

# Effects of Vessel Disturbance on Harbor Seal (*Phoca vitulina*) Abundance and Behavior at Yellow Island and Goose Island, WA, USA

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**Abstract:**

Harbor seals (*Phoca vitulina*) are pinnipeds inhabiting northern temperate coastal regions, with one of their most dense populations found in the Salish Sea of the Pacific Northwest. They use haul-out sites for activities such as rest, nursing, and protection from predators. Vessel traffic around haul-out sites has previously been shown to cause behavioral disturbance. We conducted a behavioral study on two harbor seal haul-out sites in the San Juan Islands, WA, USA: Yellow Island and Goose Island. By conducting behavioral focal and scan sampling with and without vessel presence, we quantified the impact of vessel disturbance on behavior. We observed a higher baseline vigilance rate at Goose Island. Moreover, we found that vessel presence increased vigilance at Yellow Island and decreased abundance on land at Goose Island. We believe that the varying behavior and vessel responses observed at each location are likely due to the ecological and topographical differences between the two haul-out sites. Increased vigilance and flushing incur higher levels of stress and increased energy expenditures, causing these seals to spend less time on important behaviors like rest and reproduction. While harbor seal populations are not currently at risk or endangered, vessel traffic in the Salish Sea is expected to increase by at least 25% in the near future as more vessel projects are approved every year. As this anticipated rise occurs, the observed effects of vessel disturbance on harbor seal behavior observed in this study are likely to worsen over time. This could potentially threaten the future health and abundance of harbor seal populations in the Salish Sea.

**Keywords:** Harbor seals, *Phoca vitulina*, vessel disturbance, behavior, abundance, Yellow Island, Goose Island

## Introduction

Harbor seals (*Phoca vitulina*) are pinnipeds inhabiting northern temperate coastal regions, including the San Juan Islands of the Pacific Northwest. In addition to being a tourist attraction and boating hotspot, these islands provide haul-out sites which harbor seals depend on for essential activities including rest, reproduction, thermoregulation, and protection from predators (Terhune and Brilliant 1996). The most common activities observed in harbor seals while hauled out are vigilance and loafing. Previous studies suggest that mothers become more vigilant when caring for pups, and the entire group becomes more vigilant when vessels are near the haul-out site (Newby 1973).

Vessel traffic through inhabited channels poses a risk of collision and behavioral disturbance to these populations. To minimize vessel disturbance on marine mammals, US National Oceanic and Atmospheric Administration established a vessel buffer zone of 91.4 meters. However, vessel presence outside of this zone is still correlated with increased vigilance (Johnson and Acevedo-Gutiérrez 2007). Large commercial vessel traffic is expected to increase by at least 25% as expansion projects increase in the Salish Sea (sanjuans.org). An increase in vessels in the area will further exacerbate the observed impacts that vessels have on harbor seals.

We conducted a comparative study using two haul-out sites within the San Juan Islands, Yellow Island, and Goose Island. Yellow Island has multiple offshore haul-out rocks accessible at lower tides, alongside a relatively smaller beach used primarily during high tides. These sites are on the west side of the island, facing the channel. A buffer buoy is in place to establish the minimum 91.4 m vessel distance required from the seal population. In contrast, Goose Island is a relatively larger site, with one main beach haul-out. Harbor seals haul out on the west side, opposite the channel on the east side. This island is also a nesting site for cormorants and

glaucous-winged gulls. There is currently no buffer buoy to establish the 91.4 m distance required by vessels at Goose Island.

This study aims to frame these site-specific variations in the context of vessel disturbance, particularly in relation to past research conducted by Carpenter, Ogle, and Weise in 2021. Our comparative objectives between Yellow Island and Goose Island were to (i) observe the abundance of harbor seals in the water and on land, (ii) observe the amount of time the sample population spends on different behaviors, and (iii) observe how the presence of vessels affects harbor seal abundance and behavior.

## **Methods**

### *Study Sites and Sampling Methods*

We collected data between 4-9 August 2023 at both Yellow Island (48°35'29" N, 123°02'03" W) and Goose Island (48°27'29" N, 122°57'19" W), which are smaller islands located around San Juan Island, WA, USA. Both locations were chosen because they had consistent and reliable large haul-out sites for harbor seals. All data was collected by land-based survey samples from shore using a Celestron Vortex Optics Pro GT 20-60X80 spotting scope. At Yellow Island, we accessed our study site off the west side on a dirt path approximately 50-150 m from the three haul-out sites. We collected data for Goose Island by going to the southern point of San Juan Island: Cattle Point Interpretive Area. Here, we followed a rocky shore path north of the interpretive area, viewing Goose Island's west side from about 400 m away. Three days were spent at each location, averaging around 2 hours of data collection/day between the hours of 10:00-12:00 and 13:00-16:00. This totals 6 hours of observation at each location, with a total of 12 hours over the four days. Between each survey, all members rotated between observing through the two scopes and recording.

### *Abundance Sampling*

During each day of data collection, we conducted both focal surveys on individuals and scan surveys to measure abundance. Every 15 minutes, we conducted a scan survey counting the abundance of lone adults and mom pup pairs, both in the water and hauled out on land. When only one haul-out site was present, two observers performed the scan survey, and the abundance count was averaged between the two for optimal accuracy. On days where there were multiple sites visible, each observer solely collected data for their respective site.

### *Behavioral Sampling*

Between every scan survey, we conducted focal surveys on randomly selected individuals. In instances where we had one recorder and two observers, we conducted two focal surveys at once. Each observer randomly selected a lone adult or mom pup pair by blindly moving the scope and selecting the individual closest to the center. For 10 minutes each observer noted what behavior the individual or pair was engaging in every 30 seconds. Categories of behaviors included: loafing, vigilant, swimming, nursing, aggression, other, and N/A for when the view became obstructed. “Other” behaviors were recorded when the seal exhibited more opportunistic behaviors like affection (e.g. nuzzling or licking) between mom and pup, or when an individual was actively on the move. While most of the behaviors were easy to categorize, we did specify that a seal in the water could be categorized as vigilant if they were not moving and had their head out of the water. If they were in the water and actively swimming or diving, we categorized that under swimming.

### *Vessel Traffic*

Vessel traffic was determined by recording the time at which a vessel passed closest to the haul-out site at each location (within 1000 m). We also recorded the number of vessels

present. The times at which vessels were recorded were aligned with the matching times that we recorded behavioral and abundance data. We did this to assess whether vessel presence affected general abundance and distribution or overall behavior.

### *Statistical Analyses*

While interpreting our data, we utilized means of recorded data and calculated standard error.

## **Results**

### *Abundance*

We compared the abundance of seals hauled out on land and in the water between the two sites. Yellow Island had a ratio of 5:1 seals on land vs. in water, whereas Goose Island had a ratio of 2:1 seals on land vs. in water. The mean overall abundance was 26 seals at Yellow Island and 43 seals at Goose Island (Fig.1).

### *Behavior*

We assessed variability in behavior between the three haul-out sites on Yellow Island (two offshore rocks and the beach) and found there were no significant differences. Therefore, we grouped all Yellow Island sites together for analysis. Mean percent time vigilant was 31.9% (SE  $\pm$  3.2%) at Yellow Island and 38.9% (SE  $\pm$  3.4%) at Goose Island. Mean percent time loafing was 54.5% (SE  $\pm$  4.5%) at Yellow Island and 41.2% (SE  $\pm$  4.0%) at Goose Island (Fig. 2).

### *Vessel Disturbance*

In total, Yellow Island had 62% more boats present than Goose Island – with 95 vs 36 vessels at each respective site. These vessels affected both the abundance and behavior of our study species.

The abundance of seals on land and in the water varied due to vessel presence at both study locations. On Yellow Island, we see a 0.8% decrease in abundance of seals within the water and a 0.24% increase onto land during this vessel presence (Fig. 3). On Goose Island, the mean number of seals increased by 0.5% in the water and declined by 4.6% on land when vessels were present within 1000 m (Fig. 4).

Behavioral changes were recorded across seal populations at both locations when vessels were present and absent. Overall, the sample population at Goose Island exhibited a higher percentage of their time being vigilant and spent less time spent loafing compared to Yellow Island. However, similar trends in behavioral shifts for vigilance and loafing were observed at both islands. At Yellow Island, vigilance increased by 11.4%, and loafing decreased by 9.1% (Fig. 5). At Goose Island., vigilance increased by 1.9% and loafing decreased by 6.8% in the presence of vessels (Fig. 6). Differences in trends arose between the two locations in time management when swimming, nursing, aggression, and doing other behaviors.

## **Discussion**

### *Abundance*

Yellow Island had a significantly larger ratio of seals on land vs. in water (5:1) compared to Goose Island (2:1). This discrepancy may be attributed to the presence of offshore haul-out options which were present at Yellow Island but not at Goose Island. Previous literature suggests that seals prefer offshore haulouts due to access to deep waters and proximity to foraging sites (Nordstrom, C. A. 2002). Notably, these offshore sites were used by the Yellow Island seal population whenever available, with beach migration appearing to occur only when offshore sites were submerged. Therefore, the increased relative abundance of seals on land at Yellow may be because the site had more preferential haul-outs.

There was a lower mean abundance of seals at Yellow Island compared to Goose Island. The differences in abundance may be due to the variation in haul-out structure. Goose Island has one beach haul-out that remains available across all tide heights. Yellow Island, however, has two haul-out rocks that are submerged during high tides and one relatively smaller beach that is available during all tidal heights. Therefore, the unpredictable haul-out availability and smaller surface area are likely reasons for the lower abundance at Yellow Island versus Goose Island.

Prey density can also influence the distribution of harbor seals (Härkönen, T. J. 1987). Fish abundance sampling in 2012 by Beamer and Fresh showed consistently less fish presence near Yellow Island compared to Goose Island. Hence, the lower abundance observed at Yellow Island may also be due to prey density.

### *Behavior*

We observed 13% increased loafing and 7% decreased vigilance at Yellow Island relative to Goose Island. This trend aligns with previous studies (Carpenter, Ogle, Weise 2021, Hartwig and Davis 2015). Distinct ecologies at each location may explain this difference. Specifically, Goose Island is home to large gull and cormorant breeding colonies, whereas Yellow Island has no other large groups of terrestrial animals. The gulls at Yellow Island had large flushes which would occasionally initiate a flush of the harbor seals. A study conducted in 2015 by Gallagher et. al. also found that gull species have learned to prey on weak, wandering, or small juvenile and newborn fur seal pups. Our observations and mentioned comparative studies took place during pupping season, where gull predation may impose increased vigilance and decreased loafing. Therefore, we predict that coexistence with the bird colonies may partially explain the increased baseline vigilance in the Goose Island population.

### *Vessel Abundance*

When comparing both sites, we see a higher abundance of seals in the water and on land at Goose Island before and after vessels are present. We observed that 62% less vessel activity occurred at Goose compared to Yellow. Along with having more haul-out space like mentioned earlier, less vessel activity could explain why the abundance is overall greater at Goose.

### *Vessel Presence and Seal Abundance*

Vessel disturbance did not have a significant effect on harbor seal abundance in the water or on land, with one exception observed on land at Goose Island. Yellow Island has an established 91.4 m buffer buoy that protects marine mammals from boat activity. In addition, the harbor seals can move between haul-out sites to get further away from boats and therefore may be less affected by the presence of vessels. This could explain why there is no effect of vessel presence on changes in seal abundance. On Goose Island, we saw that the number of seals on land decreased when vessels were present. It has been recorded that more vessels pass within 100 m at Goose than at Yellow because there is no buffer zone, which may cause a flush into the water (Carpenter, Ogle, Weise 2021). However, we would expect to see an increase of seals in the water for this case, but we do not. One explanation is that the number of seals in the water is underestimated. When the seals are underwater and not coming up for air, our abundance counts may be inaccurate. An accurate abundance count would best occur when there are no vessels around, as seen in a study conducted by Calambokidis et. al. 1986.

### *Vessel Presence and Seal Behavior*

As stated earlier, the baseline time spent being vigilant at each location was different, with Yellow Island starting off at a 14.3% lower baseline than observed at Goose Island. When it comes to each study site individually, a clear trend in increased vigilance and decreased loafing

during vessel presence within 1000 m was observed at both locations, with a higher change occurring at Yellow Island. A previous study found that Yellow Island experienced a clear increase in vigilance rates and a greater decrease in loafing rates due to vessels, whereas Goose Island lacked a significant trend due to high amounts of variation (Carpenter, Ogle, Weise 2021). Our data is consistent with these findings two years later.

Possible reasons why we see a sharp increase in vigilance at Yellow but not Goose may be due to the site differences discussed earlier such as the use of a buffer zone, and the availability of multiple haul-out sites. Lastly, we see an increase in swimming rates at Goose Island after a vessel passes by which supports the conclusion that the seals are flushing from land into the water due to vessel presence.

Focusing on baseline vigilance rates, we know that the Goose Island sample population experiences more ecological disturbances in the form of large gull breeding colonies. In addition, when looking at the haul-out site itself, the island creates a topographical block to visual cues of boats for the harbor seals. This results in the seals having a decreased ability to see the boats for a longer period, and we hypothesize that it may cause a startling reaction when the vessels are noticed right next to the haul-out site. At Yellow Island, the topography is relatively flat, which provides the seals with those visual cues of the vessels passing for a longer period. Because of the established buffer zone, the ability to move further away to different haul-out areas, and clear visibility of vessels, we hypothesize that the seals at Yellow Island aren't experiencing extreme reactions such as a flush. The Goose Island seals have heightened baseline vigilance rates and are more aware of their ecological surroundings; when this is paired with an increase in vessels within 100 m, and a decrease in visual cues, an extreme reaction such as a flush into the water is quite plausible.

### *Implications*

While harbor seal populations are not endangered or at risk in the Salish Sea, continued increases in vessel presence may have the potential to degrade these populations in the future. From our data collection and field observations, we can see the vessels increase vigilance and, in some cases, can cause flushing in large haulouts. High rates of vigilance may be costly energy-wise and take away time spent on other behaviors like growth and reproduction, thus increasing inefficient energy expenditure. In addition to an energetic cost, these behaviors can cause short- and long-term stress to harbor seals which may have negative health impacts. These changes to normal behavior caused by vessel disturbances could cause declines in future harbor seal populations.

### *Recommendations for Future Research*

Our study design was limited by time and sample size due to the nature of the project. One aspect of our study that could be improved is the documentation of specific vessel characterization with detailed ranges and descriptions. This would improve clarity on the effects of different types of vessel disturbances. In addition, conducting this study earlier in the pupping season would allow more accurate data on abundance between mom pup pairs and lone adults. Lastly, surveying more sites for more days might incur clearer data patterns.

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## Appendix

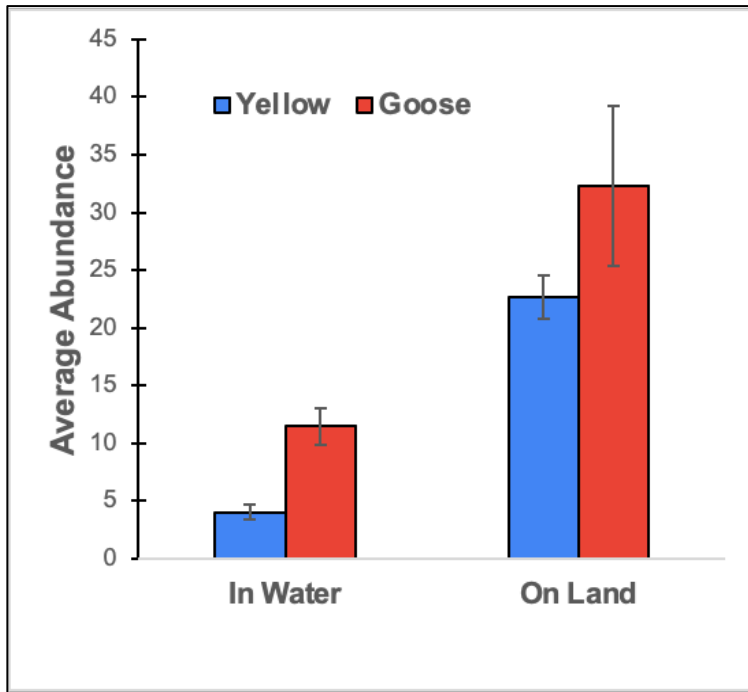


Figure 1: Average abundance of harbor seals at Yellow Island (n=29) versus Goose Island (n=22). Observations were made between 4 August and 9 August 2023.

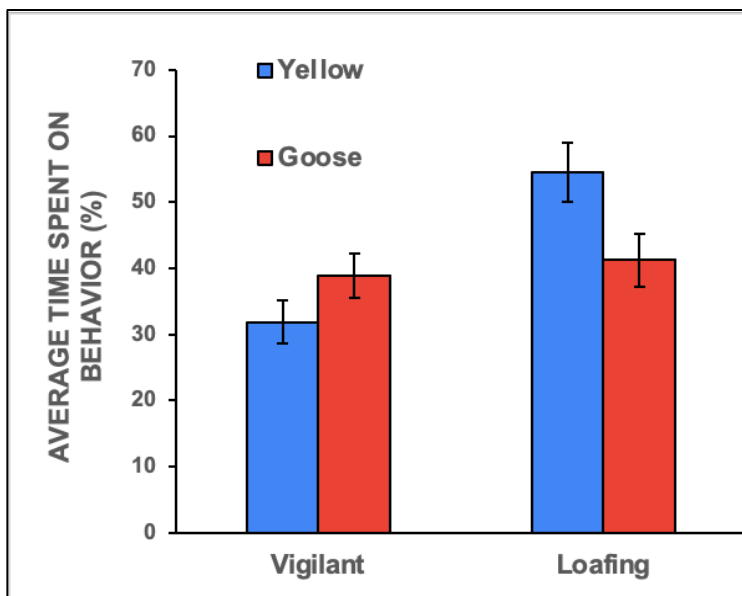


Figure 2: Average percent time spent by harbor seals on vigilance and loafing at Yellow Island (n=56) versus Goose Island (n=56). Observations were made between 4 August and 9 August 2023.

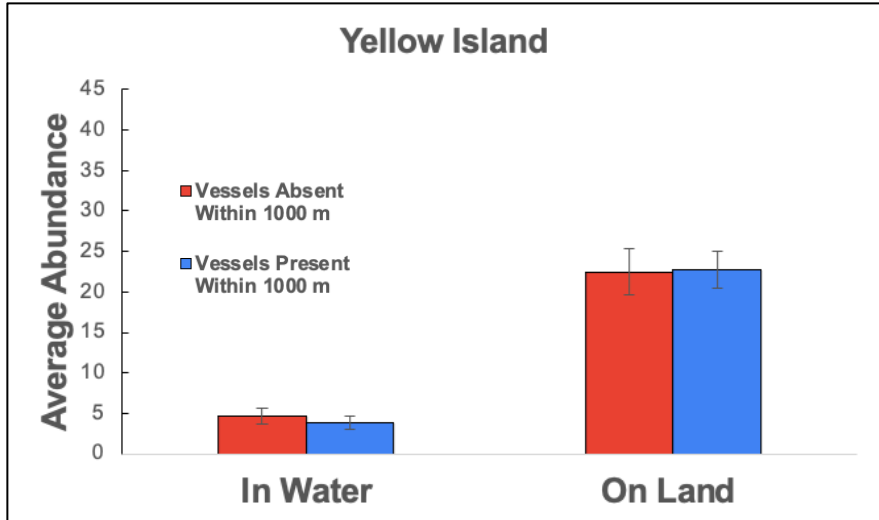


Figure 3: Average harbor seal abundance on land and in water when vessels are present within 1000 m (n=23) versus when vessels are absent within 1000 m (n=6) at Yellow Island. Observations were made between 4 August and 9 August 2023.

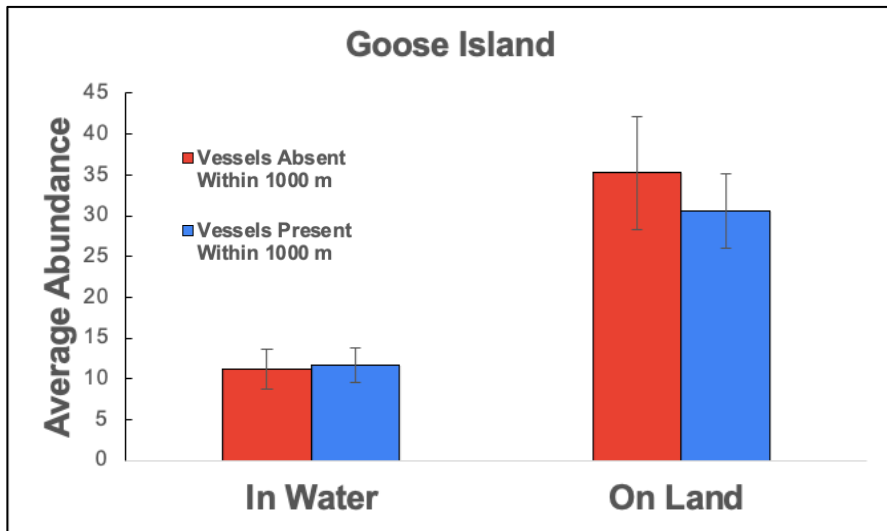


Figure 4: Average harbor seal abundance on land and in water when vessels are present within 1000 m (n=14) versus when vessels are absent within 1000 m (n=8) at Goose Island. Observations were made between 4 August and 9 August 2023.

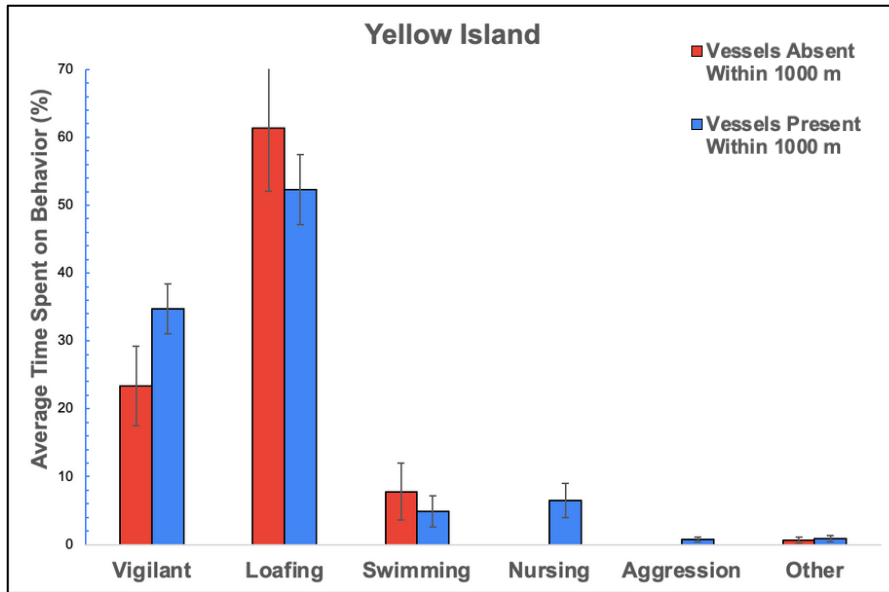


Figure 5: Average time spent on behaviors by harbor seals when vessels are present within 1000 m (n=42) versus when vessels are absent within 1000 m (n=14) at Yellow Island. Observations were made between 4 August and 9 August 2023.

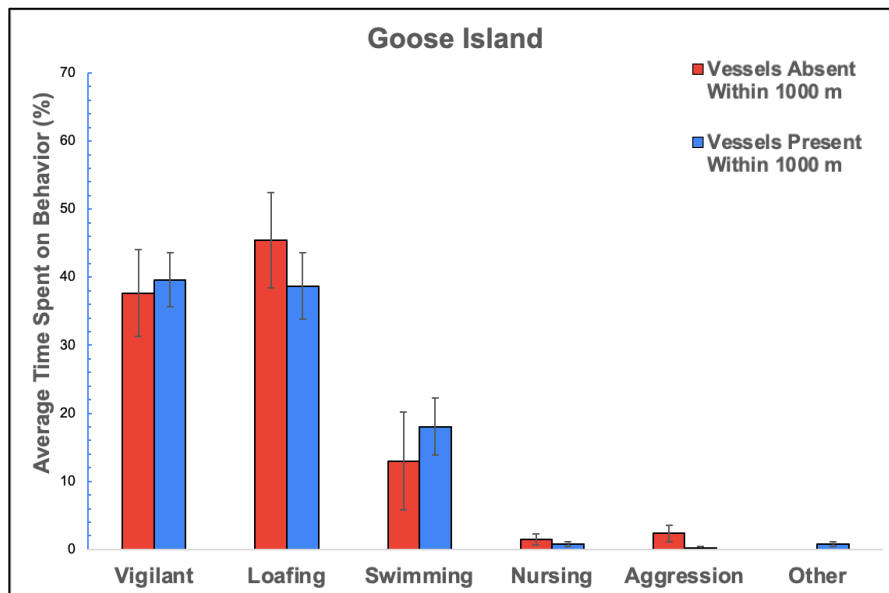


Figure 6: Average time spent on behaviors by harbor seals when vessels are present within 1000 m (n=35) versus when vessels are absent within 1000 m (n=21) at Goose Island. Observations were made between 4 August and 9 August 2023.