Behavioral response of Harbor seals (*Phoca vitulina*) to vessel disturbances on Yellow Island, WA, USA

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Abstract

In the Salish Sea, harbor seals use gravel beaches and rocky shores to haul out for rest and raising pups. While their populations have rebounded after the implementation of the Marine Mammal Protection Act (MMPA), increases in vessel traffic pose energetic and behavioral threats such as increased vigilance, flushing, and raised heart rates. Loud noises as well as human presence greatly contribute to these trends through high levels of disturbance. To understand the extent of these effects, we used opportunistic and interval surveys at Yellow Island, WA, USA to observe the types and speeds of boats that entered within 400 meters of seal haulouts and caused disturbances. We also observed harbor seal behavioral responses and categorized them by adults, mother-pup pairs, and lone pups. Our results were then compared to a prior study on vessel disturbance to analyze trends over time. We found that fast moving motor boats were the most common vessel, though kayaks and other slow vessels caused the highest levels of disturbance, notably flushing. The highest percentage of vessels was within 300 meters of the seals, though the closest vessels caused the most disturbance, especially when they entered the buffer zone (91 meters). Adults reacted the most to boat presence, with lone pups reacting the least. Vigilance also decreased from 2021 to 2025, indicating signs of habituation to consistent vessel noise. These trends indicate that regulations should be updated to account for increased habituation and stress levels to protect harbor seals. Education on the buffer zone should also be expanded.

Keywords: Harbor seal, *Phoca vitulina*, Yellow Island, behavior, vessel disturbance, buffer zone, habituation

Introduction

Harbor seals (*Phoca vitulina*) are abundant pinnipeds that are widely distributed throughout coastal communities in the Atlantic and Pacific Oceans, including within the Salish Sea (Cates & Acevedo-Gutiérrez, 2017). After the institution of the Marine Mammal Protection Act (MMPA) in 1972, harbor seals have made a steady recovery and are now at their carrying capacity (Ashley et al. 2020). They generally have a lifespan of 25 to 30 years, and females have one pup per breeding season, which is June through early September in the Salish Sea (Johnson & Acevedo-Gutiérrez, 2007). Uncharacteristically for the Phocidae family, they are income breeders, meaning mothers leave their pups on a regular basis to forage for food (Hitchcock et al. 2017).

A notable aspect of harbor seal ecology and life history is the use of haulouts. Adults, mothers, and pups cyclically use beaches and rocky shores for resting, molting, birthing, nursing, and other social behaviors, though they tend to opt for rockier haulouts when available (Johnson & Acevedo-Gutiérrez, 2007). They also favor haulouts in the middle of the day, with calm weather, low cloud cover, and incoming tides (Blundell & Pendleton, 2015). However, when disturbed or threatened, harbor seals may leave their haulouts, an action called flushing. One of the main causes of flushing is vessel disturbance. Though the MMPA requires boats to keep a minimum distance of 50 yards from harbor seals, there is also a general guideline of 100 yards (91 meters), known as the buffer zone (Cates & Acevedo-Gutiérrez, 2017). While harbor seals are supposedly protected by the MMPA and the buffer zone, it is often disregarded. On average, 86% of kayaks, 57% of motorboats, and 5% of passing powerboats around Yellow Island, WA, violate the buffer zone, despite a buoy being present to indicate the minimum safe distance (Johnson & Acevedo-Gutiérrez, 2007). This is especially concerning given that 28% of vessels within just 300 meters of haulouts can cause disturbance, and vessels 100 meters away are 25 times more likely to cause flushings than those that are 500 meters away (Blundell & Pendleton, 2015; Jansen et al. 2010).

Vessel disturbance is harmful to harbor seals because of increased vigilance, flushing, and agitated movements. When vigilance starts, seal heart rates can increase by at least 5 bpm, and continue after the disturbance has ended (Karpovich et al. 2015). If these events consistently occur, there is a high energetic cost associated with anthropogenic interference. According to a study that calculated the probability of seals flushing in Disenchantment Bay, Alaska, 14% of seals and up to 11% of pups can flush when vessels are present (Jansen et al. 2015). Colder waters can also pose a risk of thermal stress, especially for younger pups. While seals usually return to their haulout within an hour, they may abandon the area entirely, with mothers possibly leaving their pups (Johnson & Acevedo-Gutiérrez, 2007). Interestingly, seals are becoming less vigilant towards loud, faster vessels, indicating that they are becoming habituated to disturbances (Carpenter et al. 2021). These flushing and vigilance events can increase stress levels, predation exposure, and disrupt crucial periods of development for young pups, making vessel disturbance a growing problem for harbor seals.

In this study, we aimed to observe harbor seal responses to vessel disturbance, the effects of vessel speed and distance behavior, and whether vessels obeyed the buffer zone. We also sought to compare our findings to a prior study conducted at FHL in 2021to discern whether our trends differed from previous years. We hypothesized that harbor seals would show the highest responses to slow moving vessels like kayaks, due to their mimicry of predatory behavior and ability to surprise seals (Cates & Acevedo-Gutiérrez, 2017). We also hypothesized that vessels would disobey the buffer zone, and our comparative study would indicate an increase in habituation.

Methods

Study site

Our approach closely follows the methods outlined by Carpenter et al. 2021, with adjustments implemented to accommodate the current traits of the study site and our specific

research goals. We collected data from 11 August through 14 August at Yellow Island (48° 35' 29" N, 123° 02' 03" W) located off of San Juan Island, WA, USA. This location was chosen due to its accessibility and reliability of harbor seal haulouts where behavioral observations could be easily recorded. Observations at Yellow Island were made from a high vantage point on the west side of the island, roughly 150 m from the haulouts. A 15 minute buffer period was implemented after setting up before making observations to account for any disturbances caused by our arrival. Our observations took place from approximately one hour before to one hour after low tide, totalling 8 hours over our 4 day study period. Each member of our team was assigned a role at the start of the day, switching at the one hour mark to mitigate observer bias.

Vessel Traffic

To measure vessel traffic through the channel, we recorded every vessel that traveled within 400 m of the seal haulouts. For each vessel, we recorded the type of vessel passing and categorized them as motorized, non-motorized, kayak, or sail boat. Kayaks were considered a single unit no matter how many individual kayaks were present in the group. Additionally, we used a Bushnell 10x42mm fusion 1 mile laser rangefinder to track when boats came within 400 m, 300 m, 200 m, and 100 m from the haulout sites, recording the time they passed into each zone to be matched with behavioral data for analysis. Vessels entering the 100m zone were used to estimate compliance with MMPA buffer zones. Speeds were categorized as fast, medium, and slow based on visual observations. Following data collection, we used Microsoft Excel to calculate the mean number of boats per hour and the percentage of each type of vessel with respect to the total number of vessels seen over the entire study period. Using the closest distance from the haulout for each vessel, the percentage of each speed and total vessels entering each zone was recorded.

Behavioral sampling

To record behavioral responses, we used interval and opportunistic scan sampling. Harbor seals were categorized into three different groups; mother-pup pairs, lone pups, and lone adults. Mother-pup pairs were identified using proximity or direct interactions between the pair. For interval scan sampling, the designated observer used a Celestron ultima 80 20-60x80 scope. Scans were conducted every 10 minutes starting after the 15 minute buffer time and were considered our control behaviors. During each scan, the recorder took note of the time and the observer scanned the harbor seals hauled out, calling out the behaviors that each type of seal was exhibiting while the recorder tallied on the data sheet. Behaviors included vigilance (i.e. head up, eyes open, scanning environment), flushing (i.e. moving into the water), moving (i.e. shifting position, moving further up shore), and other (i.e. social behaviors, aggression). Resting or sleeping was considered the baseline for all seals and was not marked as a behavioral change or response. Opportunistic scan sampling was performed during any instance that a vessel came within any disturbance zone (i.e. 400 m or less). The observer began sampling at the end of the haulout that the vessel was approaching from and would note if there were any changes in each seal's behavior, noting the time and type of seal that was exhibiting that behavior.

Using Microsoft Excel, we calculated the percent of each seal group exhibiting each behavior for each scan. Behavioral responses were associated with specific vessel encounters if the two events happened within one minute of each other. Additionally, vessel speeds and distances were clustered (i.e. slow and close, slow and far, fast and close, and fast and far) and compared with the percent of vigilance and flushing that occurred during those scans. Lastly, the total percent of vigilance for each seal type and all seals in total in this study were compared to the total percent of vigilance from the previous Carpenter et al. 2021 study. Statistical analyses included calculation of 95% confidence intervals, which are depicted on all figures.

Results

Vessel traffic

Compared to the 2021 study, which observed a total of 173 vessels at Yellow Island and calculated about 14.4 ± 5.7 (mean ± SD) vessels per hour, we observed a total of 53 vessels with an average of about 6.6 ± 2.6 vessels per hour. Motorized boats were the most common type of vessel, constituting 74% (n = 39) of total vessel observations (Fig. 1a). Sail boats and kayaks made up a smaller proportion of the count, 25% (n = 13) and 2% (n = 1) respectively (Fig. 1a). Vessels were most frequently observed traveling at fast speeds, accounting for 42% (n = 22) of recorded speeds (Fig. 1b), followed closely by vessels at slow speeds at 38% (n = 20). Medium speed boats made up the remaining 21% (n = 11) (Fig. 1b). On average, the majority of vessels (42%, n = 22) were observed within 300 m of the haulout site at closest approach (Fig. 1c). 32% (n = 17) of vessels approached within 200 m, while 23% (n = 12) were documented within 400 m (Fig. 1c). Instances of vessels in violation of the MMPA (i.e. within 100 m of seals) accounted for 4% (n = 2) of observations (Fig. 1c).

Behavioral analysis

Among the behaviors recorded, vigilance was the most evenly distributed behavior across vessel types, with marked increases in response to kayaks and motorized vessels (Fig. 2). Motorized vessels caused the most vigilance in lone adult seals (16%, n = 39) compared to mother-pup pairs and lone pups (Fig. 2a). Overall, kayaks elicited the highest percent of behavioral responses across all seal types, specifically leading to increased vigilance (57%, n = 2), flushing (80%, n = 2), and movement (17%, n = 2) (Fig. 2).

A trend was noticed when vessels were grouped based on speed and distance. Vessels were deemed close if they were within 200m of the haulout and far if the closest distance was within the 400 m or 300 m zone. Close and slow vessels caused the second highest percent of vigilance

(23%, n = 27) and the highest rate of flushing (10%, n = 27) compared to all other vessel speeds and distances (Fig. 3).

In the Carpenter et al. 2021 study, they found that on average, vessel disturbances caused a 32% increase in vigilance (Fig. 4). This is significantly higher than our average vigilance response at 21% (n = 162).

Discussion

In this study, we aimed to observe the impacts of vessel disturbance on harbor seal behavior, the effects of vessel distance and speed, the efficacy of the buffer zone, and how trends have changed over time. We utilized a prominent haulout at Yellow Island to conduct our study and found that fast moving motorboats were the most common vessels. This is consistent with our reviewed literature and prior predictions, considering that recreational and whale watching boat presence is significantly increasing in the Salish Sea (Cates & Acevedo-Gutiérrez, 2017). Our highest abundance of vessels was within 300 meters of the haulout, indicating that the seals are consistently exposed to high levels of traffic and vessel noise. Kayaks caused the most disturbance however, due to their slow and quiet approaches that surprised the seals (Blundell & Pendleton 2015; Johnson & Acevedo-Gutiérrez, 2007). They also caused the highest levels of vigilance and flushing, which supports our hypothesis that somewhat cryptic vessels were the most stress inducing. They led to the second highest rate of vigilance as well as the highest rate of flushing compared to faster motorized boats. Adults were also shown to react the most to disturbance, with lone pups showing the least response. This result emphasizes the importance of mom and pup interactions, so young seals can learn when to be vigilant and respond to potential dangers.

Compared to the Carpenter et al. 2021 paper, there was a slight decrease in vigilance and boat traffic. The study took place during the Covid 19 pandemic, where boating actually increased as a form of social distancing while continuing recreational activities. On the other hand, the decrease in vigilance is likely an indication of habituation, where seals are less responsive to anthropogenic

noises. For future studies, we would like to obtain a larger sample size over longer survey periods to have a wider range of data and comparisons to past papers. We would also like to survey over the entire pupping season, to get a greater understanding of mother-pup interactions as well as avoiding observational bias. While our survey was limited by time and location, findings on vessel disturbance are generally in alignment with Carpenter et al., and other literature. Nevertheless, further research should be conducted to investigate the decrease in vigilance in response to boat noise and add strength to our observations.

One of the most important implications of our study is the necessity for regulations to protect harbor seals from disturbance. The MMPA defines a 'take' as capturing, hunting, harassing, or killing a marine mammal, or attempting any of these actions (NOAA Fisheries). Since this definition is only qualitative, it may be misinterpreted and the law may be easily violated. Some administrations like NOAA also advertise maintaining a minimum distance of 50 yards from seals by law, though this is not easily accessible in the actual act, making it difficult for the public to discern what is law, and what is simply a guideline. Moreover, it is imperative to increase education on the laws associated with the MMPA, in addition to enforcing them. Further, the minimum distance, or buffer zone, should also be revisited. From past research and our own observations, it seems that a flexible buffer zone should be created, where it is vessel specific (Cates & Acevedo-Gutiérrez, 2017; Johnson & Acevedo-Gutiérrez). Since kayaks and slow moving or stopped boats are the most disruptive to seal haulouts, increasing their distance as well as the distance for all vessels would help reduce disturbance and habituation. Creating concrete regulations and increasing education through public outreach would also help reduce the frequency of buffer zone violations, as many people seem to be unaware of the regulations associated with the MMPA. Furthermore, conveying the purpose of the buffer zone and the effects of disturbance on harbor seal stress and health would also help management efforts and community involvement.

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Figures

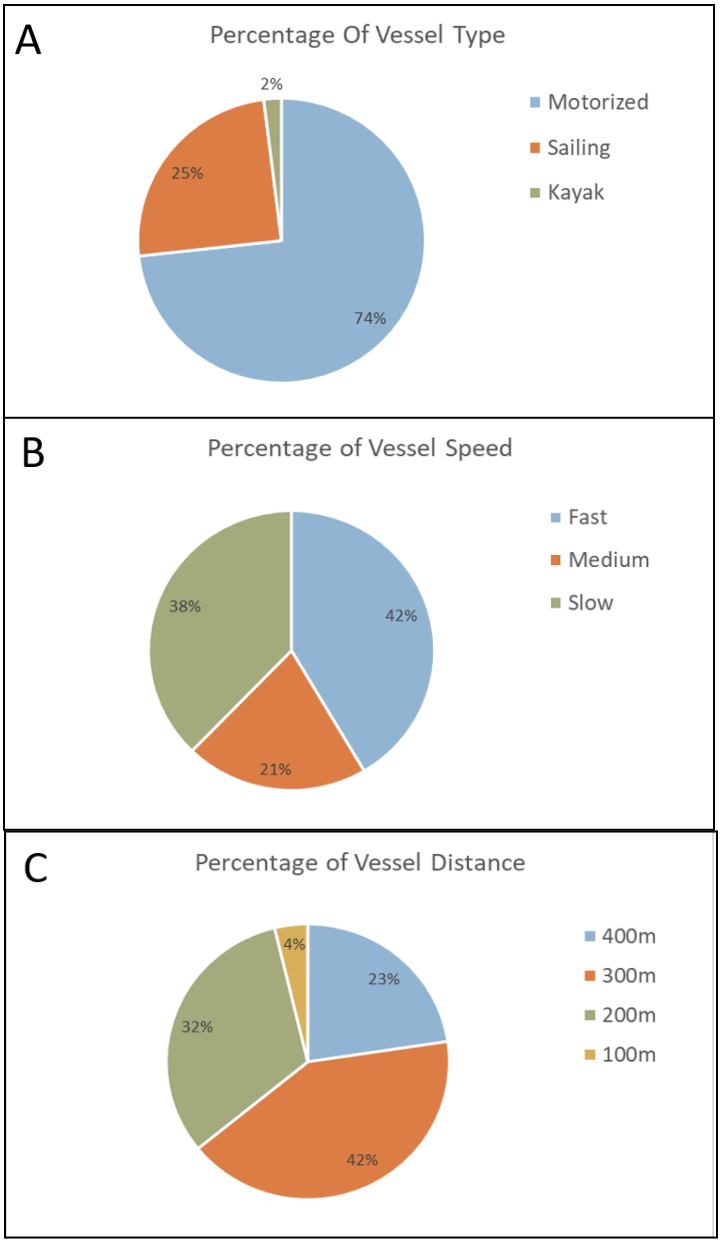
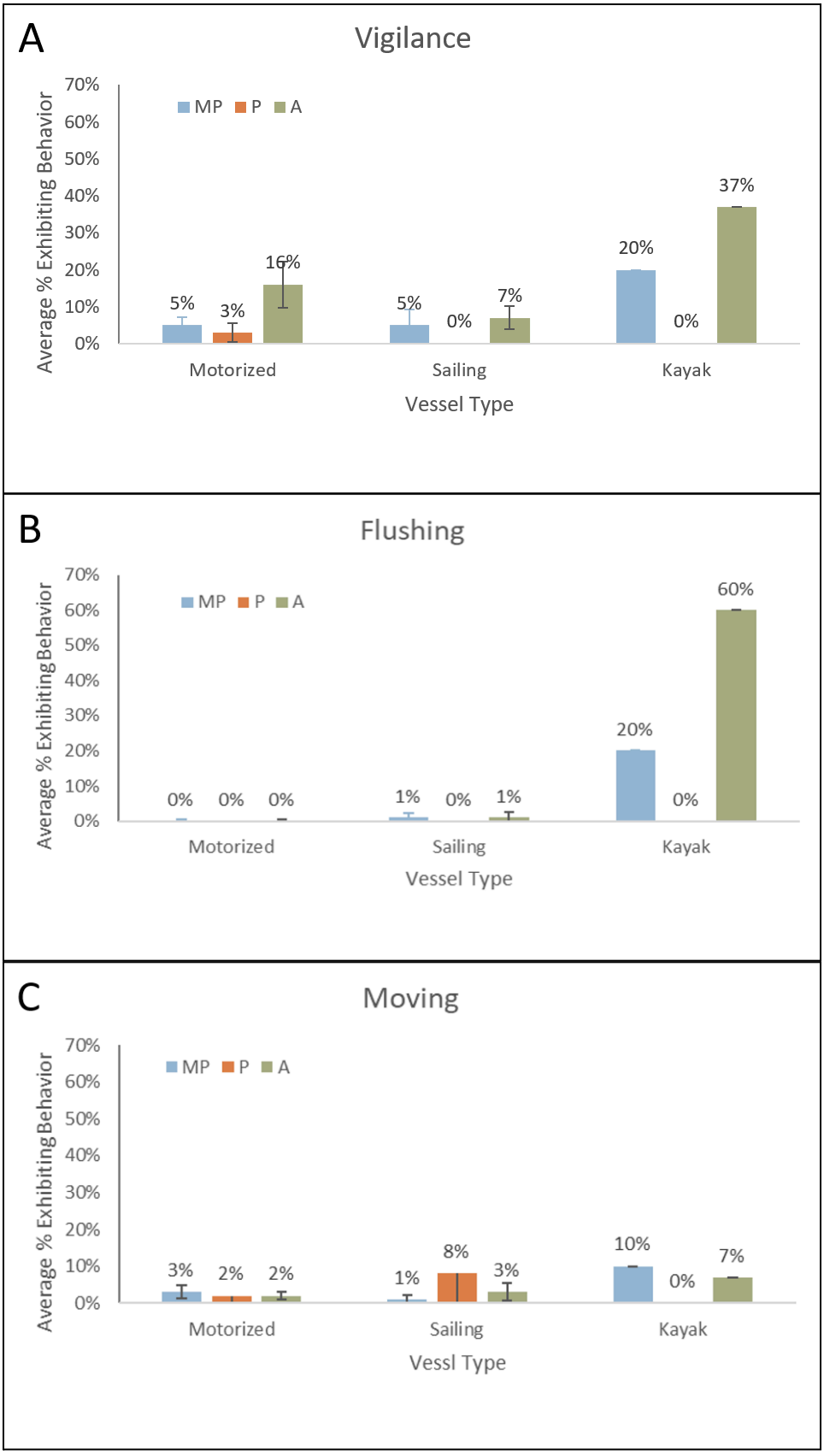


Figure 1. Average percent of a) vessel types, b) vessel speed, and c) closest distance of vessels to seal haulouts recorded.


A
Vigilance
Average % Exhibiting Behavior
70%
60%
50%
40%
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20%
10%
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16%
5%
0%
7%
20%
0%
37%
Motorized
Sailing
Kayak
Vessel Type
B
Flushing
Average % Exhibiting Behavior
MP
P
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0%
0%
0%
1%
0%
1%
20%
0%
60%
Motorized
Sailing
Kayak
Vessel Type
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Moving
Average % Exhibiting Behavior
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Motorized
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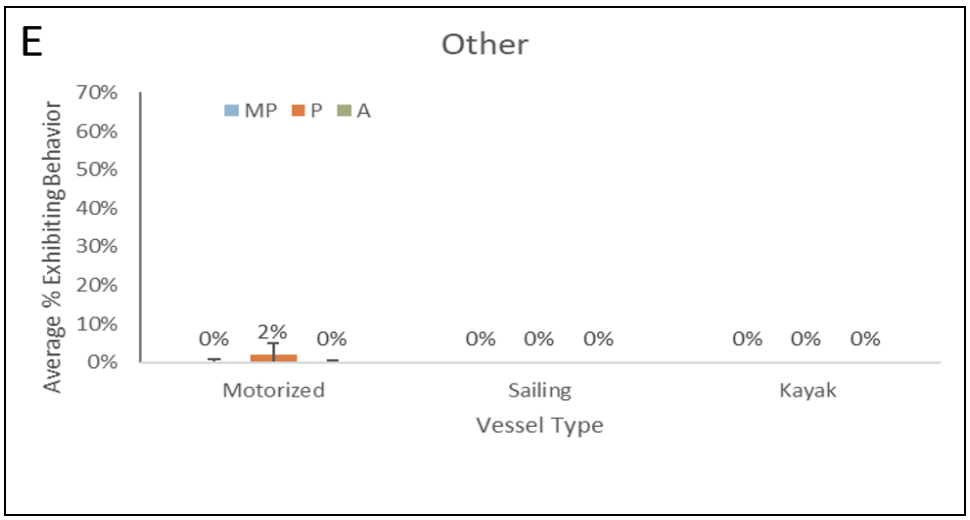

Figure 2. Average percent (± 95% confidence interval) of seals exhibiting a) vigilance, b) flushing, c) moving, and (d) other. Each disturbance was recorded based on if the seal was a part of a mother-pup pair (MP), was a lone pup (P), or a lone adult (A).

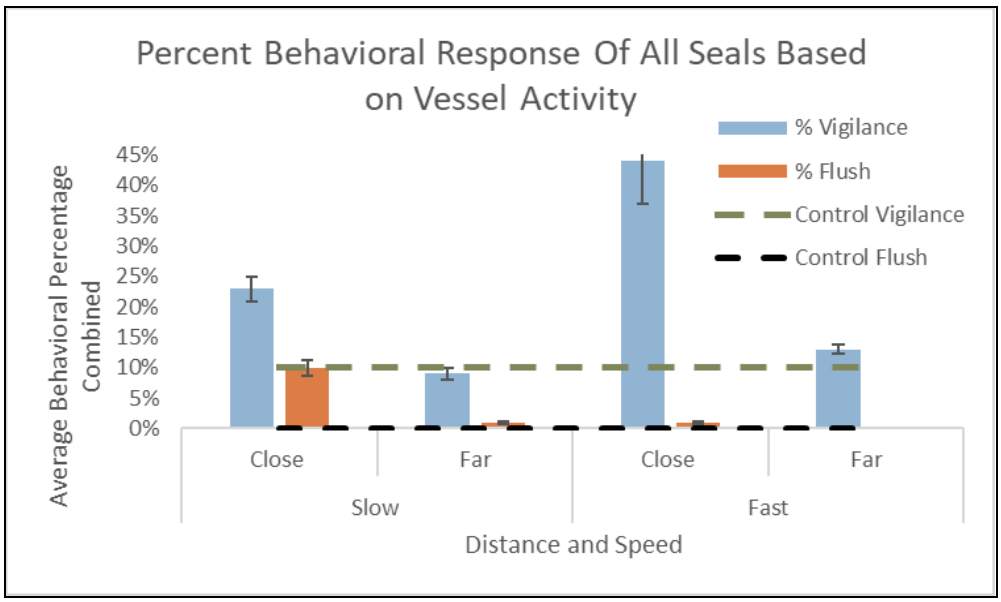

Figure 3. Average percent (± 95% confidence interval) of total seals exhibiting vigilance (blue) or flushing (orange) based on if vessels were close and slow, far and slow, close and fast, or far and fast.

The recorded control levels of vigilance (green) and flushing (black) are marked as dotted lines for comparison.

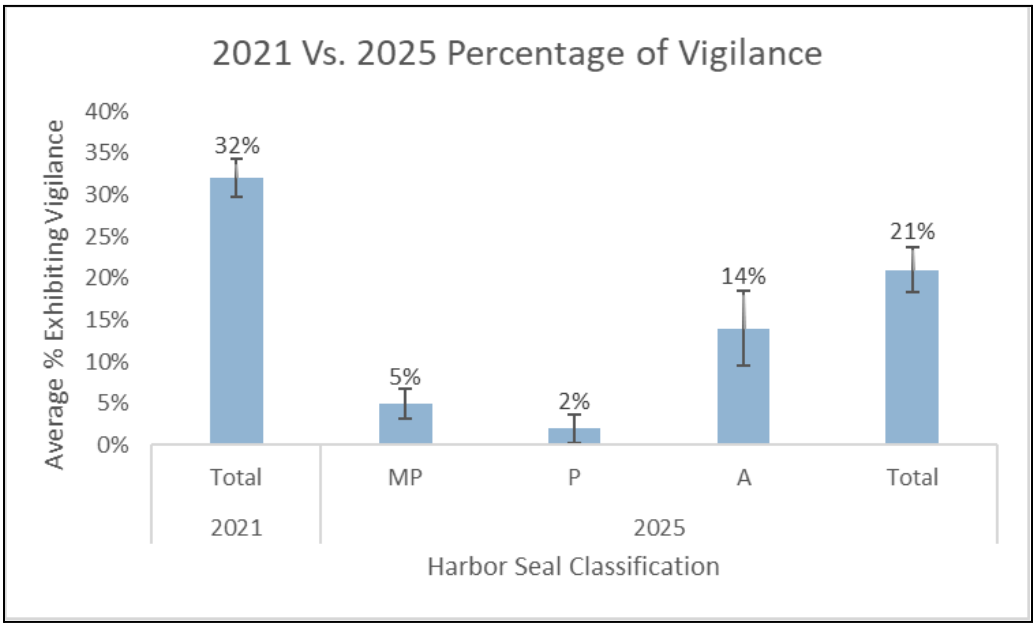

Figure 4. Comparison between average percent (± 95% confidence interval) of seals exhibiting vigilance in 2021 versus 2025. Average percentages are also recorded for mother-pup (MP), lone pup (P) and lone adult (A) from this study.