Haul Out Site Use and Substrate Preference in Harbor Seals (*Phoca vitulina*) on Yellow Island in the San Juan Islands, Washington

Ben Kuhl[1,2]

John Bradley Plinka[1,2]

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

[2] Marine Biology, College of the Environment, University of Washington, Seattle, WA 98195

Contact Information:

Benjamin Thomas Kuhl
1122 NE Boat St.
Seattle, WA 98195
bkuhl@uw.edu

John Bradley Plinka
1122 NE Boat St.
Seattle, WA 98195
johnbplinka@gmail.com

Authors contributed equally to this manuscript

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Abstract:

Harbor seals (*Phoca vitulina*) are highly abundant marine mammals in the Salish Sea and require various substrates for haul-outs. The purpose of this study is to identify the potential differences in haul-out substrate preferences, see how use changes with different conditions, and how different demographics use the haul-out. We used land-based, visual surveys on Yellow Island in the San Juan Islands to assess haul-out abundance and use. We found that tide height increases abundance and increases the proportion of lone adults using the haul-out. Increasing tide height also reduces the availability of the preferred rocky substrate. We found that increasing air temperature increases abundance and increases the proportion of mother/pup pairs using the haul-out. Substrate use showed a preference for rocky substrate available at low tide and compulsory gravel use as the tide rose. Our trends in tidal effects on haul out use are well supported, but further study is needed to decouple the time of day and air temperature variables. Understanding haul-out use and dynamics helps agencies establish protections around essential territories for marine mammals.

Introduction:

Harbor seals (*Phoca vitulina*) are the most abundant marine mammal in the Salish Sea, making them a well-researched and documented species (Gaydos & Zier 2014). They have historically been hunted for fur or culled for fishery escapement up until 1972 when the Marine Mammals Protection Act made the killing of marine mammals illegal in the United States (MMPA 1972). Since the introduction of the act, harbor seal populations in the Salish Sea increased until 2000 when it appeared they reached an ecological equilibrium and population growth stagnated (Ashley et al. 2020).

Harbor seals are income breeders, meaning that they continuously forage during the nursing period. This sets them apart from other phocids, which are capital breeders and use fat stores for the entirety of the pupping period (D'Agnese 2015). The pupping period for harbor seals in the San Juan Islands and surrounding areas of the Salish Sea is between June and August (NOAA fisheries 2021).

Pinnipeds use haul-outs for reproduction, resting, thermoregulation, and predator avoidance (Nordstrom 2002). These unique uses and reliance on this habitat make the conservation and management of known haul-outs highly important.

A previous study by students at Friday Harbor Labs shows that harbor seals prefer rocky islets, very rarely using larger island habitats as haul-outs, including both rocky and gravelly island haul-outs (Castillo, Davis, Keil 2017).

In this study, we examined possible effects on harbor seal haul-out preference. Specifically, we looked at tidal and temperature effects on (1) habitat substrate preference, (2) haul-out usage, and (3) demographic differences in haul-out use.

Methods:

Site:

Our study focused on Yellow Island in the San Juan Island chain (map. 1). Specifically, we surveyed the Western haul-out of the island because of the established seal population at the haul-out. Preliminary scouting of the island revealed that very few seals used the Eastern beach of the island, whereas the Western beach and rocky habitat were highly utilized. We designated 2 habitat types (rocky and gravelly) and 13 habitat zones (map. 2). The site lookout had a view of the rocky islets that were used as haul-outs, and full view of the gravelly beach habitat (fig. 1). Our vantage point provided as much a view of the haul-out as possible, however it did not encompass the entirety of the haul-out area.

Process:

The time frame of our study consisted of 7 days in an 8-day period from 08-10-2025 to 08-17-2025 which is towards the end of the harbor seal pupping season in the upper Puget Sound and San Juan Islands. Within the data collection period, the average observation window was about 2 hrs per day with the final observation window consisting of 9 hrs of continuous monitoring. We took observations in 10 min intervals, with an average observation time of 4 min. We alternated between observing and recording every 30 min.

Our observations consisted of visual scans of each habitat zone from zone 1 to zone 13, distinguishing lone adults (LA), mother and pup pairs (MP), and lone pups (LP). Mother pup pairs were determined by proximity and major size difference, or nursing. At harbor seal densities higher than N=17 on haul-out zones and laid in similar orientation, we only counted LAs and LPs, finding that the conditions made MP counts unreliable.

Equipment and Supplemental Data:

The equipment we used for our survey included two pairs of 10x 42mm binoculars and a 16-48x 60mm field scope for counting seals and identifying demographic makeup. Tidal height and air temperature data was collected from the NOAA tides and currents website for the 9449880, Friday Harbor Labs, Washington station. We used predicted tide height and measured air temperature for all observation periods.

Results

We collected 20 hours of observations over the period of 8-10-2025 to 8-17-2025 (Fig. 2). We made most of our observations between 11:15 AM and 3:20 PM. Our observations from earlier in the day came from one period on 8-16-2025 and one extended field day on 8-17-2025. On five occasions, we observed a combined ebb-slack-flood period. The other two observation periods occurred during flood tides only.

Our observations revealed a potential link between tide height and changes in harbor seal haul-out usage on Yellow Island. The number of seals using the haul-out trended higher as tide height increased (Fig. 3a). Seals mostly used the rocky outer islands (Z1-Z5, Z10) when the tide was below 0.6 m and used mostly gravelly substrate (Z7 and Z12) when the tide was above 0.6 m (Fig. 3b). There is a strong correlation between the average tide height per day and the average substrate usage per day. The seals also showed preference for rocky substrates when the tide was low, with 100% of seals using roughly 65% of the assessed haul-out area.

Air temperature also appeared to influence haul-out dynamics. Harbor seal presence at Yellow Island increased as air temperature increased, like the relationship found with tide height (Fig. 3c). There were two shifts in primary substrate use associated with air temperature (Fig. 3d). From 12.9 °C to 15 °C, harbor seals used exclusively rocky substrate before switching to primarily gravelly substrate at above 15 °C. Between 18.5 °C and 23 °C there is a gap in temperature data, but above 23 °C, the seals in our study did not use the gravelly substrate at all. Average air temperature per day compared to average haul out usage per day showed a potential link between those factors.

Shifts in demographics using the haul-out showed unique signatures for both tide height and air temperature. When we considered the concentration of adults and juveniles as a function of tide height, we saw the proportion of adults hauled-out increase as tide height increased (Fig. 4). Those same variables considered as a function of air temperature showed very little divergence as air temperature increased. When we considered the concentrations of individuals by relationship status as a function of tide height, we found that increased tide height results in increased proportions of lone adults and decreasing proportions of mother/pup pairs and lone pups (Fig. 5a). When the relationship status groups were compared over air temperatures in the same way, we found an increase in mother pup pairs, a decrease in lone pups, and relatively little change in the proportion of lone adults (Fig. 5b).

Discussion

This study works to fill gaps in an extant body of work. Our observations indicate that tide height plays a major role in seal abundance, haul-out substrate selection, and demographic proportions. Air temperature has similar effects on haul-out dynamics, but the narrow observation period for the study makes it difficult to decouple the influence of air temperature from the time of day. The observation and analysis processes revealed areas for future study that would benefit greatly from implementing technology expanding the observation period.

The purpose of our study was to perform a focused study on haul-out preference including the factors that affect that choice. Previous studies at Friday Harbor Labs and on Yellow Island had not

covered the influential factors on harbor seal haul-out preferences, but rather focused on interactions between mothers and pups, distribution, or flushing reactions (Castillo, Davis, & Keil 2017; Carpenter, Ogle, & Weis 2021). The findings of Castillo, Davis, & Keil 2017 show that the behavior of this population of seals is consistent with our findings that harbor seals prefer rocky islets. Our study expands on theirs by associating the variables of tide height and temperature with that preference. Understanding the causes of different haul-out behaviors can allow for better habitat protection. Our results show that there is a compelling case for the continued study of the harbor seal population on Yellow Island, especially considering the proximity and resources of San Juan Island.

Tidal influence of haul-out abundance is well documented, with the majority of haul-out populations using their site from the low slack-tide and early flood tidal periods (Watts 1996). The Yellow Island population follows this trend, with total seal counts generally increasing as the survey period progressed each day. The literature support for the observed trend reinforces our confidence that the data reflects true abundance in relation to tide height, despite the truncated observation period. The seals showed a preference towards the rocky substrate at low tides, exclusively using those areas when the rocky islands were exposed. Seals would only move to the gravel beach when the rocky area they had been using was inundated, despite the gravel beach being available at all times during the study period. It is possible that the choice to use the rocky islands was influenced by our presence near the gravel beach, but in most instances the seals were on the rocky islands when we arrived. When we arrived after the seals had already transitioned to the beach, our presence did not cause them to switch to the rocky outcrop at the end of the beach. These two anecdotal observations caused us to believe our presence was not having a major effect on the haul-out substrate selection and we were seeing a normal use of the various haul-out types. Increasing tide height resulted in an increase in the proportion of adults using the haul out. Given that more seals in total are known to haul out as the tide rises and the adult proportion of the haul out increases with tide height, we suggest that most of the additional seals hauling out are lone adults or adults from mother/pup pairs who had been foraging during lower tides.

Future studies on harbor seal haul-out dynamics will have both challenges to overcome and advancements to aid in research. One challenge will be the time needed to make observations at consistent temperatures throughout the year to disentangle data related to air temperature, time of day, and season. A multi-year study that allowed the same team of observers to collect data in similar-as-possible conditions throughout various seasons would build a robust profile on the Yellow Island haul out specifically, and add to the greater academic body that exists regarding harbor seals. These detailed profiles will help track population health and serve as a baseline to analyze the impacts of future ecological threats. These future endeavors will almost certainly benefit from the adaptation of aerial drone research techniques. Drones are already aiding ecologists in multiple fields, and their demonstrated usefulness in pinniped research strengthens the argument for their adoption in a project like ours (Larsen and Johnston, 2023). Our time observing the seals revealed no response to overhead stimulus in the form of flying birds and airplanes. This behavior suggests that a drone flown overhead would not alter behavior or cause flushing. This could allow for more in-depth area surveys, with pictures being taken for later abundance analysis, atmospheric conditions being timestamped for comparisons, and overhead area maps being used in GIS systems to better determine substrate availability. This level of clarity would make detection of small scale shifts in haul-out dynamics more noticeable, potentially giving managers more time to evaluate threats and intervene as needed.

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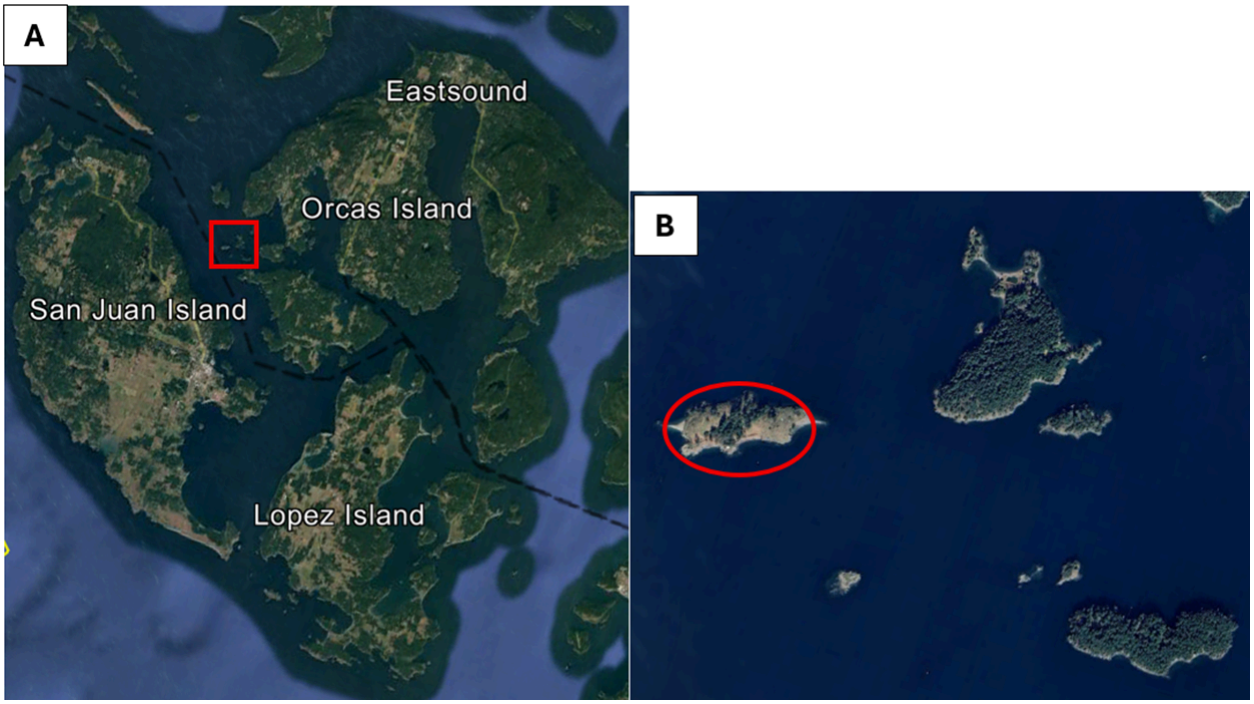
Figure 1: Perspective from the lookout site showing the difference in habitat availability at both low tide (A) and high tide (B).



Map 1: Position of Yellow Island (B) in the San Juan Island chain (A).

Map 2: Haul-out site on Yellow Island and labelled zones (Z1-Z13) including the land-based survey lookout.

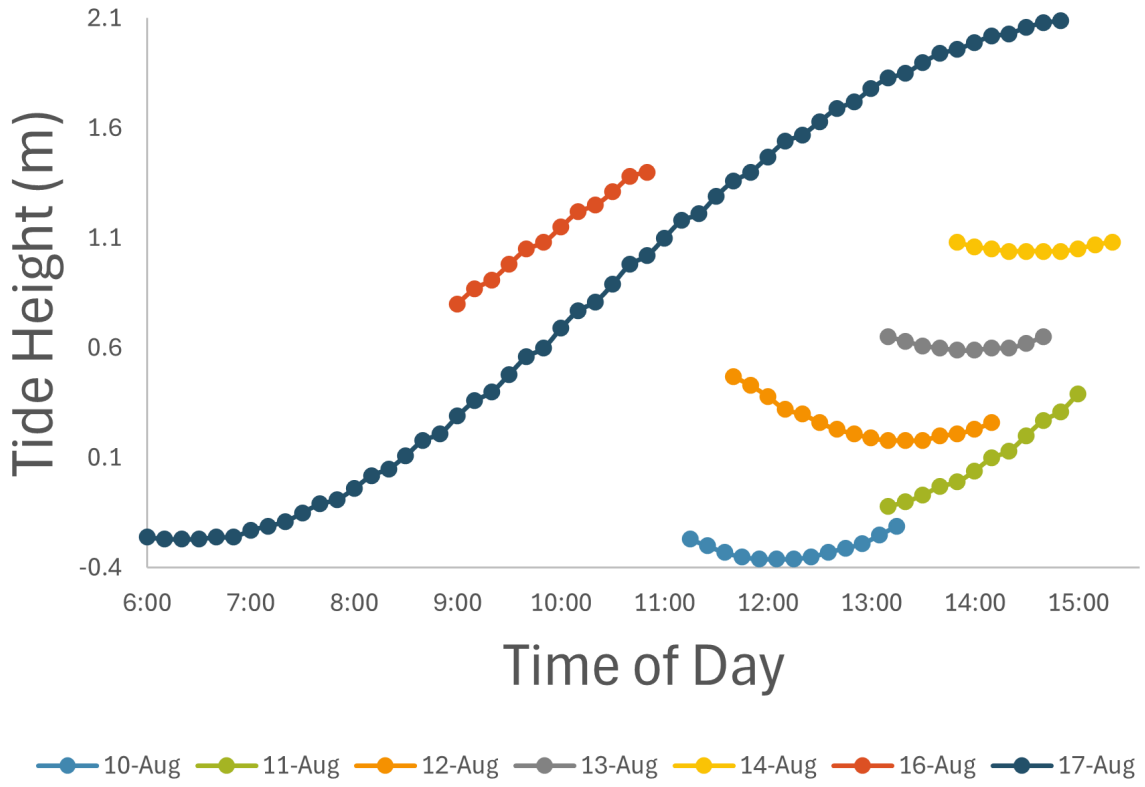


Figure 2: The tide height (in meters) at the time of day every observation of the study was made. Tide height is determined by matching observation time with tidal data from NOAA.

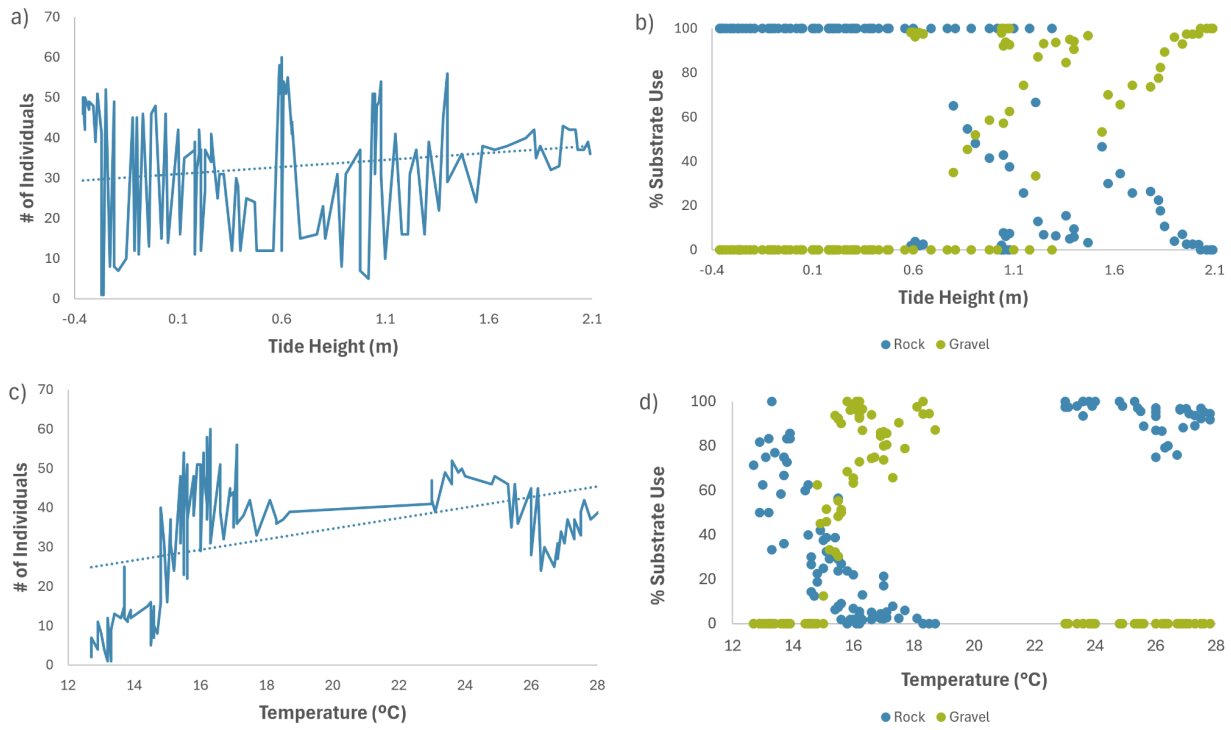


Figure 3: Changes in haul-out use due to tide height are reflected in harbor seal abundance (a) and in the percentage of substrate use (b). Changes in use due to air temperature are reflected in harbor seal abundance (c) and in the percentage of substrate use (d).

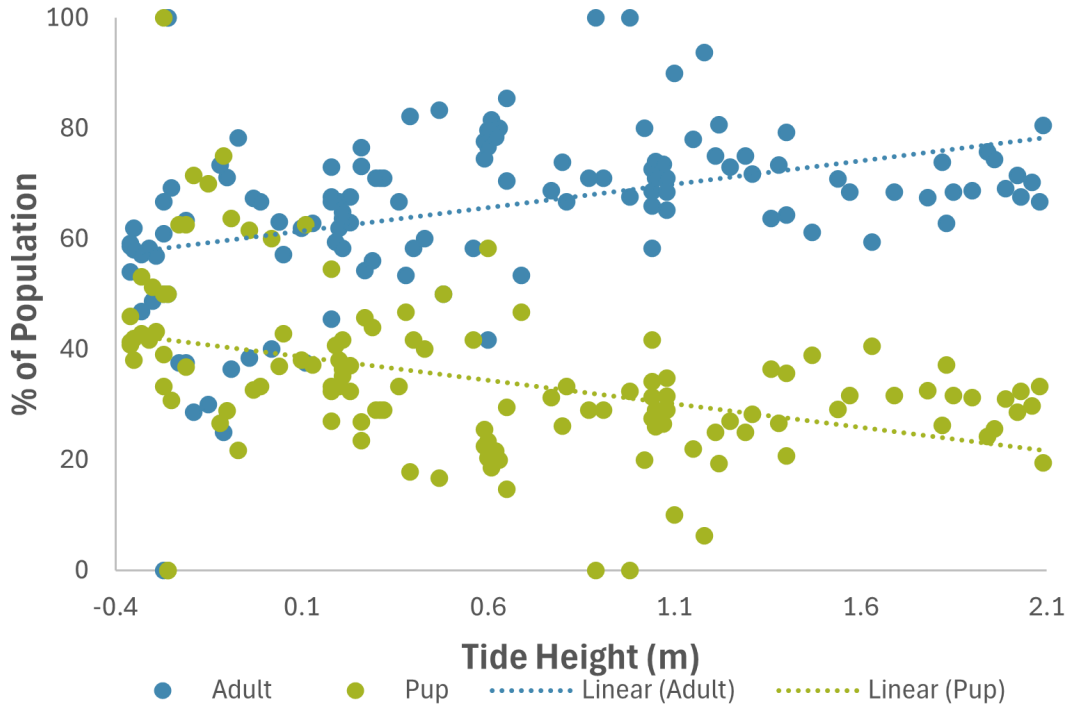


Figure 4: As tide height increases, adults represent a larger proportion of hauled-out seals.

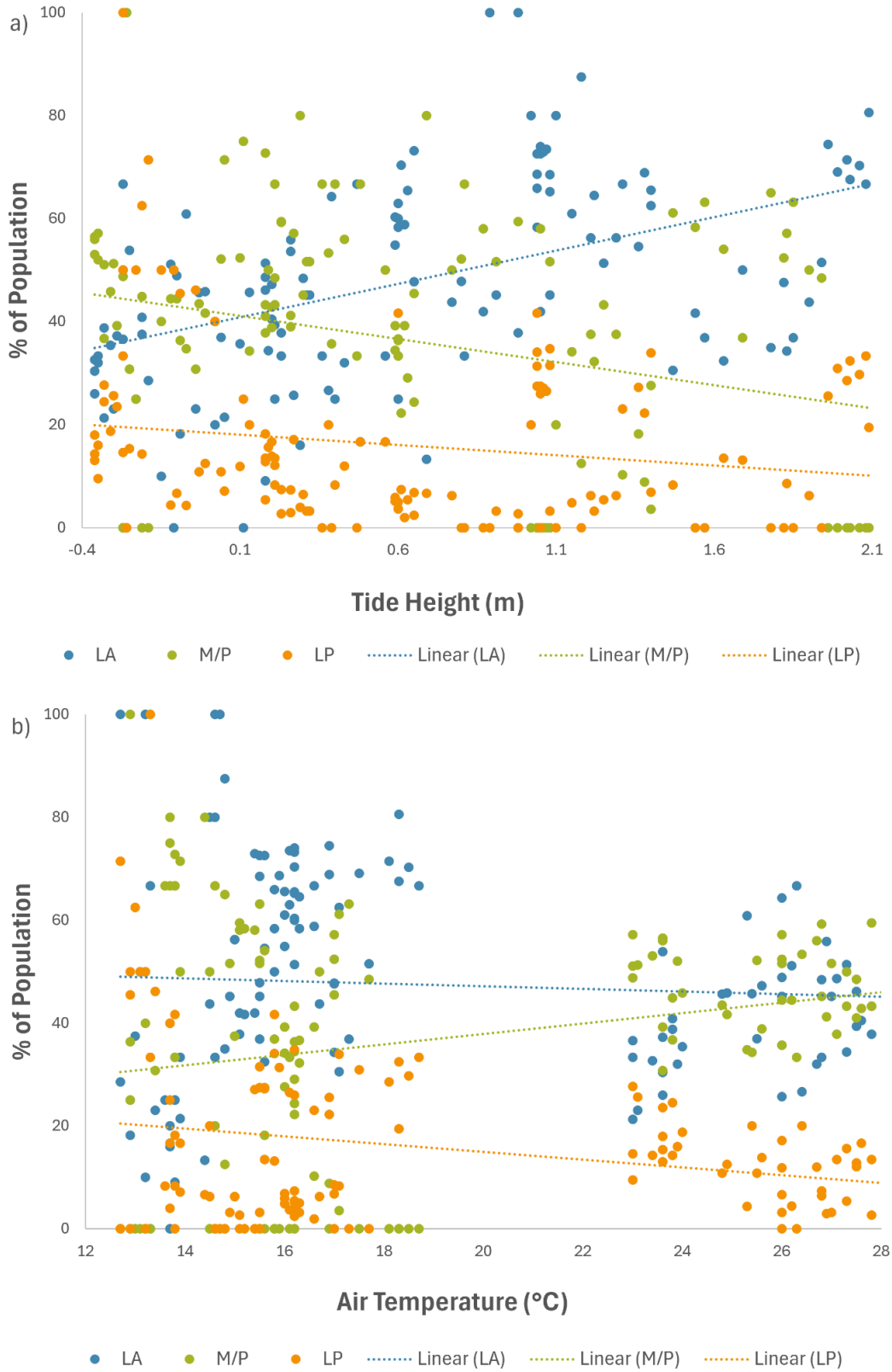


Figure 5: As tide height increases, the proportion of LA goes up while M/P and LP goes down (a). As air temperature increases, the proportion of LA stays the same, M/P rises, and LP goes down (b).