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In-Water Photo Identification, Site Fidelity, and Seasonal Presence of Harbor Seals (*Phoca vitulina richardii*) in Burrows Pass, Fidalgo Island, Washington

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Abstract: Little is known about the in-water behavior and site fidelity of harbor seals (*Phoca vitulina richardii*), as most photo-identification (photo-ID) studies are typically conducted while they are hauled-out on land. We investigated in-water site fidelity rates and seasonal presence in Burrows Pass, Washington, using photographs collected during a long-term photo-ID and behavioral study from January 2015 through November 2019. There was a minimum of 161 individuals and a maximum of 286 individual harbor seals using Burrows Pass. Harbor seals were present in all seasons, with the lowest sighting rates during summer. Individuals were more likely to be sighted/re-sighted in fall and spring. There was large variations in the level and seasonality of site fidelity among individuals. The majority of seals (69.62%) were seen only once, but 22.69% showed low to moderate site fidelity (2–5 sightings) and 7.69% showed strong site fidelity (≥6 sightings) over seasons and across years. These seasonal variations were likely due to foraging, life history, and individual behavioral variabilities. Studies like this provide necessary information about harbor seal in-water site fidelity and behavior, which are less well known but vitally important in harbor seal management and conservation.

Keywords: harbor seal; *Phoca vitulina*; *Phoca vitulina richardii*; Washington; Salish Sea; seasonality; site fidelity; photo ID; local population

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1. Introduction

The Pacific harbor seal (*Phoca vitulina richardii*) is found year-round in Washington State waters of the Salish Sea (inland waters of Washington State and Canada) [1–4]. Like many pinniped species, harbor seals regularly haul-out on land for rest along inner and island coastlines, as well as substrates such as rocks, piers, jetties, sand bars, and mudflats, peaking during the pupping and molting seasons [2,5,6]. During these times, the animals are conspicuous and visible either from land, sea, or air. For these reasons, most photographic-identification (photo-ID) studies are conducted during these haul-out periods [7,8], despite representing only a small proportion of their daily activities. Harbor seals can spend 40–75% of their life in water depending on the season and location [9], yet little is known about their in-water behavior [10].

Harbor seals in the Salish Sea have been known to exhibit a high degree of site fidelity to haul-out sites, typically traveling less than 30 km from their primary haul-out location [6,11–13]. Considerably less is known about their movements, behavior, and site fidelity for in-water locations; however, more recent studies have explored these aspects. A study in Washington State, U.S.A. (hereafter referred to as Washington), was conducted documenting in-water density and abundance in the Hood Canal [14]. Unusually large groupings of harbor seals were documented in water in Burrows Pass and Puget Sound, Washington [10]. A study covering the eastern San Juan Islands, Washington, and the Belle Chain Islets, in British Columbia, documented individual harbor seals showing site fidelity and utilization of specific areas in the water, demonstrating distinct regions of use and suggesting individual spatial preference for certain areas within the region [15]. Long distance movements and disjunct spatial use were documented, emphasizing that the ecological influence of individual seals may extend farther than commonly thought [15]. Aside from these recent examples, however, there are relatively few other studies on the in-water behavior of harbor seals and, in particular, site fidelity outside of haul-out locations. For species like harbor seals that utilize both land and sea, and spend a large amount of time in the water, data on individuals' site fidelity and habitat usage in aquatic environments are important for a fundamental understanding of their behavior and ecology. This information is important for conservation, as well as individual behavior and movement patterns, which can influence how natural (e.g., disease transmission) and anthropogenic (e.g., toxin loads or lethal/nonlethal management practices) threats may affect local and/or larger populations.

Identifying individual harbor seals is conducted by examining the pelage spotting pattern of the animal. These markings are asymmetrical and unique to each individual, remaining stable over time [16,17]. Traditionally, the photo-ID of harbor seals is conducted during haul-out periods, where the full body of the individual is visible. Pelage patterns on the head and neck area are the most commonly used [18,19], but the ventrum [20,21], the flanks [22], or a combination of these [7,23] have also been used to identify individuals on land. When in the water, harbor seals generally only keep their heads above the water line (sometimes with part of their back showing). Thus, for in-water identification of seals, the side profiles of the head are used for identification. This technique of using the head and neck regions in water has been successful in the identification of gray seals (*Halichoerus grypus*) in Europe [24,25]. Previous research conducted in Burrows Pass showed that harbor seals can be identified utilizing this technique [26], and, recently, it was also used to identify and track individuals over time in Bellingham, Washington [27,28], as well as for an undergraduate project in Sweden [29].

The land-based observation point used in this study is located on the northwest corner of Fidalgo Island, Washington, on the northern shore of Burrows Pass (Figure 1). This is an area where harbor seals are found year-round and can easily be observed from land [26,30], providing an ideal location for a long-term behavioral and photo-ID study investigating in-water site fidelity, seasonal variation, behavior, and habitat usage. The objectives of this study were to 1. use photo-ID to determine the level of in-water site fidelity and the seasonal presence of individually identifiable harbor seals and 2. Utilize the sightings of all seals to investigate seasonal patterns of in-water habitat use for harbor seals observed in Burrows Pass.

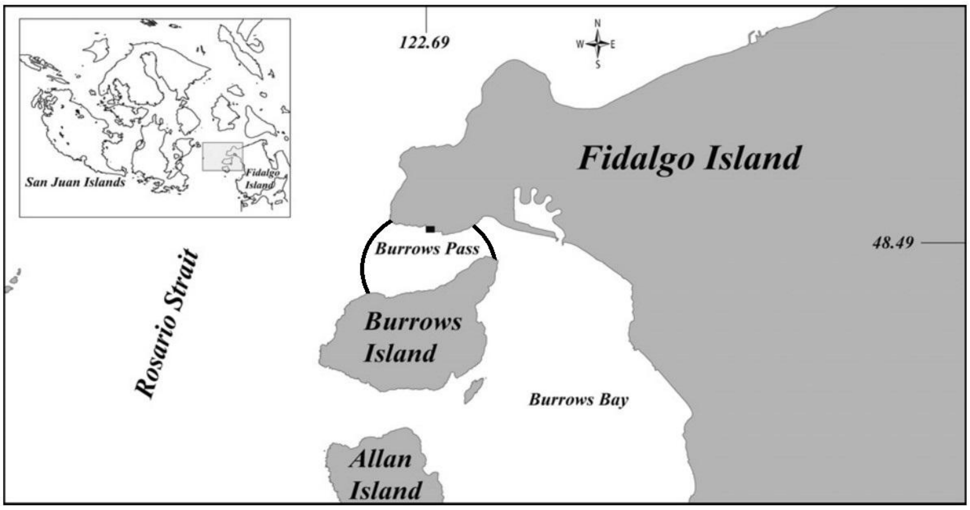

Figure 1. Map of the land-based observation point and study area. Shaded areas indicate land, white indicates water. The black square on Fidalgo Island (north of Burrows Pass) represents the location of the land-based observation point. The entire passage between islands (located within the black semi-circle) represents the study area. Inset shows the study area (shaded) in relation to surrounding San Juan Islands, Washington.

2. Methods

2.1. Study Area

Observation periods were conducted from a land-based observation point located on Fidalgo Island, near the center of Burrows Pass. Burrows Pass flows between Burrows Island and Fidalgo Island, connecting Burrows Bay to Rosario Strait (Figure 1). Burrows Pass varies in depth from 12 to 40 m and is approximately 1300 m long, with a maximum width of approximately 915 m at the western end, opening into Rosario Strait, and a minimum width of approximately 460 m at the eastern end, heading into Burrows Bay. Burrows Pass, from the eastern to western openings, composes the study area used for observations. The low-elevation observation point is located on a protruding rock formation approximately 6 m above sea level, allowing for good visibility throughout the majority of the study area [30]. Because of the size of the study area and its uneven geography, there are some parts of the study area that are hard to see/are obscured (mainly close to shore); thus, it is possible that seals may be missed during an observation period if surfacing in these specific areas. However, this location provides the best vantage point for viewing the entire pass, and the number of missed seals is likely to be minimal.

2.2. Data Collection

The study period spanned from January 2015 through November 2019. Observation periods were typically 120 min in duration (range of 60–160 min), conducted only during daylight hours on various days of the week and times of the day. The observation periods were normally conducted on different days; however, rarely, 2 observation periods were conducted on the same day but at different times. The observation periods were conducted year-round, and they were dependent on the viewing and weather conditions. Observations were typically not conducted when precipitation and/or consistently high winds (>20 mph) occurred or when sea states were at or above a Beaufort 3, which reduces the ability to accurately detect animals. Adverse weather conditions, such as strong winds and/or precipitation, increased during the winter months; thus, efforts varied by season. Occasionally, observation periods could not be conducted because of other environmental conditions that reduced visibility in other seasons as well (e.g., fog and/or smoke from wildfires). During observations, environmental data were collected, including temperature, wind direction and speed, Beaufort state, tidal rip current, sun/cloud cover, lunar phase, and tidal state. Sometimes other marine mammals were sighted, and their presences, as well as behaviors, were also documented. Additionally, a lack of any marine mammals during an observation period was also documented.

A harbor seal sighting was defined as a seal surfacing in the study area during the observation period. Each time a seal was sighted, the time, grid location (quadrant-like delineations created by the researchers to track gross locations in the field site), behavioral notes, frame numbers and profile (left/right side) of photographs (if taken) were recorded. Cameras used included the Canon (Canon, Ota, Tokyo, Japan) EOS Rebel T3i and T5i digital SLR cameras, which were equipped with an image-stabilized zoom lens (100–400 mm). Because of a seal quickly diving or being too far from the camera, not every seal sighting was successfully documented with photographs.

Photographs were taken with animals approximately 6 m to 900 m away from the observation point. Harbor seals were photographed at different angles, primarily focusing on the side of the head profiles. Every sighting of a seal was counted toward the total seal sightings calculation for an observation period, except when it was clear that it was the same animal. This occurred in scenarios in which a seal was sighted within a few yards and within 30 s of its last location and/or whether it could be identified through the telephoto lens as the same animal. In those cases, the seal was not recounted for these repeated sightings (usually 1–2 additional sightings) in the total seal sightings calculation for that observation period.

The data collected on every surfacing by a seal, along with photographs, allowed for assessing both individual habitat use and site fidelity, as well as the overall seasonality of habitat use. Each database (i.e., total sightings and photo-ID) has its bias, but utilizing both databases allows for a comparison of the trends observed, minimizing the effect of potential biases and increasing the reliability of the results. Collecting and analyzing data as if each surfacing is a new animal (i.e., total sightings dataset) provide an absolute maximum for how many seals were in the study area during an observation period. Because we cannot capture photographs of every seal that surfaces (due to distance or seal behavior), the photographs (photo-ID dataset) will likely underrepresent the number of seals but will provide a good minimum estimate of how many seals were in the study area during an observation period. Thus both databases (with their respective biases) were analyzed to compare trends in seasonality and whether they were similar, we could be confident that the observed results were true representation of their seasonal behavior. Identification of individuals is required to assess site fidelity, individual seasonality and the rate at which new seals were observed over years, thus only the photo-ID database was used for these analyses.

2.3. Individual Identification and Site Fidelity (Photo-ID Dataset)

Photographs were subjected to an initial visual screening process to identify those of sufficient quality to attempt identification. The conditions assessed were 1. proximity (i.e., distance from the seal to the photographer); 2. clarity of the image; 3. angle of the seal to the camera; and 4. the proportion of the pelage pattern visible (similar to the conditions used for photo-ID studies on cetaceans [31]). Only photographs with clear images (nonpixelated and not too far away, where spots could not clearly be delineated), the head mostly perpendicular to the camera, and with more than half the head/neck pelage pattern visible were used for identification.

Using standard photo-ID methodology, whereby individually unique spotting patterns were matched [19,27], photographs were visually compared to existing identified seals to re-identify previously sighted individuals, as well as to identify new individuals not already in the catalog. The identification catalog contains 286 individuals observed in Burrows Pass since 2015 and includes good-quality photos of the left side, right side, and/or both sides of each seal's head. Using left and/or right profiles, matches to known individuals were determined by matching $\geq$ 3 unique pelage markings in combination with any additional features such as scars (Figure 2). All matches were initially identified by the first author (C.J.E.) and then reviewed by one to three trained researchers to confirm the identifications. If no matches were found among existing individuals, it was assumed to be a new animal and was added to the catalog. On occasion, the seals would turn at the surface, offering the opportunity to photograph both the right and left head profiles, thus enabling us to positively match the left and right heads of the same individual. However, more commonly, harbor seals only showed the left or right side of their head, meaning that for many individuals only one profile was available for identification. This factor may result in higher rates of misidentifying the same individual as two different seals [31]. Utilizing only a single side profile of the animal (e.g., only left-side profile photos) eliminates this type of error but will likely result in an underestimate of the true number of seals in the study area. On the other hand, utilizing all photographs (left and right profiles) may overestimate the number of individuals present. To most accurately describe the number of individuals using the study area, we therefore provide data analyses using both datasets, as follows: first, including all profiles (left only, right only, and both profiles, providing a maximum estimate); second, including seals with both profiles and left head profile (left profiles were chosen because there were slightly fewer left side profiles than right side in the dataset and, thus, provided the best minimum estimate). This leads to a range of possible individuals, with the true number of individuals likely between the minimum and maximum estimates. An individual seal was considered present within an observation period if $\geq$1 photo was successfully used to identify the individual as a new or re-sighted individual.

Figure 2. Examples of identified harbor seal photo-ID matches, where the photographs on the left represent a first identifiable photo of an individual and on the right are the matched photos taken 2 to 3 years later: (**a**) Seal#2, Left Head—1/28/15 and 1/15/18; (**b**) Seal#41, Right Head—9/30/15 and 12/4/17; (**c**) Seal#4, Left Head—2/20/15 and 3/7/18.

Site fidelity, which is the tendency to return to a previously occupied location, was determined by the number of sightings per individual over the course of the study period. The levels of site fidelity were defined as follows: 1. no sight fidelity (individuals seen only once); 2. low (individuals identified twice); 3. moderate (individuals identified 3–5 times); or 4. high (individuals identified 6 or more times). These data were also analyzed for individual seasonal trends in habitat use by counting how often individual seals were seen in particular seasons across years.

2.4. Sightings and Seasonality (Total Sightings and Photo-ID Datasets)

Seasons were defined as winter (December–February), spring (March–May), summer (June–August), and fall (September–November). Because effort was not even across seasons, sightings were calculated correcting for effort in order to compare harbor seal seasonal habitat use. Sightings per unit effort (SPUE) was calculated as the number of individual harbor seals sighted during an observation period (1 sighting per individual per observation period) divided by the total number of observation periods.

It was not always clear whether each sighting of a harbor seal during an observation period was a different individual, as sometimes identifiable photos of every sighting were not always captured. To address this potential bias, we calculated the SPUEs using three different datasets. The first set assumes every sighting during an observation period is a unique individual (not based on photo identifications) and is called 'total possible seals'. This provides the maximum number of seals that were present. However, this is likely an overestimate, because individual seals can and have been sighted multiple times within an observation period. The second and third datasets were restricted to only seals identified using photo-ID. These represent more conservative estimates of the number of seals present. The second dataset includes the sightings of individually identified harbor seals using left head photos only and both side profiles, which was called 'min identified seals'. This represents the minimum number of seals that were present. The third dataset includes all those individually identified with left-side-only head and right-side-only head photos, as well as both side profiles, and it is called 'max identified seals'. While there are likely some duplicates in this dataset, it may be a more accurate representation of the true number of seals documented in the study area, as the number probably lies in between the 'min identified seals' and 'total possible seals' estimates. As discussed, there are inherent biases in each of the datasets. However, by utilizing all three, trends can be compared. If the datasets show similar results, it is likely the trends observed are true, rather than due to any potential bias in the data. In addition, it provides a minimum/maximum range of the number of seals utilizing this area.

3. Results

The number of individual harbor seals identified and which profile(s) were documented are shown in Table 1. If all left-side-only head and right-side-only head photographed individuals are considered to be different, then the maximum estimate of individuals is 286 (Table 1). The minimum estimate, calculated as the number of seals with left-side-only head profiles photographed (n = 113) plus the number of seals with both profiles photographed (n = 48), is 161. The actual number of individual harbor seals likely lies in between those two estimates.

Table 1. The number of individual harbor seals with left, right, or both head profiles (i.e., left and right) photographed that were identified. Maximum number of seals = left side of head only + right side of head only + both profiles. Minimum number of seals = both profiles + left side of head only (the profile with the least number of seals).

Profile Obtained	Number of Individuals
Left Side of Head Only	113
Right Side of Head Only	125
Both Profiles	48
Minimum Number of Seals	161
Maximum Number of Seals	286

During the study period, 661.95 h of observation (winter, n = 105.25; spring, n = 197.5; summer, n = 186.45; and fall, n = 172.75) were conducted over a total of 351 observation periods. winter had the lowest number of hours of effort due to the increased wind/rain during those months, which restricted field work opportunities. Fall and winter had consistently high sighting rates across all datasets. The 'total possible seals' dataset showed the highest SPUE in fall, followed by winter, exhibiting the lowest in summer (Table 2). The 'max identified seals' dataset showed a similar trend, where the SPUE was highest in winter, followed closely by fall (0.07 lower), and the lowest was in summer (Table 2). The 'min identified seals' dataset had slightly different results, with relatively similar re-sighting rates across fall, winter, and spring, with winter having the highest, and the lowest SPUE was in summer (0.59) (Table 2).

Table 2. Sightings per unit effort (SPUE) for the study period for the total observation periods per season, 'total possible seals' (i.e., every seal surfacing counted as a new seal), 'max identified seals' (i.e., all profiles included), and 'min identified seals' (i.e., only the left side of the head and both profiles were included) of identified seals. SPUE was calculated as the number of individual seals/total observation periods.

	Winter (n = 57)	Spring (n = 105)	Summer (n = 99)	Fall (n = 90)
Total Possible Seals	1122	1913	622	2032
Max SPUE	19.68	18.22	6.28	**22.58**
Max Identified Seals	181	291	80	279
Mid SPUE	**3.17**	2.77	0.81	3.10
Min Identified Seals	135	231	58	189
Min SPUE	**2.37**	2.20	0.59	2.10

Discovery curves (Figure 3) were calculated using both the maximum (n = 286) (Figure 3a) and minimum (n = 161) (Figure 3b) numbers of identified seals. The discovery curves show the rate and seasonality of newly identified seals documented over the course of the study period. For the maximum number of identified seals, new individuals were identified in every season of the study period and for all years, ranging from 3 to 37 newly identified seals per season (Figure 3a). For the discovery curve, with the minimum number of identified seals, similar results were found with the exception of two summer seasons in 2015 and 2017 where no new seals were identified (Figure 3b). These data suggest an open population model in which the number of new seals identified in Burrows Pass is continually increasing. Both the maximum and minimum discovery curves show that the highest sighting rates of new individuals occurred in fall (n = 114 and n = 65, respectively), with the lowest number of new individuals sighted in summer (n = 36 and n = 14, respectively).

(a)
(b)

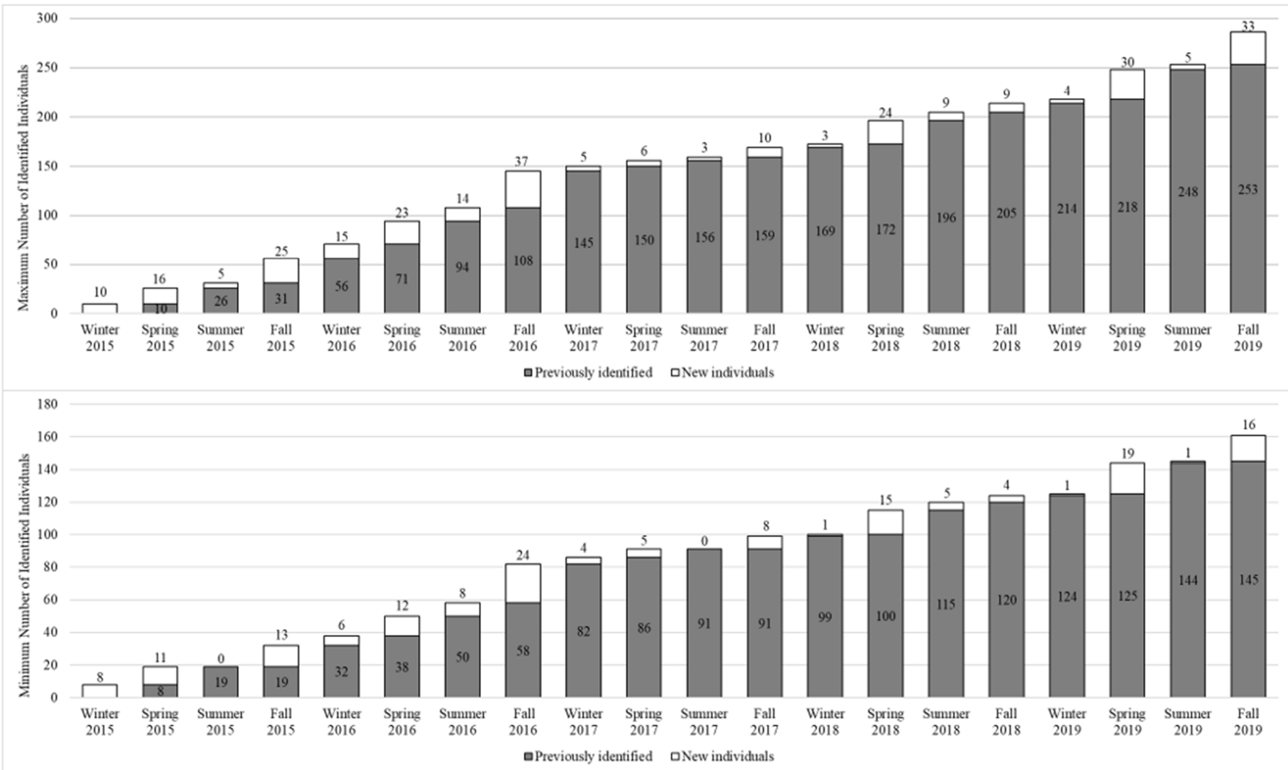

Figure 3. Discovery curves calculated using (**a**) the maximum number of harbor seals identified (n = 286) and (**b**) the minimum number of harbor seals identified (n = 161) per season during the study period. New individuals identified are shown in white, and previously identified seals are shown in gray.

The total number of times a known individual was sighted throughout the entire study period had a large range (1–69), with an average of 2.9 sightings per individual. There were more seals seen once (n = 198) or twice (n = 42) than those seen 3–5 times (n = 22) or ≥6 times (n = 22). It should be noted that 5 of the 22 seals seen ≥6 times have only a single head side profile photographed. Because of the pelage patterns and sighting histories, it is unlikely that duplicates exist within this group of 22 individuals; however, it is possible that there may be one, as seal #22 and seal #26 were both sighted in the same observation periods 13 times (out of 52 total observation periods of either seal), and they share close similarities in their pelage colorations and spotting patterns.

Identified seals were sighted/re-sighted most often in the spring and fall seasons (winter, n = 182; spring, n = 294; summer, n = 81; and fall, n = 265). This pattern was also observed when looking at seals seen only in one season; 234 of the possible maximum 286 identified seals showed the highest presence in spring and fall (winter, n = 23; spring, n = 87; summer, n = 30; and fall, n = 94). The remainder of the identified seals were seen in more than one season. There was variation among individuals, as some were seen in two, three, or four seasons.

The majority (69.62%) of seals were only identified once over the course of the study period, indicating no site fidelity. The rest (30.38%) showed low (15%), moderate (7.69%), and high (7.69%) site fidelity. Seals with no site fidelity were mostly seen during spring and fall (winter, n = 19; spring, n = 70; summer, n = 28; and fall, n = 82). The seals with the highest site fidelity were seen fairly consistently throughout spring, winter, and fall (winter, n = 138; spring, n = 158; summer, n = 37; and fall, n = 122). Seals with low and moderate site fidelity had higher sighting rates in spring and fall compared to winter and summer (Figure 4). Summer was the lowest sighting season for seals of all site fidelity levels (Figure 4).

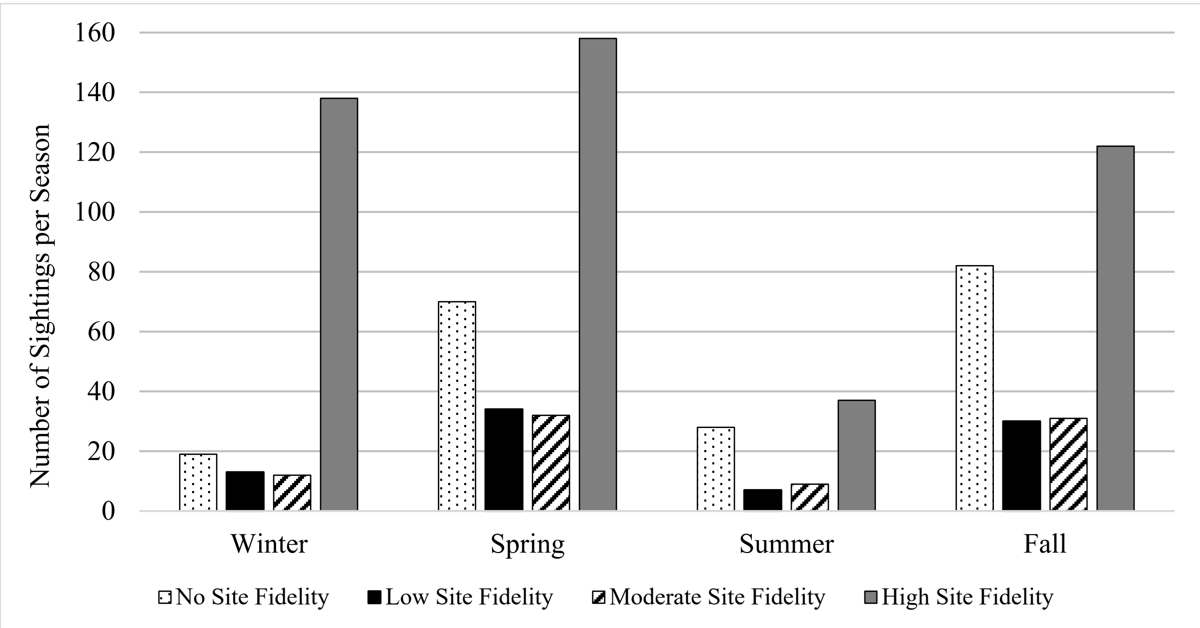

Figure 4. Seasonal variations in habitat use by harbor seals identified in the study area, categorized by site fidelity levels (no sight fidelity—individuals seen only once, low—individuals identified twice, moderate—individuals identified 3–5 times, or high—individuals identified 6 or more times) and the respective number of sightings per season.

The seasonal sighting patterns of seals seen two or more times varied dramatically from individual to individual, with some being seen over multiple observation periods in a row to seals only returning in specific seasons over the years of the study and to those seen consistently throughout the year (with a reduced presence in summer) across all years.

This consistent pattern is also shown for the high site-fidelity group of identified seals in Figure 5.

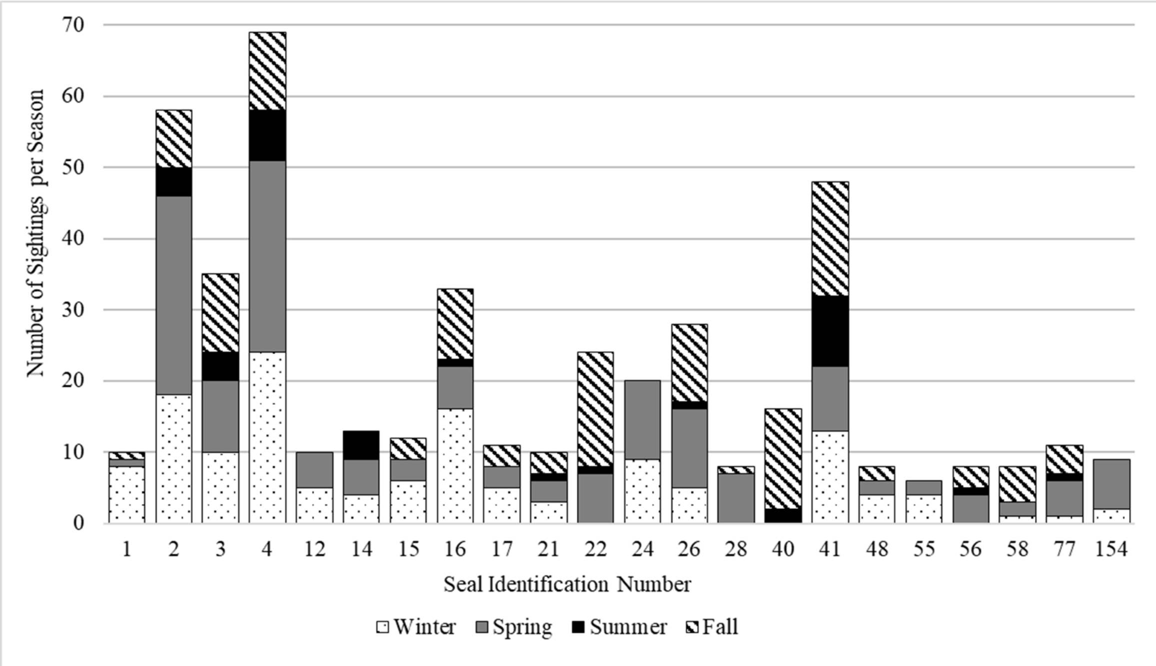

Figure 5. The seasonal variation in re-sightings of the 22 identified seals with high site fidelity (seen ≥6 times) in Burrows Pass during the study period.

4. Discussion

To date, little research has focused on the in-water behavior of harbor seals, which leaves a large portion of their daily lives unknown, as they spend a significant portion of their lives in water. Consequently, beyond the distance traveled around haul-out sites, little is known about where harbor seals travel between haul-out periods, including other areas of use (i.e., foraging locations). This study shows that documenting individual harbor seals using photo-ID of the head and neck regions while in water is an effective way of determining long-term, in-water site fidelity and seasonal patterns. The individual harbor seals showed varying degrees of site fidelity and seasonality to the waters of Burrows Pass those seen once and those seen consistently over all five years of the study period.

4.1. Site Fidelity

Harbor seals were present year round; however, there was considerable individual variation in the levels of in-water site fidelity. Individuals with high site fidelity (i.e., sighted ≥6 times) were seen regularly throughout all seasons and across all years after their first sighting. Some identified individuals showed moderate site fidelity, but with individually unique patterns in their return to Burrows Pass (i.e., returning during two individually specific seasons (fall, winter, or spring) or returning in only one season (fall, winter, or spring) every year since first being identified). A study conducted in Whatcom Creek, Bellingham, located inthe Salish Sea, documented that even during the use of targeted acoustic startle technology (TAST) (startling pulses of sound emitted to elicit a reflex/response and meant to deter seals from an area) certain seals continued to frequent the area to forage, even though their foraging success rate was lowered [28]. This suggests that individual seals can show preference to an in-water area of use, even if adverse conditions (e.g., usage of TAST) may negatively affect their foraging success. Another study also documented harbor seals showing individual preference to multiple areas, indicating that seals are using areas in a more complex manner than previously assumed, resulting in individual variation in their distribution and habitat usage [15]. The fact that many of the seals in our study were only seen once but others were consistently re-sighted supports this idea of complex habitat usage that may be highly variable among individuals, and may relate to their haul-out patterns and/or life history or demographic factors.

Previous research in the Salish Sea examined movement patterns and haul-out site fidelity, and the data indicate that seals remain within <30 km of their haul-out sites with high haul-out site fidelity [11,12,32]. Using the Atlas of Seal and Sea Lion Haul-Out Sites in Washington, there are 138 documented haul-out sites within a 30 km radius of the Burrows Pass study area, 117 of which can host up to 100 seals and 21 can host up to 500 [2]. Thus, there are a variety of haul-out locations and associated large numbers of potential individuals that could be utilizing Burrows Pass within that range. However, this may be an underestimate of usage because the study documenting the 30 km radius relied on the use of very-high-frequency (VHF) radio-telemetry, which is limited in its ability to track animals over large spatial scales for extended periods of time [13,15]. Understanding the limitations of VHF radio-telemetry, researchers have begun using satellite telemetry to accurately quantify the timeframe for adult harbor seal movements, in addition to tracking individuals over long distances without limitations [33,34]. A recent study in the Salish Sea has adapted the use of satellite telemetry for tracking harbor seals and site fidelity, finding movement patterns that had not previously been observed, as 14 of 20 seals, 12 of which were male, moved farther (up to 280 km) from their capture haul-out site, covering a much larger area than expected [15]. The study also documented that harbor seals show individual spatial preferences for certain areas within the region, in addition to some individuals utilizing multiple activity centers [15]. Thus, there may be an even larger pool of individuals (from the many available haul-out locations) that may be using Burrows Pass than previously thought. This, along with the individual (and possibly sex-biased) variation in distance traveled to and from haul-out sites and the number of activity centers seen in the satellite telemetry study [15], is likely the reason why the number of new seals identified in Burrows Pass continues to increase but site fidelity is variable. Seals that frequent nearby haul-out sites may be more likely to be seen in the study area than those that utilize haul-out sites located farther away and/or travel longer distances on average. As seen in our study, some individuals may have a strong preference for certain activity center(s), whereas others may not. If males are more likely to travel farther, then it is possible that there are sex differences in which seals show different levels of site fidelity (i.e., more males than females might be seen in the no to low site fidelity categories). Our results show varying levels of site fidelity patterns and support the idea that there is individual variation (perhaps related to age, sex, or other demographic factors) in harbor seal in-water habitat use. This further emphasizes the need to research in-water site fidelity and habitat use in other regions (as is conducted for haul-out locations) to better understand their movements, behavior, and distribution.

Individual variation seems to be a theme for harbor seals, as seen in habitat usage, site fidelity, and also in diet. Harbor seals are generalist, opportunistic feeders, consuming over 60 different prey species, with locally abundant species comprising the majority of their diet [4,35–38]. Haul-out site fidelity impacts foraging, as it determines where seals begin and end foraging trips [13]. Studies have shown that foraging behavior can be site-dependent and also vary between males and females, between breeding and nonbreeding individuals, and between haul-out locations [38–40]. As opportunistic foragers, harbor seals adjust their foraging behavior in relation to seasonal prey availability [41]; thus, their diet composition tends to follow differences in prey distribution within distinct habitats [42–44]. Harbor seal diet composition can also show large variations temporally, spatially, and among individuals [11,37,39,43,44]. During the study period and throughout the long-term research project, foraging was a common behavior observed in Burrows Pass, and harbor seals were witnessed consuming a variety of prey, including small fish, salmonids, giant Pacific octopus (*Enteroctopus dofleini*), and even a skate (species unknown, likely a Big Skate *Beringraja binoculata* based on photographs taken). Fluctuations in prey availability, life history status, and variation in individual behavior are likely strong combined drivers behind the varying differences in the presence and site fidelity of seals in Burrows Pass.

This variability across individuals shows the highly adaptable nature of these animals to changing conditions in their environment.

4.2. Seasonal Patterns

Although observed year-round in Burrows Pass, there were seasonal variations in harbor seal habitat use. As mentioned above, harbor seals show strong individual variation when it comes to their behavior and diet. Individual foraging behaviors and prey preferences can affect when and what individuals forage in an area. Harbor seals are regularly reported in coastal areas [1,2,45], including areas that have high tidal flow [46,47]. The topography of Burrows Pass is relatively narrow, with strong rip currents creating eddies and boils, thus categorizing it as a tidal-stream habitat [30,47]. Tidal-stream habitats have monthly, as well as daily, tidal cycles that can result in favorable foraging conditions [47], and this is likely the reason why seals are consistently using this area. In addition, the motivation to forage in a particular area may be stronger for some individuals than others. Previous long-term research at Whatcom Creek reported that individual harbor seals aggregated during the fall salmon run over multiple years [28], which is evidence of individuals exhibiting seasonal site fidelity to an in-water location. Individuals who previously experienced the benefits of foraging in this area continued to exhibit this behavior, even with the decrease in individual foraging success experienced under TAST exposure conditions [28]. Similarly, the seasonal and site fidelity variations seen in Burrows Pass may be indicative of individual preferences for a particular habitat and/or prey.

Seasonal changes in prey type and availability may also explain why there was a higher seasonal presence of seals in Burrows Pass during spring and fall. Juvenile Pacific sand lance (*Ammodytes hexapterus*), Pacific herring (*Clupea pallasii*), and Northern Anchovy (*Engraulis mordax*) were found to make up significant proportions of harbor seals' diet in the San Juan Islands and nearby estuarine ecosystems [35,37,38,46], all of which can also be found in Burrows Pass [26]. The two most energetically important prey groups for biomass consumed by harbor seals in the San Juan Islands are salmonids and herring (*Clupeidae*) [35]. The end of January through the beginning of April is an important spawning season for herring, which have near-by spawning grounds in Fidalgo and Skagit Bays [48]. Each spring, juveniles of eight native salmonid species enter the marine waters of the Salish Sea [49], and during the late summer through fall there is a large influx of adult salmonids when they migrate from marine waters to their natal streams [35,37,38]. Consequently, harbor seal predation on salmonids increases during this time [38]. In addition to salmonids and herring, other forage fish seasonalities could also affect seal presence. In the Salish Sea, Pacific sand lance utilize near-by spawning beaches (Skagit Bay) during the fall, while Northern Anchovy spawning is known to occur in nearshore habitats during the summer months [48]. In conjunction with spawning, other factors such as prey migration periods [26], diurnal patterns [48], seasonal upwelling [50], and seasonal zooplankton composition [51] all affect when and where forage fish are found in the Salish Sea. Since harbor seals take advantage of locally abundant prey [4,26,37,39] they likely exploit these seasonal patterns found in their food sources.

Over all analyses, the lowest seasonal presence of harbor seals was during summer. This may be in part related to the timing of the harbor seal's annual molt, which can vary in length depending on their location [52–55], however seals from this region typically molt from August through October [1,4]. All ages and sex classes go through a complete molt every year [1,4,52–55], with the exception of pups which molt in-utero [1,52]. Harbor seals spend the majority of their time ashore for the molting process [53,55–57] to reduce energy spent on thermoregulation [58], thus we would be less likely to see them in the water at our study location during summer.

In addition, seals are also ashore for pupping season during summer, where they spend more time on haul-out sites than any other time of the year [55,58–60]. For the inland waters of Washington State, pupping season runs summer through fall [55], specifically June through August for seals in the area surrounding Burrows Pass [61]. The coastline along Burrows Pass is fairly sheer and rocky, not conducive for hauling out, especially for prolonged periods of time. During pupping season and the weeks following, females and pups tend to isolate themselves into smaller groups, away from the main seal colony [57]. While adult females and their pups spend time ashore, male harbor seals spend considerable time in the water around nursery sites establishing and defending aquatic territories in preparation for mating season, which occurs immediately following the weaning of new pups [60,62,63]. The pupping season, and lack of suitable haul-out sites in Burrows Pass itself, is likely a primary driver of lower sighting rates in Burrows Pass during the summer. The pupping season also correlates with the higher number of new individuals sighted in fall (many of which are juvenile seals and/or pups), as new individuals are being added to the population as they begin exploring the surrounding area

It should also be noted that Burrows Pass is adjacent to Skyline Marina, a very busy harbor. While the number of boats recorded during the summer months are higher than in any other season [30], it is unknown whether this is directly correlated with lower harbor seal presence in Burrows Pass. We observe that harbor seals in this area usually do not show strong signs of disturbance by vessel traffic as they often do not dive when the boats are near (even within one to two boat lengths), and have even been observed surfacing in the propeller wash or riding the wake after the boat passes. Previous studies have indicated that harbor seals are sensitive to disturbance, and that it can impact seal haul-out behavior [56,58,64–66], however, more detailed research is needed to ascertain the extent of vessel impacts on in-water behavior of harbor seals in Burrows Pass.

4.3. Methodology Benefits and Limitations

This study supports the idea that in-water photo-ID is an effective way to identify and track individual harbor seals through time [26–29]. Photo-ID will often underestimate seal presence, whereas total sightings of seals may overestimate seal presence. Our methodology of using a combination of these two datasets provides more robust data that can provide an accurate range of individuals utilizing the study area, and accurate representation of seasonal habits that help mitigate the biases inherent in the data. In-water photo-ID also provides complimentary data to more traditional land-based photo-ID, giving a more accurate depiction of harbor seal life on land and in-water. It should be noted that traditional photo-ID (on land or in-water) is used to track individuals during daylight hours, so their nocturnal habits are not accounted for in this methodology. Tagging is an alternative, more costly method of collecting similar data on harbor seals. It has the benefit of being able to track individuals day and night, and it provides more detailed movement patterns for each individual. However, this is usually implemented for a smaller number of individuals due to the high cost and logistical restraints, and, additionally, it has the downside of potentially negatively impacting the animal, which could affect their behavior patterns [15,33,34]. Although photo-ID methods will likely not document every individual, it provides a noninvasive, cheaper way to collect data on a larger number of individuals than tagging can provide. Adjustments in analyses like those presented in this paper can help mitigate inherent biases that come from the limitations involved in collecting data on wild populations. All three methods—land-based photo-ID, in-water photo-ID, and tagging—can provide important and complementary information about harbor seal populations, but in-water photo-ID is a relatively new method. This study further supports the validity and importance of in-water photo-ID as a valuable method for tracking harbor seals, and we hope that other researchers will incorporate this into future studies.

5. Conclusions

Documenting the behavior and site fidelity of harbor seals while in water is important for understanding the life history and ecology of this species, as well as for determining biologically meaningful conservation measures, as they spend the majority of their time in water. This study shows that in-water photo-ID is a viable way to determine seasonality and site fidelity of harbor seals. Seasonal presence is likely linked to foraging conditions, prey availability, life history status, and also to individual behavior variability. Our findings determined that harbor seals showed varying individual preferences in Burrows Pass. A small percentage were seen throughout and across years, indicating a high site fidelity and strong preference for this in-water location. Others with moderate site fidelity showed strong seasonal patterns or no pattern at all, and the majority were seen only once or twice. This type of information is necessary for understanding the movement and behavior patterns of harbor seals and how they may vary within and between regions and populations. Future research would benefit from an integrated approach through the sharing of identification catalogs with researchers in other areas of the Salish Sea, documenting them in water, as well as at haul-out locations. For species like harbor seals that utilize both land and sea, it is important to use in-water photo-ID along with land-based haul-out location data to more accurately understand their distribution and behavioral patterns that will serve to better conserve and manage their populations.

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