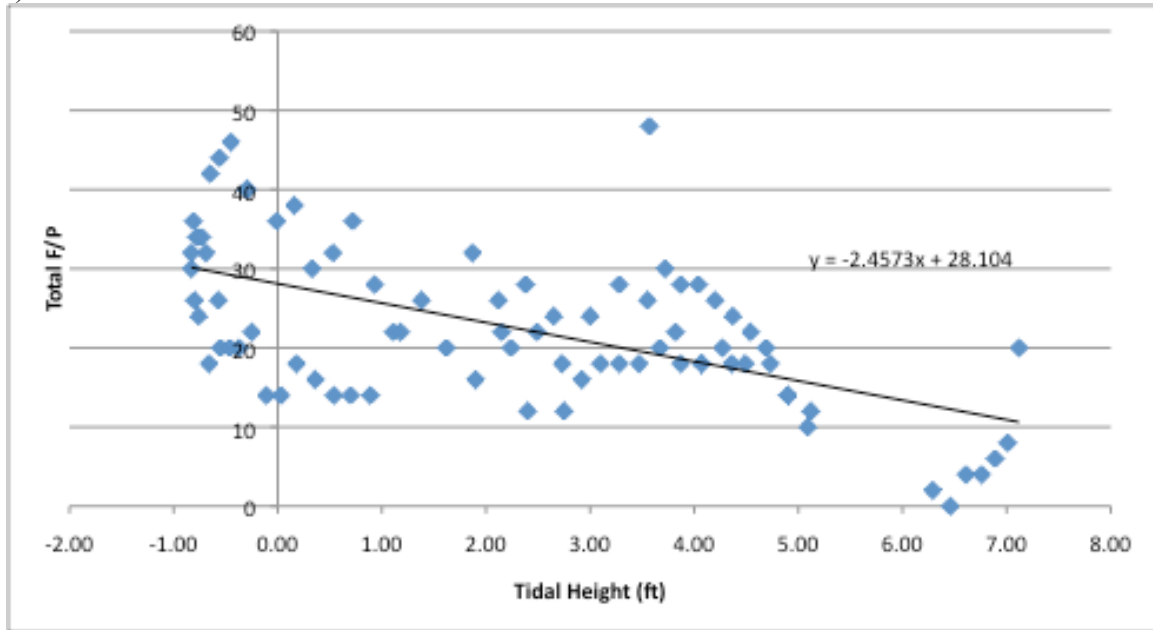


Figure 7: Number of (a) total female-pup pairs and (b) total seals relative to tidal height on Yellow Island, Washington.

a)



b)

