Monitoring Harbor Seal Abundance Counts at Haul-Out Site on Goose Island

Galadriel Donahue

Zoology Botany Program

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1 Friday Harbor Laboratories, University of Washington, Friday Harbor, WA 98250

Contact information:
Galadriel Donahue
Marine Biology
University of Washington
620 University Road
Seattle, WA 98250
gdonahue@uw.edu

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Abstract

Phoca vitulina (harbor seal) haul-out behavior provides metabolic benefits, safety, and reproduction opportunities. Collecting seal count data at these sites between different times of day can provide indications about harbor seal abundance as well as have larger implications for local food webs and impacts of anthropogenic-induced climate change. It was hypothesized that Harbor seal counts will be significantly higher at later times of day due to higher temperatures (thermoregulatory advantages). Overall, it was found that time of day had a significant impact on hauled-out harbor seal counts. This has implications for how their ability to detect predators may decrease with rising sea levels, and in turn affect food web dynamics.

Introduction

Harbor seals are important to marine food webs as well as ecosystem stability and predator-prey interactions (Shields et al. 2018). They are an important food source for transient killer whales (*Orcinus orca*) and can be indicative of the whales' presence (Shields et al. 2018). "Hauling-out" refers to the behavior of some pinnipeds in which they temporarily leave the water, often between periods of foraging, to facilitate ecological functions such as blood circulation without heat loss, hair regrowth, resting, and reducing aquatic predator risk (Hamilton et al. 2014). Locations for harbor seal haul-out sites may include reefs, rocks, and beaches (Montgomery et al. 2007). Haul-out behavior is essential for most pinniped species in terms of thermoregulatory advantages, rest, reduced risk from predators, etc (London et al. 2012).

The purpose of this study is to further investigate how harbor seal haul-outs differ between morning times and afternoon times, as well as individually compare temperature and tide between morning data and afternoon data to see if there is a significant difference between

them. Collecting data on harbor seal abundance and environmental factors at a haul-out site, Goose Island, can be correlated to how harbor seals are impacted by anthropogenic-induced climate change. The accumulation of greenhouse gasses by anthropogenic input has caused a rise in the Earth's mean temperature and ocean heat content, which consequently leads to the melting of glaciers; the combined effects of ocean warming and glacial melt cause sea level to rise (Cazenave and Cozannet 2014). Studies have found that increasing sea levels restrict the amount of habitat available for hauling-out (Backe 2018), and by observing changes in tide it can be determined whether higher water levels cause there to be less seals present at a given time of the day.

There have also been studies on marine organism circadian rhythms in response to the tidal cycle, as well as how these tidal rhythms and temperature coincide with time intervals (Palmer 1973). It is assumed that the air temperature throughout the day will increase as the sun rises, which is why there may be a difference between morning and afternoon. Previous studies suggest that tide rhythms operate on a 12.4 hour period, but there is not a specific time of day at which these cycles are specified to happen (Palmer 1973) (Palmer 2000). Lack of previous research correlating time of day to haul-out abundance is a motivating factor for exploring these interactions. Our null hypothesis states that afternoon Harbor seal abundance counts at Goose Island will not be significantly different from the morning counts. Our alternative hypothesis states that harbor seal abundance counts will be significantly higher at later times of day due to higher temperatures (thermoregulatory advantages of warmer weather).

Methods

All research for this project was conducted near a harbor seal haul-out located in the Salish Sea ecosystem in Pacific coastal waters of Washington state. The haul-out site chosen for

observation was Goose Island, a small nearshore island approximately 0.262 miles east of the Cattle Point peninsula of San Juan Island, WA; Figure 1, red star. This site was chosen based on recommendation by local marine mammal experts conducting year-round surveys of pinniped haul-out sites around San Juan Island to understand harbor seal abundance (Jessica Farer, personal communication). The location where observer data collection took place is shown in Figure 1 and represented by the red circle. This observation location was chosen for data collection as it was 1) the nearest accessible shoreline location (a distance of 0.262 miles) to the haul-out site and 2) it was clear of any physical obstruction blocking the view of seals at the haul-out site.

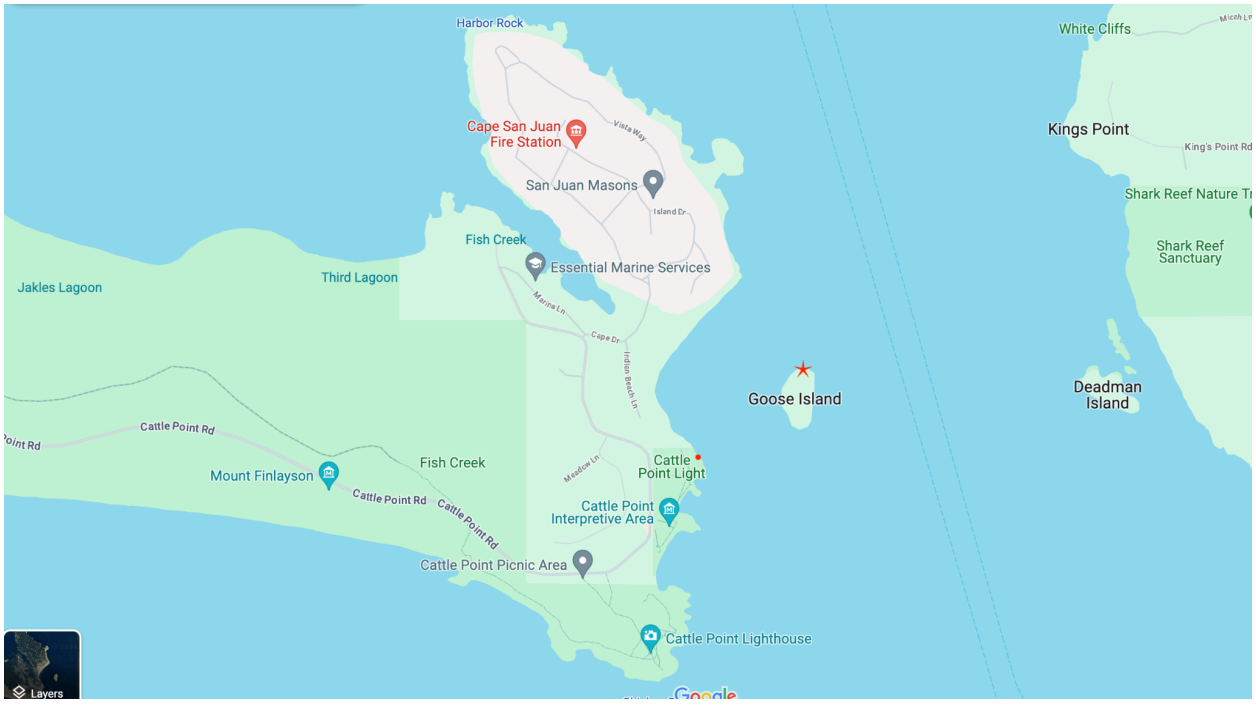

Figure 1: Cattle Point, SJI: Goose Island haul-out site (red star), and observers location (red dot)

Equipment needed includes binoculars, a camera, field notebook, and phone for weather/air temperature/time data. Field efforts conducted at this site resulted in a total of 20

observations of harbor seal abundance; 10 occurring during morning hours and 10 during afternoon hours. Seal abundance data (a count of visible, individual hauled-out seals) were collected using two complementary methods: 1) real-time counts using binoculars (compact/300x25/5000m), and 2) digital photography (Nikon B500 Coolpix, lens length = 900 mm) for counts based on review of digital images. If an individual pops up in the site, i.e. completely hauls out in the middle of a count, they will not be included in the overall count number, unless they haul out in an area that has not been counted yet. Data collection occurred between April 27th and May 24th. Each site will have n =10 data points per morning/early afternoon and evening time frames. Upon arrival at the site, a team of two observers took approximately five minutes to count every seal visibly hauled-out on Goose Island through binoculars. One observer counted individuals through the binoculars while the other recorded data, then the observer roles were switched, and the haul-out site was recounted. These counts collected by each observer for each counting method (binoculars and camera imagery) were averaged and this value was recorded as the official count for that date/time/location/method. Tide will be recorded using values from NOAA's Tides & Currents online charts. Tide was categorized into two categories, low and high, with low being negative tide values and high being positive tide values. Air temperature was categorized into two categories, cool and warm, cool being 12 degrees C and below, warm being 13 degrees C and above. These values were categorized for the purpose of conducting t-tests, and specific values were chosen based on the data recorded from the experiment.

Photographic seal count data and the binocular-based count data were combined for each observation session to create the final seal count data point to be used for analysis. However, the comparison of datasets collected via photographic and binocular methods were also analyzed to

calculate relative error due to survey methods. Individual t-tests (two-sample assuming equal variances) were performed on seal counts to see if there was a significant difference between morning counts and afternoon counts, as well as comparing high vs. low tide and warm vs. cool temperatures.

Results

Figure 2 shows the comparison between morning and afternoon counts for each of the ten surveys conducted. Overall, the morning had higher average seal abundance (total average of 10 morning surveys = 28 seals) than the afternoon (total average of 10 afternoon surveys = 7 seals). The minimum amount of seals counted occurred during afternoon surveys 8 through 10 on May 24th, with an average of 0 seals counted. The highest number of seals counted occurred at afternoon survey 1 on April 27th, with an average of 45 seals. Only the first survey from the afternoon showed higher average harbor seal abundance count compared to the morning data. Additionally, there were seals present at every morning survey, whereas five afternoon surveys had zero reported seals by at least one observer. A t-test (two-sample assuming equal variances) was performed on the average seal count values comparing the morning and afternoon, which showed a significant t-statistic of 3.003, and a significant p-value of 0.004.

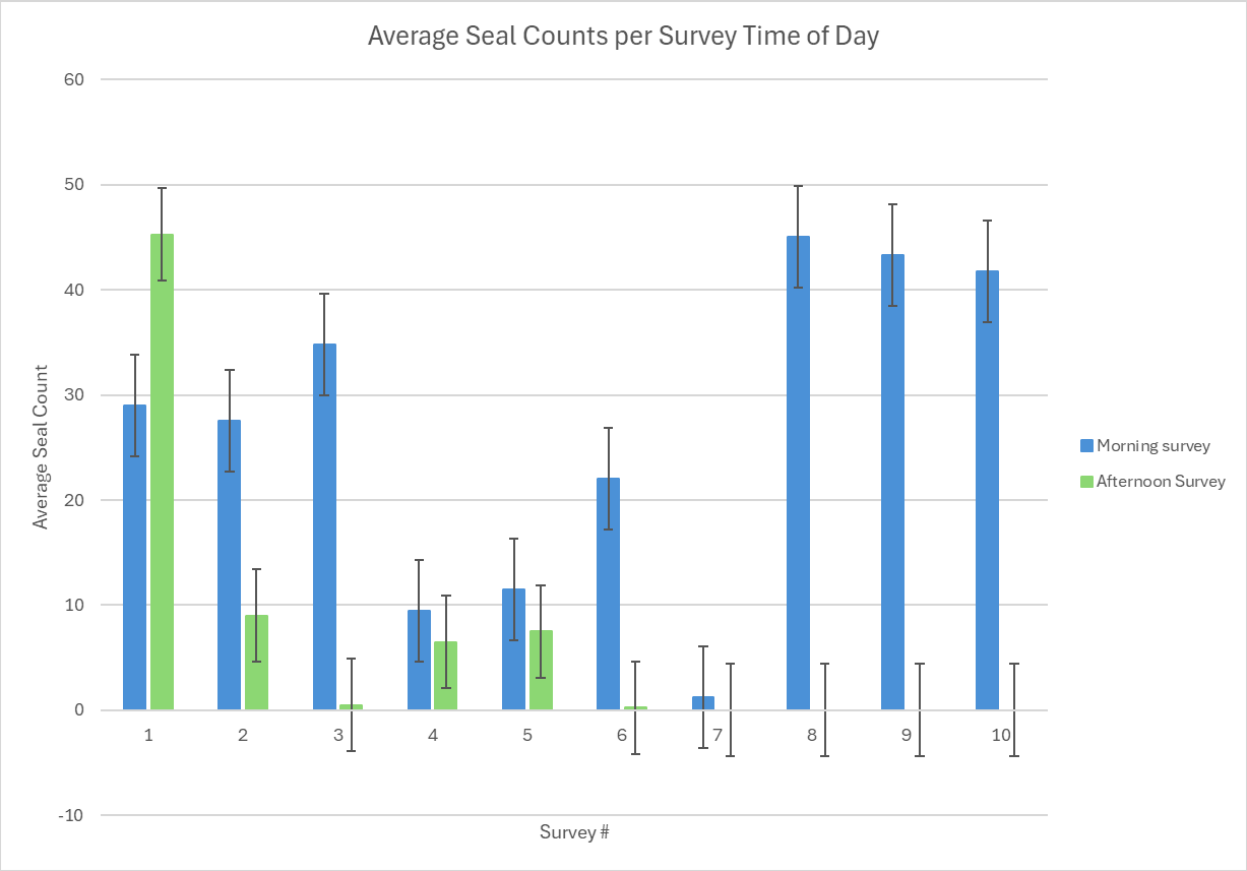

Figure 2: Average harbor seal abundance counts for each time of day (morning and afternoon) over the course of ten surveys per each group.

The relationship between average seal counts for each survey and the corresponding tide height to that time of day was compared (Figure 3). Overall, the morning surveys had much lower tide heights (average morning tide height of -0.13 ft) than the afternoon surveys (average afternoon tide height of 2.57 ft). An average of zero harbor seals were reported in the 7th afternoon survey on May 23rd when the tide height reached a record high for this data set at 7.84 ft. The lowest tide occurred during afternoon surveys 8 through 10, with a height of -2.13 ft. A t-test was performed (two-sample assuming equal variances) to determine if there was significance between average seal count at high and low tide. It resulted in a p-value of 0.24 and a t Stat of -0.72 which is not statistically significant.

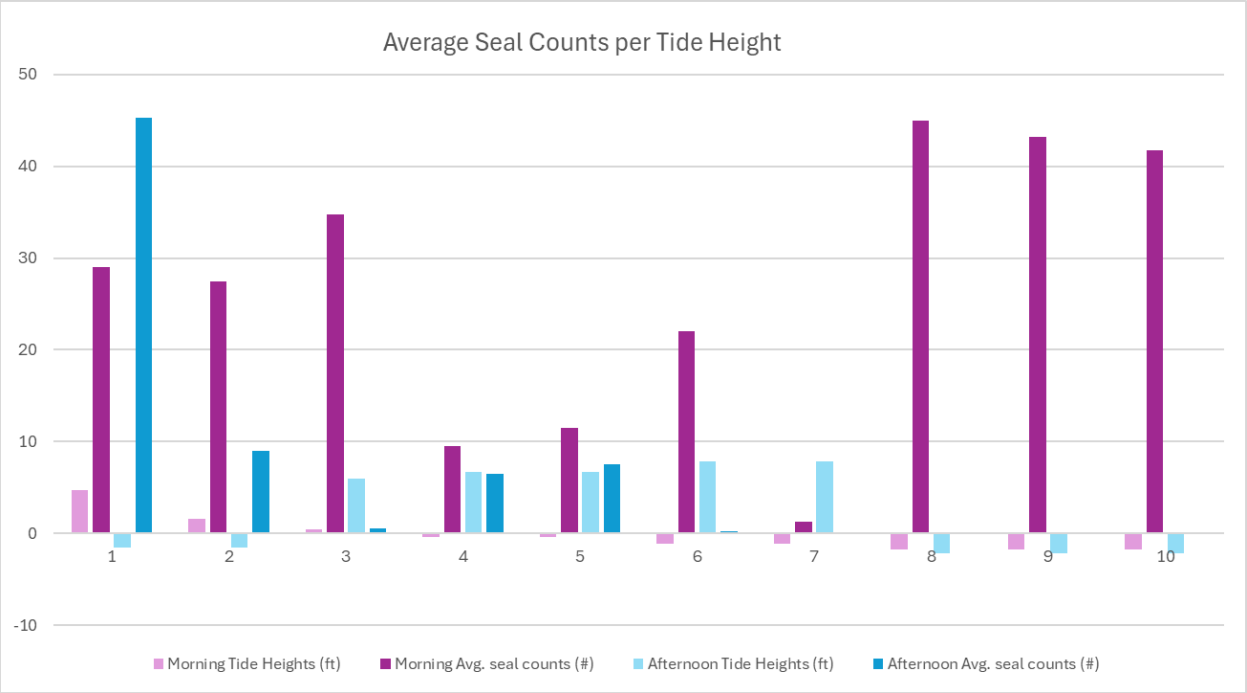

Figure 3: Average seal counts per survey for both morning and afternoon compared to tidal heights for each survey for both times of day.

Abundance in warm and cool temperatures was compared using a t-test (two-sample assuming equal variances) to determine if there was correlation between these two variables. The results were not significant, with a p-value of 0.057 and a t Stat of 1.65. Figure 4 shows how temperature varied across the 20 surveys conducted. The highest temperature recorded was during afternoon surveys 6 and 7 on May 23rd at 16 degrees Celsius. The lowest temperature recorded was during morning surveys 4 through 7 and survey 9 on May 21st-23rd at 10 degrees Celsius. Weather did vary across the 20 surveys, but did not influence whether or not seals were present. Harbor seals were observed both during sunny weather as well as harsh winds and rain during low tide in the morning. Figure 5 shows a table with the weather data compared to seal counts; the results of this comparison are highly variable, therefore weather cannot be considered a factor influencing harbor seal abundance. According to these findings we would reject our null

hypothesis that harbor seal counts would not be significantly different between the morning and afternoon. However, we would not accept our alternative hypothesis either - although they vary from each other, the afternoon seal counts are lower than the morning seal counts.

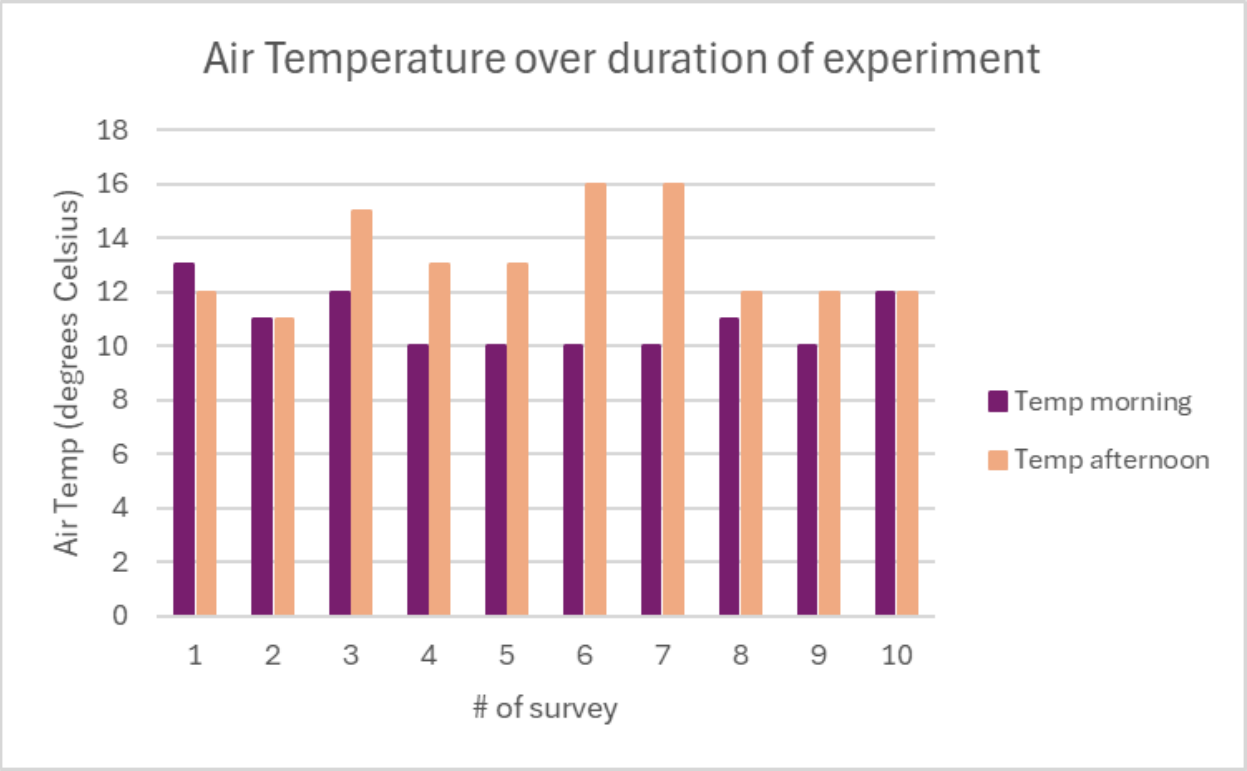

Figure 4: air temperature in degrees Celsius over the duration of the experiment. Temperature was recorded for each of the 20 surveys, in the morning and afternoon.

Weather	# of seals (binoculars)	# of seals (camera)
windy/cloudy	39	56
windy/cloudy	30	56
windy/cloudy	11	10
windy/cloudy	5	10
partly cloudy/sunny	23	38
partly cloudy/sunny	16	39
windy/cloudy	29	34
windy/cloudy	12	35
partly cloudy/sunny	35	37
partly cloudy/sunny	30	37
sunny	0	0
sunny	2	0
windy/rainy	8	n/a
windy/rainy	11	n/a
windy/rainy	10	n/a
windy/rainy	13	n/a
windy/rainy	8	n/a
windy/rainy	5	n/a
windy/rainy	8	n/a
windy/rainy	7	n/a
partly cloudy/sunny	25	22
partly cloudy/sunny	16	25
partly cloudy/sunny	2	1
partly cloudy/sunny	1	1
cloudy	46	48
cloudy	36	50
cloudy	33	51
cloudy	37	52
cloudy	33	48
cloudy	37	49
sunny	0	0
sunny	1	0
sunny	0	0
sunny	0	0
windy/cloudy/sprinkling	0	0
windy/cloudy/sprinkling	0	0
windy/cloudy/sprinkling	0	0
windy/cloudy/sprinkling	0	0
windy/cloudy/sprinkling	0	0
windy/cloudy/sprinkling	0	0

Figure 5: Table depicting weather conditions for each survey compared to the harbor seal count data for both binoculars and camera. Windy/rainy data is listed as N/A for camera data because weather conditions were too harsh to bring camera equipment to the survey.

Discussion

Based on these findings, it can be concluded that there is a significant difference between the amount of harbor seals hauling-out onto Goose Island in the morning compared to the

afternoon. There is not a significant effect of tide on average harbor seal abundance. There is also no significance between air temperature and how many seals were hauled-out at a given time. Weather was highly variable and did not have attributable impacts on harbor seal abundance.

Previous studies on harbor seal haul-outs show that tide, air temperature, and wave intensity had the greatest impact on seal abundance, which was similar to ours in that the tide was significant (Schneider and Payne, 1983) (Steingass et al. 2019). Tide and time of day combined have been associated with harbor seal haul-outs as well, supporting our most significant finding about time of day (Patterson & Acevedo-Gutiérrez 2008). One study focused on anthropogenic noise found that harbor seals can become more sensitive to noise in lower activity zones, or more tolerant in higher activity zones (Bankhead et al. 2023); more data would be needed to determine if this factors into our findings. A behavioral haul-out study observed that larger groups offered better predator detection with less energy devoted to the task, supporting our suggestion that harbor seals haul-out in energetically efficient ways (Terhune 1985).

This type of defensive strategy with low energetic costs can be tied into anthropogenic disturbance as well; when high boat activity occurs in the area, the seals are able to quickly navigate away from the stressor (Bankhead et al. 2023). They may also be using high tide to their advantage by hunting out in the open ocean when water covers a greater amount of area (Hanke and Dehnhardt 2018), and can therefore rest when it drops again. Unfortunately, these findings do not support our original hypothesis, as it was stated that there would be higher seal presence in the afternoon.

General trends in the graph data suggest that certain assumptions can be made about these findings; although it wasn't statistically significant, low tidal height is generally associated with a higher presence of harbor seals (Figure 3). This may be a prevalent factor at Goose Island due to the rocks that become exposed at low tide in the area. Figure 6 shows a comparison between the Goose Island rock and beach exposure at low and high tide. It can also be assumed that this low rocky outcropping gives a wide range of view, whereas being higher up on the beach means that part of the water view would be obstructed by the island. The trend observed in harbor seals may be associated with the energetic costs of hauling out, especially since this behavior is associated with resting advantages; it may be easier for the seals to pull themselves up onto the low, wet rock rather than the more highly elevated beach. It also allows them to easily drop back into the water in the presence of predators. On May 22 during the morning survey, four transient killer whales appeared behind the rock outcropping of Goose Island where an average of 22 seals were hauled-out. After detecting the whales nearby, a large portion of the harbor seals dropped into the water swiftly, whereas farther on land they may not have been able to perform this quick movement. A study found that harbor seals abandon their haul-outs in the presence of a predator, which supports the observations made when the transient killer whales approached Goose Island (Nordstrom 2002). The low tide and complete absence of seals on the afternoon of May 24th might have been associated with a whale watch boat passing close by Goose Island during the survey, potentially disturbing the seals that may have been hauled-out there.

Figure 6: a comparison between the low and high tides at Goose Island. Low tide (top picture) shows a long stretch of exposed rock, along with the beach, where harbor seals are

commonly seen hauling-out. High tide (bottom picture) shows the beach at high tide, with all of the low rock being covered by water, along with some of the beach.

In order to answer similar questions about anthropogenic disturbance, it would be worthwhile to repeat these observations with close attention to boat traffic and harbor seal behavioral responses. It could also be improved by conducting these observations over multiple seasons, especially between winter and spring or summer and fall, to determine if there is a higher correlation between temperature and seal counts during these seasonal transitions.

Overall, this data can have higher implications for climate change and trophic level interactions. As sea level rises, the same amounts of low tide rock exposure may not be available for harbor seals, onto which they have shown a preference for hauling-out (Schneider and Payne 1983). This can have an impact on their susceptibility to predators such as transient killer whales (Blanchet et al. 2021). They may not be as evasive if they are unable to haul-out in groups for easy predator detection (Terhune 1985). A decrease in harbor seal abundance can have cascading effects on marine vertebrates and alter food web dynamics (Mathews and Pendleton 2006). By further assessing seal counts and harbor seal behavior at haul-out sites, researchers can better understand how environmental and anthropogenic factors are influencing this species.

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