Bass Harbor Head Light Station Comprehensive Visitor Management Plan

An Interactive Qualifying Project Report

An Interactive Qualifying Project submitted to the faculty of

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Abstract

The purpose of this project was to guide the park in developing a comprehensive visitor management plan for the Bass Harbor Head Light Station. The team collected data using direct observation, surveys, photographs, and big data. Recommendations were made to reduce the congestion of and facilitate parking for vehicles on site while maintaining the quality of the visitor experience and safety, as well as the ecological integrity of the landscape.

Executive Summary

Introduction

The National Park Service (NPS) was created to preserve the country's natural resources and create recreational spaces for the public to enjoy. With increased visitation to National Parks, the NPS faces new challenges maintaining the national parks. In 2021, over 297 million people attended national parks (National Park Service, 2022c). This increased visitation poses the challenge of controlling overcrowding in the parks. This overcrowding deteriorates the visitor experience and can be harmful to the surrounding wildlife.

One National Park currently facing overcrowding is Acadia National Park. Acadia is located on Mount Desert Island on the coast of Maine. The beautiful coastal views attracted approximately 4.1 million visitors in 2021 (National Park Service, 2022i). Since Acadia is one of the smallest National Parks, this large number of visitors contributes to overcrowding in the park. This overcrowding includes traffic congestion, busier peak times, and deteriorated visitor experiences. These issues are especially present in the most popular sites in Acadia.

One of the most popular sites in Acadia is the Bass Harbor Head Light Station. When Acadia acquired the lighthouse in 2020, the site became an instant hot spot for visitors (National Park Service, 2021a). This new influx of people presented challenges such as overcrowding, illegal parking, and blocking private residences. The goal of our project is to help the park develop a comprehensive visitor management plan to address overcrowding, parking accessibility, visitor safety, and visitor satisfaction at the lighthouse.

Background

The Bass Harbor Head Light Station is the only lighthouse located on Mount Desert Island (MDI) (Hartford, 2020). Since it is the only lighthouse on the Island, the site quickly became the fifth most popular location to visit in Acadia (National Park Service, 2021a). This surge in popularity has led to a sudden spike in visitation to the site. Since the site only has 25 parking spots, this increased visitation had many residents of the lighthouse area reporting visitors parking on the side of the road and even blocking their driveways. This issue caused by the overcrowding of the Bass Harbor Head Light Station needs to be addressed to help maintain the philanthropy which continues to support Acadia National Park.

Methodology

Our plan to aid the park in developing a comprehensive visitor management plan for the Bass Harbor Head Light Station was outlined by three main objectives. These objectives were as follows:

1. Execute data collection methods
2. Analyze collected data
3. Develop recommendations for visitor management at the Bass Harbor Head Light Station

Our first objective involved a wide range of data types and collection methods. Our second objective had us organizing our collected data into comprehensible and useful graphs. Our third and final objective used our interpreted data to form recommendations that would help the park manage visitor use of the Bass Harbor Head Light Station.

Before beginning data collection, our group determined what our areas of interest would be when collecting data, by giving us a series of questions we wanted answered by the

end of our research. Through this line of questioning, our team decided upon five data collection categories for our methodology. These categories are accessibility, dwell time, people at one time, visitor experience, and residential experience. To evaluate the site's availability, our team determined how people are accessing the site over the day and recorded how the arrival and departure of visitors varies based on factors such as weather and time of day. To determine how visitors were getting to the site, we surveyed the visitors of the Bass Harbor Head Light Station (*See Appendix A*). Then we used direct observation to determine these visitors' arrival and departure times. We stood in the lighthouse parking lot, recording the time a vehicle parked in a spot, the group size in that vehicle, and when they left. We then compared the arrival times to see fluctuation throughout the day and with varying external factors.

We also observed the dwell times of vehicles—dwell time meaning length of stay on site. We used the same data from the previously mentioned direct observation; however, we subtracted the arrival time from the departure time for each vehicle. This operation gave us the dwell time of each vehicle observed. We also tracked the dwell times of visitors walking or biking onto the site. To do this, we used a "time-stamp" card (*See Appendix J*). We marked the time and group size of visitors walking or biking to the site, wrote the initials of the teammate who distributed the card, and handed the card to those visitors. We also marked the number of the card we distributed to determine a card return rate. Then when the visitor left, they handed the card back to us, and we marked their departure time. Similar to the method used for vehicle dwell times, basic subtraction would give us the visitor's dwell time.

The next data point our team considered was people at one time (PAOT also referred to as PAOTs). PAOT is defined as the number of people in one area at a single time. Our team used PAOTs to quantify the level of overcrowding on the site as opposed to just the parking lot. To collect these PAOT counts, we placed cameras set to take photographs every 15 minutes in various locations across the site. Our team then looked through all these photographs, counting and recording how many people appeared in each. We also recorded the date and time of each image. This allowed us to track the crowdedness of the site for different times of day, days of week, and types of weather.

Another important aspect our team considered was the visitor experience. To gauge this, our team used the same survey as was previously mentioned. In this survey we also asked visitors to rate the crowdedness, safety, and overall experience at the lighthouse (*See Appendix A*). We also asked if they thought a reservation system would benefit the lighthouse to see how visitors felt about this potential aspect of the comprehensive visitor management plan.

Finally, we considered the residential experience. This point considers how people living in close proximity to the lighthouse are affected by visitation to the lighthouse. To do so, our team conducted surveys on many of the roads near the lighthouse. We asked residents questions such as how the proximity of the lighthouse affected their daily life and what ideas for solutions they supported (*See Appendix B*).

After collecting data for these five different areas of interest, our team was able to move on to the data analyzation phase of our methodology. For this objective, we performed three types of analysis: vehicular use pattern, visitor use pattern, and survey analysis. Vehicular use pattern analysis dealt with vehicle dwell times as well as vehicle arrival and departure times. For this, we looked at how the time of day, day of week, and weather affected the number of vehicles traveling to the site and how long these vehicles were parked in the lot. To do so, we averaged our collected dwell times over each of these time frames and external factors to see

how they compared to each other and the overall average.

Next, we considered visitor use patterns. This differs from vehicle use patterns as it deals more so with how many total visitors were on the site at one time, where these visitors were located on the site, and how each of these statistics varied with time of day, day of week, weather, and tides patterns. For this we looked at our recorded PAOT counts and the dates and times they were taken to determine how the number of people on site varied over the day. We also looked at where visitors were going on site by asking in our previously mentioned visitor survey if visitors went to either of the viewing areas on site (*See Appendix A*).

Our last type of analysis was for our surveys. In our visitor survey, we asked visitors if they had any extra comments about the lighthouse. Additionally, our residential surveys were entirely semi-structured, or open-ended. Due to the open-endedness of these surveys, our team employed a five-step "coding" process which outlines how to turn qualitative survey data into quantitative, analyzed data.

Our team's final objective was to use all of this now analyzed data to help the park develop a comprehensive visitor management plan. This included a reservation system among other supplementary solutions which are described in more detail later on.

Results

In total, our team collected data for 22 days. After the data collection process, our team performed a few of the following tasks: traffic pattern, dwell time, PAOT, visitor survey, and residential survey analysis.

To begin, our traffic pattern analysis examined increased visitation, peak times, parking availability, and use of accessible spots. In regard to increased visitation and peak times, our team compared the traffic counter on Lighthouse Road with information obtained from Big Data to compare trends from 2018 through 2021. Our team also compared this data to the data collected on site during 2022. This analysis revealed a spike in visitation between 2018 and 2021 of approximately 12,122 vehicles. This finding suggests that the lighthouse likely received an influx of new visitors due to the transfer of the lighthouse in 2020. Additionally, from 2019 to 2021, our team determined the site receives the highest volumes of visitation between 10 a.m. and 3 p.m. Additionally, after comparing our data from 2022 to the 2021 car counter data, our team noticed two distinctive peaks during this interval of time: 10:00 a.m. to 11:00 a.m. and 12:00 p.m. to 2:00 p.m. In regard to parking availability, our team observed three distinct patterns when the parking lot filled to capacity: queues of cars idling on Lighthouse Road, cars turning around rather than waiting to park, and cars parking in unmarked spots. In regard to handicap accessible spots, the data collected suggests these spots are not being fully utilized by visitors. Over the course of our data collection, our team only observed one instance in which all three spots were occupied. Additionally, during this time, the spots were only filled for a total of 6 minutes.

In total, our team collected 2,462 vehicular dwell times. During our analysis, our team examined elements such as dwell time distribution, group size dependency, and time of day variability. The distribution was rightly skewed, indicating that a large proportion of dwell times were 30 minutes or less in duration and a relatively small proportion of dwell times were longer than 30 minutes. Given the shape of this distribution, the average dwell time, 28 minutes, was larger than the median dwell time, 26 minutes, for this set of data. In regard to group size dependency, the data suggests that group size does have an effect on how long

visitors dwell on site. More specifically, our team found that for group sizes between 1 and 6 people, as the group size increased, the average dwell time also increased. Transitioning to time-of-day variability, our team discovered the longest dwell time durations typically occur during sunset.

Our PAOT analysis looked at how crowdedness varies across different locations on the site and different times of the day. The data revealed a higher level of visitation at the rocks than at the lighthouse viewing area. This finding is likely due to the fact that the rocks have a larger surface area and allow visitors to obtain a more scenic view of the lighthouse. While the rocks received higher levels of visitation, both locations experienced spikes in visitation during the hours leading up to and following sunset. Additionally, our team evaluated the distribution of group sizes per vehicle. The majority of visitors arrived in groups of two, and the average was approximately 2.95 people per vehicle. In regard to carrying capacity, our team was unable to determine a specific carrying capacity for the site; however, the results from our visitor survey revealed zero correlation between visitors' perception of crowdedness and their overall experience rating. This finding seems to suggest that the carrying capacity was likely not reached during our data collection process.

The results from our residential and visitor surveys provided useful insights into the impacts of increased visitation, sentiment around possible recommendations, and site-wide interaction patterns. Our visitor survey indicated that the majority of respondents discovered the lighthouse through the NPS website. Additionally, the overwhelming majority of respondents reported accessing the site by motor vehicle. These results from this survey also corroborate our team's direct observations of group size. In terms of site-wide interaction, a lower percentage of visitors reported walking down the Bass Harbor Head Trail to the rocks than the paved path to the lighthouse viewing area. Our survey also suggests that visitor sentiment around implementing a reservation system is evenly divided down the middle. Unlike our visitor surveys, many respondents in the residential surveys reported visiting the lighthouse during the off-season to avoid the large crowds. Additionally, the majority of residents we spoke to expressed that their lives were negatively impacted by the lighthouse's close proximity. They reported increased levels of traffic on the roads and visitors parking near and turning around in their driveways. In regard to possible recommendations, a larger percentage of residents supported implementing a reservation system than the visitors surveyed. However, a higher percentage of these residents supported providing additional parking over implementing a reservation system.

Recommendations

Using our results, our team was able to form three larger recommendations and five smaller recommendations. Our three larger recommendations are traffic control, a reservation system, and additional parking. The five smaller recommendations include accessible parking spots, signage, numbering the spots, additional bicycle racks, and updating the website.

Our three recommendations ranged based on their level of extensiveness, from least extensive to most extensive. Our first major recommendation is traffic control. During our time on site, our team directed traffic for a few days and noticed this helped with the congestion of vehicles on the site and allowed vehicles to move in and out of the lot easier. From our experience, we would recommend this as the simplest solution for the National Park Service. Our next recommendation would be a reservation system like the one on Cadillac Mountain. This recommendation would prevent the long queues of cars and large number of turnarounds

we observed. Our final and most extensive recommendation would be additional parking. Our team understands that the National Park Service tries to avoid adding additional parking and infrastructure, but we wanted to mention the option anyway. Additional parking would allow the queue of cars to be able to park instead of having to wait in line. Our hope with providing these three recommendations is that the National Park Service can look at these options and compare them to decide what would be best for them and the Bass Harbor Head Light site.

Finally, our team developed five additional, smaller recommendations that could be implemented much sooner and could likely all be implemented together. These include modifying accessible parking spots, improving signage, numbering the parking spots, adding more bicycle racks, and updating the website. We noticed that the accessible parking spots on site were not being used as frequently as other spots. Additionally, the site had more spots than required by the ADA. We also saw these accessible spots were not meeting all of the ADA requirements, such as having a sign for each spot. Our team also realized during our time on site that there were two separate signs with two different hours of operation. We recommend that the park update these signs to have the same hours of operation. While collecting data, our team numbered the valid parking spots which helped visitors know what spots they could park in and which spots were ones that were not official spots. This was something that helped manage where visitors were parking without the help of any person. Another additional recommendation we had was to install additional bicycle racks. Many cyclists would not see the first rack when they came in and would either put their bikes anywhere or would go down the Bass Harbor Head Light Trail with them and leave them on the side of the trail. The bikes being left on the sides of the trails caused some trail widening which is why we suggest adding additional bicycle racks. Our final smaller recommendation was updating the website to have more detail about the site. We observed that there were times when visitors arrived not knowing much about the site or how accessible the site is. We recommend adding more detail about the layout of the site and the accessibility of the site so that visitors can learn these things before arriving.

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1.0 Introduction

In 1916, President Woodrow Wilson established the National Park Service (NPS) to preserve the country's natural resources and create recreational spaces for the public. Today, the NPS manages over 423 national park sites (National Park Service, 2022d). Over the past decade, growing visitation to these sites presents new challenges. In 2021, over 297 million people attended the national parks (National Park Service, 2022c). This visitation spike spotlights how overcrowding diminishes the quality of the visitor experience and the surrounding landscape. As visitation continues to rise in national park sites, the NPS struggles to uphold its initial mission statement.

One site where growing visitation and overcrowding are particularly relevant is Acadia National Park. Acadia is located on Mount Desert Island in coastal Maine. Acadia's origin has roots in local philanthropy, and this spirit remains active today. The coastal area provides beauty in the wilderness and views. This beauty continues to attract more visitors to the small National Park. However, increased visitation threatens the balance Acadia has with both local philanthropy and the natural landscape.

Acadia National Park is the 15th smallest national park (National Park Service, 2022h). Despite this, it received approximately 4.1 million visitors in 2021 (National Park Service, 2022i). This park's growing popularity combined with its small size contributes to issues such as overcrowding. Too many people arriving at the same time causes traffic congestion, chaotic peak hours, and diminished visitor experiences. As a result, the park began implementing reservation systems in densely visited areas such as Cadillac Mountain and Ocean Drive Corridor.

Another site in Acadia that may benefit from park intervention is the Bass Harbor Head Light Station. When Acadia acquired the lighthouse in 2020, the site became an instant hot spot for visitors (National Park Service, 2021a). This new influx of people presented challenges such as overcrowding, illegal parking, and blocking private residences. The goal of our project is to help the park develop a comprehensive visitor management plan to address overcrowding, parking accessibility, visitor safety, and visitor satisfaction at the lighthouse.

2.0 Background

2.1 Introduction

The following background sections describe factors contributing to overcrowding at national park sites across the country. In this project, our team will look at overcrowding through the lens of Acadia National Park and the Bass Harbor Head Light Station. Relevant sections include the National Park Service (NPS), Acadia National Park, overcrowding in Acadia, the Bass Harbor Head Light Station, and the project description.

2.2 The National Park Service

2.2.1 History of The National Park Service

Yellowstone National Park laid the foundation for the development of the National Park Service. On March 1, 1872, President Ulysses S. Grant signed the Yellowstone National Park Act, recognizing Yellowstone as the first national park. President Grant created Yellowstone to preserve land in Montana and Wyoming "as a public park or pleasuring-ground for the benefit and enjoyment of the people " (Mackintosh et al., 2018). Yellowstone's purpose was both to protect the landscape from westward expansion and utilize the area for public recreation.

With its induction in 1872, Yellowstone set a precedent for placing natural resources under federal jurisdiction. By 1916, "the Department of the Interior oversaw 14 national parks… [and] 21 national monuments" (Mackintosh et al., 2018). While growing in size, this collection of sites lacked clear management. To address these management concerns, President Woodrow Wilson signed the Organic Act on August 25th, 1916. This act established a federal bureau called the National Park Service and clearly outlined the NPS's mission "....to conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means[,] as will leave them unimpaired for the enjoyment of future generations" (National Park Service, 2021b).

2.2.2 Increased Visitation to National Parks

The scope of the NPS has expanded since 1916. Today, the NPS manages 423 national park sites, covering more than 85 million acres of land (National Park Service, 2022d). These sites include lakeshores, recreation areas, national parks, national monuments, military parks, trails, and seashores (National Park Service, 2022d). The growth in the National Park System also mirrors the heightening visitation rates. Over the past decade, national park visitation continues to rise. From 2011 to 2021, the number of people visiting national park sites increased from 237 to 297 million (National Park Service, 2022c).

National Park attendance also rose in response to the COVID-19 pandemic. As shown in Figure 1, from 2020 to 2021, the number of people visiting national park sites increased by nearly 60 million. With more downtime during the pandemic and updated protocols, people swarmed the national parks. To keep up with the increase in visitation, the NPS began implementing reservation systems. One of the first national parks to successfully adopt a reservation system was Haleakala National Park in Hawaii. In 2017, the park introduced the Haleakala National Park Summit Sunrise reservation to limit the number of cars entering the park during sunrise. The success of this reservation system set a precedent for controlling visitation (Sachs, 2022). National parks requiring reservations in 2022 include Glacier, Rocky Mountain, Arches, Shenandoah, Zion, and Acadia National Park (Sachs, 2022).

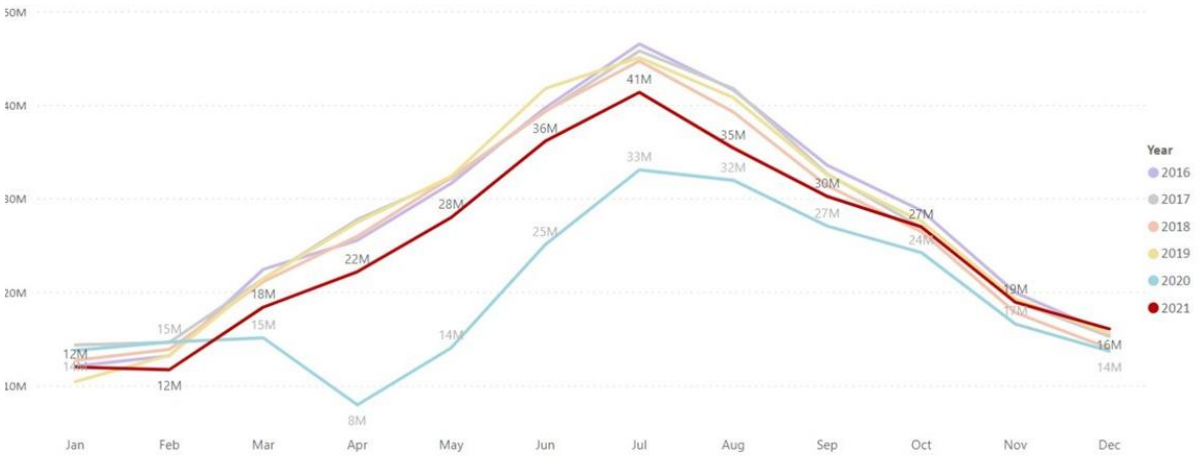

Figure 1: Plot of monthly visitors to the National Park System from 2016 to 2021 (National Park Service, 2022b)

2.3 Acadia National Park

2.3.1 History of Acadia National Park

An example of a national park site dealing with an influx of visitors is Acadia National Park. To understand the congestion at Acadia, one must understand the park's unique history and geography. Acadia is located along the Atlantic Coastline of Maine. Figure 2 displays a map of Acadia's most prominent features: Mount Desert Island (MDI), Schoodic Peninsula, and Isle au Haut. The popularity of this land ties to the area's coastline geography. While this coastline attracts millions of visitors today, it was also influential in the park's formation.

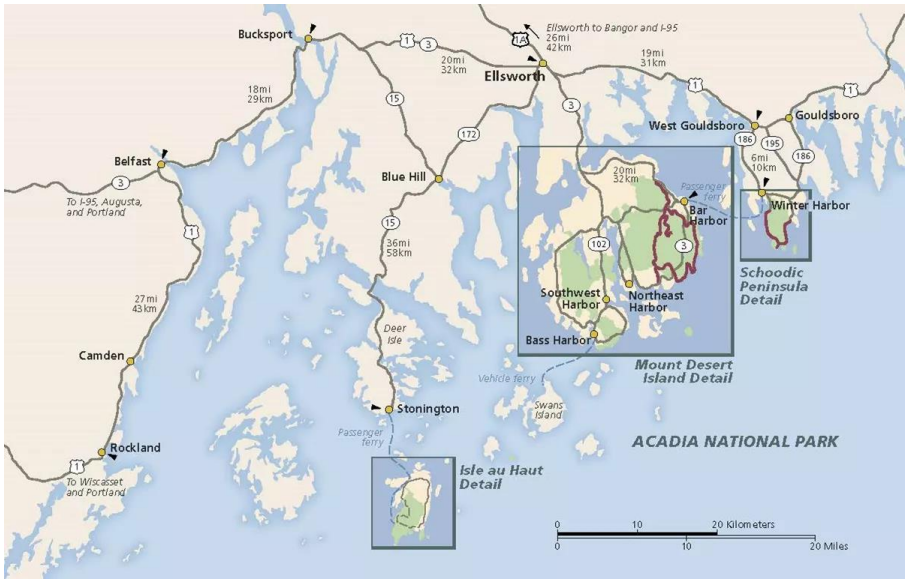

Figure 2: Map of Acadia National Park's prominent islands and peninsulas (National Park Service, 2022e)

By the 1880s, MDI became a popular summer destination for "American corporate elites" such as the Fords, Vanderbilts, Astors, and Rockefellers (Hornsby, 1993). Their

appreciation for the coastline geography sparked the park's creation. Charles W. Eliot, former president of Harvard University, and George B. Dorr, an American preservationist, helped John D. Rockefeller pursue national park status for the land. In 1916, these men "presented 5,000 acres to the American people in the form of a national monument, penned into existence by President Woodrow Wilson" (National Park Service, 2022a). The initial name was Sieur de Monts National Monument. In 1919, with the addition of more property, the monument became Lafayette National Park. In 1929, with the donation of the Schoodic Peninsula, the name changed to Acadia. Acadia was "the first national park created from private lands gifted to the public through the efforts of conservation-minded citizens" (National Park Service, 2022a).

This philanthropy spirit is still alive today. Friends of Acadia is a philanthropy group that works closely with the park. This group leads restoration projects and fundraisers to restore important landmarks. Additionally, Friends of Acadia is influential in raising funds to develop transportation plans that reduce vehicular congestion at popular sites.

2.3.2. Transportation in Acadia

Acadia has many different methods of transportation for visitors to travel throughout the park. Visitors may choose to "hike, bike, camp, horseback ride, boat, fish, and ski against a landscape of largely unspoiled forest and coastline" (National Park Service, 2022f). Visitors can also use both local and park roads to drive throughout the park. Additionally, a fare-free shuttle system called the Island Explorer is available. Friends of Acadia was influential in funding and organizing the Island Explorer. According to the NPS, "Regularly scheduled buses stop at specific destinations in the park-including campgrounds, carriage road entrances, and many trailheads" (National Park Service, 2022f). While there are a variety of transportation options, many visitors rely on cars to navigate Acadia. Acadia's management seeks to reduce the number of vehicles by promoting the use of the Island Explorer. In 2015, the park implemented a program known as "car-free mornings," in which only local bus tour companies were allowed access to the park. Despite the park's attempts, cars remain the dominant form of transportation. According to Acadia Social Scientist Adam Gibson, "Most [visitors]… are entering Acadia in cars, not motor coaches or Island Explorer buses" (Broom, 2021a).

2.4 Overcrowding at Acadia

2.4.1 Factors Influencing Overcrowding

In a previous Interactive Qualifying Project (IQP) for Worcester Polytechnic Institute (WPI) on tourist congestion at Acadia, the team found that from the years 2008 to 2018 visitation increased by approximately 74% (Barakian et. al., 2020). Increased visitation is just one example of the many factors contributing to overcrowding in national parks like Acadia.

Acadia's size also contributes to overcrowding. Acadia is one of the smallest national parks in the country. While many national parks span millions of acres, Acadia only covers 49,057 acres of land. Acadia also attracts some of the largest crowds of any national park. According to the NPS, in 2021, Acadia was the 16th most popular national park site, receiving over 4 million recreational visits (National Park Service, 2022d). Due to Acadia's small size and large popularity, factors like increased visitation led to congestion at each of the park's points of interest (Cosmopulos et. al., 2017).

Visitation patterns also affect overcrowding. According to the *Cadillac Mountain Transportation and Visitor Use Model*, Acadia experiences major visitation spikes from the

hours of 4 a.m. to 7 a.m., 10 a.m. to 2 p.m., and 6 p.m. to 9 p.m. (Cosmopulos et. al., 2017). When these spikes occur, they exacerbate the effects of large visitation on overcrowding. In addition to the frequency of these spikes, we must look at how spikes alter transportation. Another factor to consider is vehicular traffic. As mentioned earlier, many visitors rely on cars to navigate Acadia. Consequently, increased visitation often leads to vehicular congestion. In some sites, the number of vehicles circulating the area exceeds the capacity. Exceeding site capacity leads to illegal parking, roadblocks, and difficulty for emergency access. From the summer of 2000 to the summer of 2002, one source reported that the parking at Sand Beach exceeded capacity by anywhere between 81 and 124 vehicles (Daigle & Zimmerman, 2004). This finding is significant because the parking lot at Sand Beach only contains 101 spots (National Park Service, n.d.).

2.4.2 Impacts of Overcrowding

Understanding overcrowding at Acadia involves understanding the impacts of increased visitation and vehicular congestion. The influx of vehicles and visitors at Acadia poses a challenge to the NPS's mission to protect the landscape while also providing a recreation space for the public. In this way, overcrowding at Acadia proves detrimental to both the visitor experience and the surrounding environment. In Robert Manning's extensive work on carrying capacity, he reports that as the parks become more crowded, visitors report increased negative feelings of crowdedness (Manning, 2001). Additionally, due to the vehicular congestion at Acadia, another past IQP reports that many visitors have a great deal of trouble finding parking at most sites (Barakian et. al. 2020). Beyond the inconvenience, there are also many ecological effects from constant congestion. As noted by another past WPI IQP project, "Acadia received a failing grade from the National Park Conservation Association" (Dziuban et. al., 2016). Factors contributing to this failing grade include air and noise pollution generated by various transportation methods. This pollution disrupts animals, other wildlife, and visitors alike (Manning et. al. 2014).

2.4.3 Reservation Systems at Acadia

To address overcrowding, it is important to consider methods the park implemented in the past. Two examples include the Ocean Drive Corridor Reservation System and the Cadillac Mt. Reservation System.

Acadia implemented the Ocean Drive Corridor Reservation System to limit traffic flow to frequently driven areas: Sand Beach and the Ocean Drive Corridor Road. While the reservation system did not operate as planned, the pilot's shortcomings provide valuable lessons about the use of reservation systems. Despite the park's best efforts, many visitors were unaware of the new need for a reservation on the affected road (Wheelock et.al., 2021). As indicated by the directional arrows in Figure 3, Park Loop Road, the road leading to Sand Beach, is a one-way street. In this way, the reservation system made the road more difficult to access. Poor cell coverage also plagued this pilot reservation system. The issue arose when visitors could not access their online reservations at the gate (*'Nightmare' sand beach*, 2020). Consequently, the system created greater amounts of traffic in surrounding areas of the park. It is reported that locations such as the Sieur de Monts and Schooner Head Overlook experienced elevated levels of traffic following the implementation of this reservation system since they have direct connections to Park Loop Road (*'Nightmare' sand beach*, 2020).

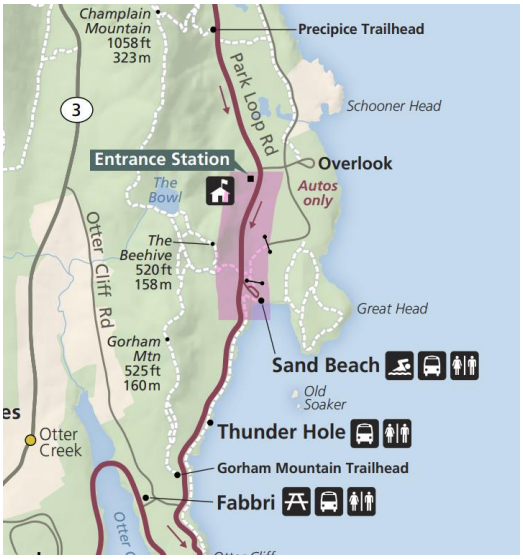

Figure 3: Map highlighting location of Ocean Drive Corridor/Sand Beach reservation system (National Park Service, 2022e)

While the shortcomings of the Ocean Drive Corridor Reservation System led to its removal and re-evaluation, many lessons can be learned from its failures. For instance, Acadia needs to ensure that visitors are informed about new reservation systems. Additionally, the park should have options for offline reservation validation and place reservation checks in locations that will avoid diverting traffic to other sites.

While unsuccessful attempts indicate what to avoid, successful attempts offer promising next steps. Conveniently enough, Acadia operates a successful reservation system on Cadillac Mountain. After trialing the Cadillac Mt. Reservation system for a two-week period in October of 2020, the park fully implemented the system in May of the following year (Lu, 2021). As described by the Friends of Acadia, "[t]he reservation system was designed as a tool to improve the visitor experience, ensure visitor safety, and protect park resources" (Friends of Acadia, 2021). Since then, the Cadillac Mt. reservation system shows more promise than the Ocean Drive Corridor system. Relevant features of the Cadillac Mt. system include reservation slots for different times of day, timed entry for vehicles, and a limited number of reservations per week for each car (National Park Service, 2022g). In this way, the Cadillac Mt. reservation system is a model of how to control overcrowding at other highly visited areas in Acadia, such as the Bass Harbor Head Light Station.

2.5 Bass Harbor Head Light Station

2.5.1 History of the Bass Harbor Head Light Station

Located in Tremont, Maine, the Bass Harbor Head Light Station was constructed in 1858 using funds given by Congress. The lighthouse was automated in 1974 (Hartford, 2020) and added to the National Register of Historic Places in 1988 (National Park Service, 2021a). On July 8, 2020, the lighthouse was formally transferred to the NPS from the United States Coast Guard (USCG) (National Park Service, 2021a).

The Bass Harbor Head Light Station is one of three lighthouses managed by Acadia (National Park Service, 2021a) but the only lighthouse located on MDI (Hartford, 2020). This lighthouse is the most visited area on the western side of MDI and the fifth busiest place in the entire park (National Park Service, 2021a). The Bass Harbor Head Light Station attracts an

average of 180,000 annual visitors (National Park Service, 2021a). In terms of operation, the lighthouse is open to the public from 9 a.m. to sunset, but visitors have expressed that those hours are not enforced (National Park Planner, 2020). The lack of enforcement surrounding the hours of operation and the parking at the lighthouse can make accessing the site a challenge.

2.5.2 Accessibility

To understand the congestion at the Bass Harbor Head Light Station, we must understand how visitors access the area. Visitors accessing the site by car follow Route 102A past the village of Seawall, directly to the entrance of Lighthouse Road. Lighthouse Road is a 0.5-mile stretch of roadway that leads directly to the entrance of the parking lot. According to Dick Broom, a writer at the *Mount Desert Islander*, the parking lot at the lighthouse only contains 27 available parking spaces (Broom, 2021b). After going on site and counting the spaces we learned that there are actually 25 spaces and 3 of those are handicap spots. To access the site without a car, visitors can take The Island Explorer shuttle. Figure 4 outlines the route of the Southwest Harbor Bus. The Southwest Harbor Bus runs every 50 minutes and operates between Bar Harbor, Southwest Harbor, and Bass Harbor. To access the lighthouse, visitors get off at the Bass Harbor Campground and take Lighthouse Road to the site. As of 2021, the Island Explorer did not offer transportation to that portion of MDI (Broom, 2021b). The Bass Harbor Head Light Station experienced a 36% increase in visitors during 2021 with reduced operation of its shuttle system (Broom, 2021b). With the lack of available parking spaces, many visitors either park illegally or idle along Lighthouse Road and Route 102A (Broom, 2021b). This build of cars causes issues both for emergency vehicles and for residents of Tremont.

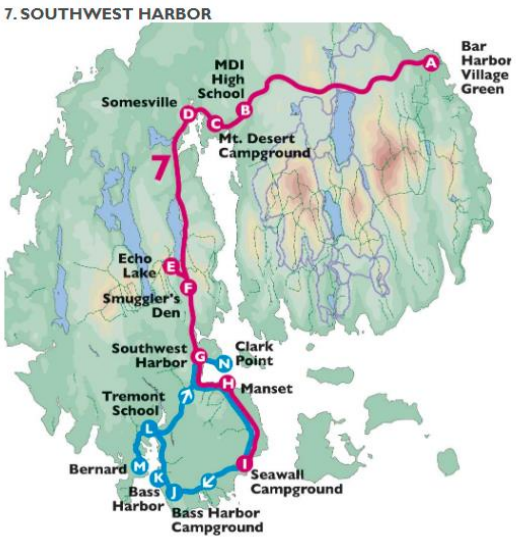

Figure 4: Map of Island Explorer's Southwest Harbor bus routes (Island Explorer, 2022)

2.5.3 Residential Impacts

Tremont, Maine is the residential area impacted by the increase of visitors to the Bass Harbor Head Light Station. According to a 2000 census available on the town's official website, there are approximately 1,529 residents in Tremont (*About Tremont*, n.d.). Residents of the area have reported that when the number of visitors at the Bass Harbor Head Light

Station exceeds the parking capacity, many visitors park along the surrounding residential roads, blocking their driveways. Furthermore, it is estimated that about 81.7% of residents in Tremont drive their own cars (*Commuting in Tremont, Maine*. n.d.). This reliance on cars means that the overcrowding at the lighthouse area impacts residents' ability to leave their homes. According to Sarah Hinckley, a writer for *Mount Desert Islander*, in 2018, "neighbors of Bass Harbor Head Light asked the town to prohibit parking on Lighthouse Road" (Hinckley, 2020). During the 2019 season, the town placed "No Parking" signs along Lighthouse Road to prohibit visitors from blocking private driveways. Today, there are currently 19 "No Parking" signs posted. During the 2020 season, visitors began parking along the part of Route 102A that leads up to Lighthouse Road. Now that the park manages the site, many residents request that the park also place signs across Route 102A. However, the park does not have jurisdiction in this area because Route 102A is a "state-aid highway" (Hinckley, 2020). While Acadia is "aware of the impact this is having on the neighbors, on the town [of Tremont]," the park has not yet implemented a management plan to control the traffic at the lighthouse (*About Tremont*, n.d.).

2.5.4 Ecological Impacts

Since Acadia only acquired the Bass Harbor Head Light Station in 2020, there is not much data on the ecological impacts of overcrowding. The site contains only one trail: The Bass Harbor Head Light Trail. Consequently, this trail will be our main focus for documenting ecological impacts. According to an article titled "Examining the Impact of Overcrowding on Hiking Trails*,"* the overuse of trails causes "[s]oil erosion, damaged vegetation, altered hydrology, widening of trails, and increased muddiness" (Sperry, 2018). The Bass Harbor Head Light trail stretches 0.2 miles and leads to a viewing spot for the lighthouse. Since our team did not have a lot of information regarding the ecological impacts of overcrowding on this trail, we investigated this further during our time at the park.

2.5.5 Visitor Experience

Overcrowding at the Bass Harbor Head Light Station also impacts the quality of the visitor experience. This section addresses why people visit the lighthouse and how visitors interact with the site. Additionally, we address how vehicle congestion at the lighthouse overshadows Acadia's future plans to transform the site into a more interactive space for visitors.

While located on the "quieter side" of MDI, people visit the Bass Harbor Head Light Station for its breathtaking views. According to Alyson Horrocks, a writer for *New England Today Living*, visitors often photograph "the lighthouse, the harbor, wildlife, and the small islands that dot the surrounding Gulf of Maine" (Horrocks, 2022). The two most densely populated areas on the site are the lighthouse grounds and the Bass Harbor Head Light Trail. The lighthouse grounds include the lighthouse tower, the keeper's dwelling, the boathouse, and the bell. This area also provides a direct overlook of the ocean and surrounding islands. The Bass Harbor Head Light Trail leads to an observation point, surrounded by collections of boulders and rocks, where visitors can photograph the lighthouse and the landscape. According to Horrocks, "caution is needed as the rocks can be slippery and there are no guardrails" (Horrocks, 2022).

Another component of the visitor experience is visitor safety. During our research, our team found two instances in 2012 where visitors of the Bass Harbor Head Light Station fell and

injured themselves. Although the park did not own the lighthouse at that time, it is important to consider these cases within the larger framework of visitor safety. In one instance, "[a] 65-year-old man from Texas was at Bass Harbor Head Lighthouse around 10 a.m. when he walked down a set of steps to the shore to be able to get a view of the lighthouse, according to Ranger Richard Rechholtz. He fell while walking down the steps, hitting his head and injuring his knee" (Steeves, 2012). In the second instance, "[a] 70-year-old woman was injured after hiking alone by Bass Harbor Lighthouse " (Trotter, 2012). According to this article, "It took rescue searchers about an hour and a half to find the unidentified woman who called 911 on an untraceable TracFone " (Trotter, 2012). While these visitors are older in age, viewing sites such as the Bass Harbor Head Light Station should be safely accessible to people of all ages.

While visitors may access the lighthouse grounds, Acadia does not allow visitors inside any of the lighthouse buildings. However, starting in 2022, volunteers live in and maintain the keeper's dwelling from May to the end of the summer. These volunteers mainly provide information to visitors; they are not able to enforce parking laws within the parking lot. In the future, Acadia plans to make the lighthouse an interactive space for visitors. However, to achieve this goal, Acadia must restore the interior of the lighthouse buildings. According to the 2020 Friends of Acadia "Bass Harbor Head Light Station Historic Structure Report," "the historic main stairway" in the keeper's dwelling "is dangerous due to slippery carpet and inconsistent treads and risers" (Kong & Ring, 2020). While Acadia recognizes the need for restorations, the park cannot tackle the interior of the lighthouse until it addresses overcrowding and traffic congestion on the site.

2.5.6 Interview with Adam Gibson

Our team met with environmental sociologist Adam Gibson to discuss the future management plan for the Bass Harbor Head Light Station. Gibson's research at Acadia focuses on areas such as social carrying capacity and public perceptions of climate change. According to Gibson, the park has not yet developed a management plan for the lighthouse because the site presents many unknown variables. When the USCG managed the lighthouse, people were not allowed on the grounds. According to Gibson, during this time, visitors' mentality was all about "the goal of getting there" (A. Gibson, interview, June 25th, 2022). With the transfer of the lighthouse in 2020, the park finally allowed visitors to not just access the site, but also interact with the area. Today, Acadia wants to adopt a "new mentality of [the lighthouse] being a destination to stay at" (A. Gibson, interview, June 25th, 2022). Now that the site is open to the public, the park must address the ecological and social impacts of increased visitation. According to Gibson, the park does not know "what the carrying capacity looks like" for the lighthouse. In fact, "any data [our team] can provide [about] how many people use the site, how long they spend there, [and ...] what people are doing once they get there" would be influential in helping the park develop a management plan (A. Gibson, interview, April 6th, 2022).

2.6 Project Description

In this project, our team advises Acadia on how to develop a comprehensive visitor management plan aimed to improve visitor experience, visitor safety, public access, and parking at the Bass Harbor Head Light Station. More specifically, this project examines the implementation of a reservation system to reduce overcrowding and manage vehicle congestion.

3.0 Methodology

3.1 Introduction

The goal of this project is to guide Acadia in developing a comprehensive visitor management plan for the Bass Harbor Head Light Station. This plan addresses factors such as visitor experience, visitor safety, accessibility, and parking. This section provides an overview of the methods used to achieve this goal. These methods are organized into three main objectives:

1. Executing data collection methods
2. Analyzing the collected data
3. Developing recommendations for visitor management at the Bass Harbor Head Light Station

The first objective quantifies the overcrowding at the Bass Harbor Head Light Station. In order to quantify the overcrowding, our team investigated the contributing factors. More specifically, we collected information conveying the full scope of vehicular congestion and accessibility.

The second objective organizes the data and information collected into a more helpful form. After organizing the data, our team analyzed this information to determine useful trends and correlations interpretations. These trends establish visitor and vehicular use patterns at the Bass Harbor Head Light Station.

The third objective applies our interpretations of visitor and vehicular use patterns to suggest recommendations for a reservation system. The development of a reservation system depends on local and visitor sentiment and is subject to change over time.

3.2 Data Collection Methods

To improve the visitor experience and address visitor safety at the Bass Harbor Head Light Station, one must be familiar with the factors contributing to overcrowding at the site. Here, our team details approaches to define the layers of this problem. The six questions we must answer appear in Figure 5. These questions helped us determine the best methods for collecting data based on the areas of interest we have identified. To answer the questions in Figure 5 our team had to determine the site's accessibility, record quantities such as dwell time and people at one time (PAOT), and conduct surveys. Our team outlined our approaches in the following sections.

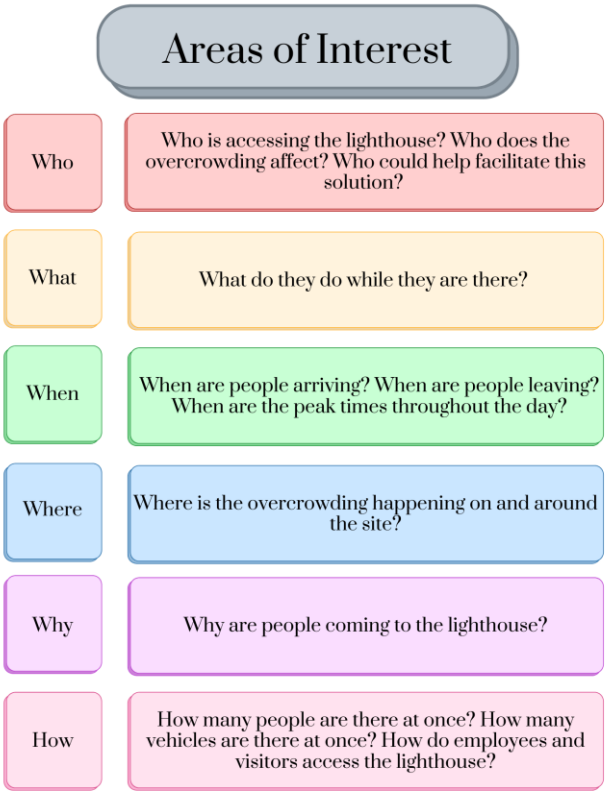

Figure 5: Comparative chart of the who, what, when, where, why, and how of the lighthouse

3.2.1 Accessibility

Our team determined the accessibility of the lighthouse in two steps. The first step involved determining how people access the site. The second step records how the mode of arrival and departure varies based on factors such as weather and time of day. Figure 6 breaks down the four primary modes of access to the Bass Harbor Head Light Station: car, bus, bike, and foot. Visitors accessing the lighthouse by bus use the Island Explorer shuttle system. The Southwest Harbor Bus drops visitors off at the entrance of Lighthouse Road, from which point they must walk 0.5 miles to reach the site.

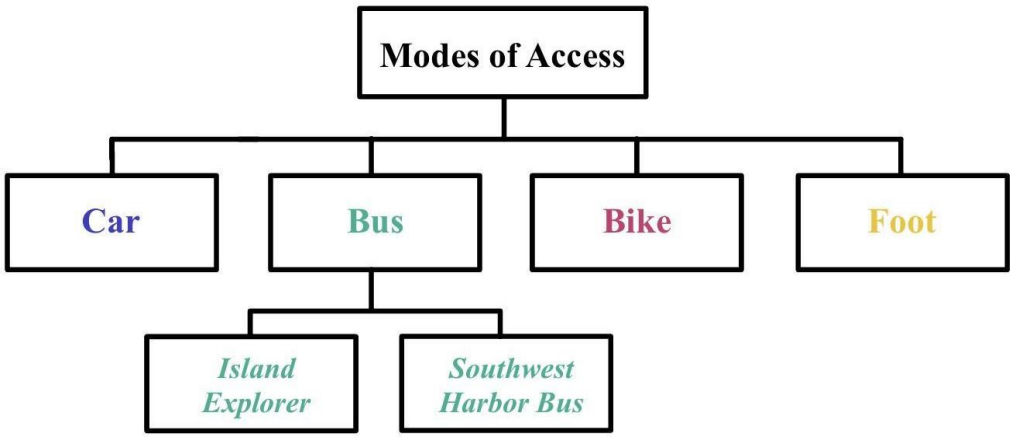

Figure 6: Organizational chart of modes of access to the Bass Harbor Head Light Station

To record how modes of arrival and departure vary based on external factors, our team first determined the frequency of each mode of access. We administered visitor surveys to establish these proportions (*See Appendix A.1)*. For more information on how these surveys were administered, see section *3.2.4*. In these surveys, we ask visitors to estimate their arrival time and select their mode of arrival from the four options displayed in Figure 6.

In addition to identifying the frequency of each mode of access, our team established vehicle counts. The site has a traffic counter on Lighthouse Road that records cars coming onto and off of the roadway in hourly bins. We first verified the validity of the counter using a motion detection camera. After validating the car counter, our team compared how the vehicle counts and the frequency of each mode of transportation varied based on external factors. To make this kind of correlation, our team recorded daily weather conditions and tide patterns.

3.2.2 Dwell Time

After determining the site's accessibility, our team examined how visitors interact with the site. We used dwell time to quantify visitors' length of stay. Dwell time refers to the "[t]he length of time a visitor spends at a single location" (Duncan et al., 2017). In this project, we recorded both the dwell time of vehicles in the parking lot and visitors on the site. To measure the dwell time of cars in the lot, two members of our team stationed themselves in the parking lot and marked observations for each parked car. These observations included the following pieces of information: arrival time, departure time, vehicle make, group size, and dwell time. To facilitate this process, our team assigned each parking space a number from 1 to 25 and recorded the daily arrival and departure times by the parking spot number. A copy of the spreadsheet used to record this data can be found under *Appendix G.* To measure the dwell time of visitors walking to the site, our team used time-stamped cards. We distributed these cards to visitors arriving on site by foot or on bike and asked them to return the cards upon departure. For each card, we marked the time each visitor arrived when we handed them the card and their time of departure when they returned the card (*See Appendix J*). Additionally, we recorded the number of time stamp-cards distributed to track the return rate.

3.2.3 People at One Time

Additionally, our team used PAOT to quantify crowding at the lighthouse. PAOT refers to the number of people in one location at a given instance in time (RSG, 2017). Our team measured PAOT using photographs. We used cameras to capture photographs of the lighthouse and the Bass Harbor Head Light Trail every 15 minutes (See Figure 7 for camera placements). We placed one camera at the front of the parking lot facing Lighthouse Road, two cameras on the Bass Harbor Head Trail, two cameras on the rocks at the end of this trail, one by the car counter at the end of the park property, and one camera by the lighthouse grounds. These photographs provided a more objective statistic of how many people on average visit the lighthouse at each time of day. Additionally, this information allowed us to determine how the average number of visitors varies based on the weather, time of the day, and the day of the week.

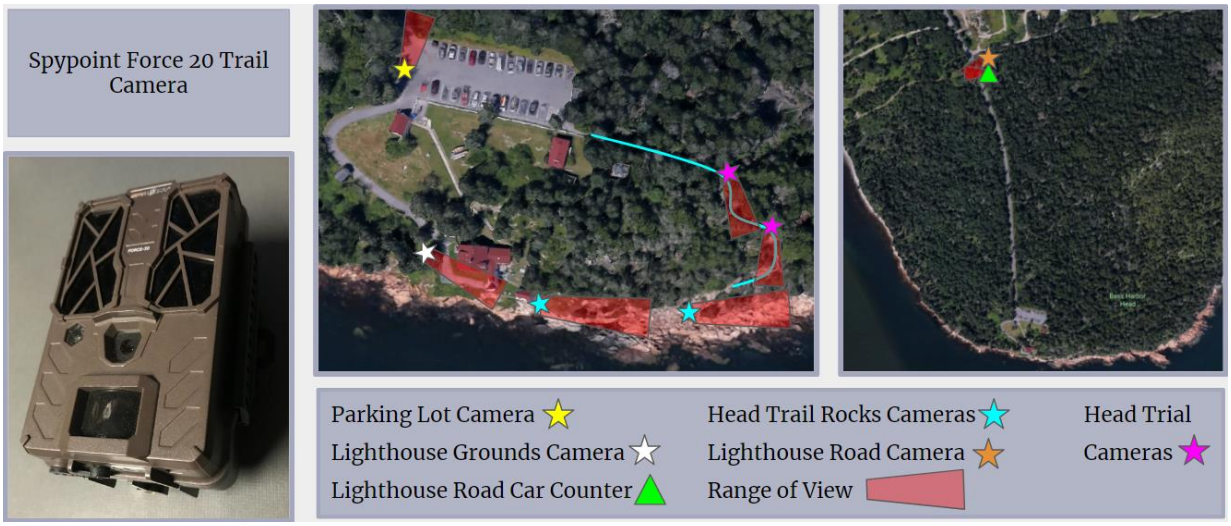

Figure 7: Instrumentation and placement of cameras/counters (Google, n.d.a, Google, n.d.d)

3.2.4 Visitor Experience

To gauge visitor experience, our team conducted surveys of visitors over the course of several days (*See Appendix A*). The survey questions included questions about how safe, crowded, and acceptable visitors felt the lighthouse area was. We also included questions about the size of each group, an explanation of how visitors heard about the lighthouse, what mode of transportation they used to get there, and what they ended up doing on the site. The survey also asked visitors to rate their overall experience at the lighthouse and if they felt a reservation system would affect this experience. This survey requested both quantitative and qualitative feedback from the visitors. This indicated how satisfied visitors are with the current state of the site, where they are getting their information about the lighthouse, what modes of transportation seem most popular, and how a reservation system may improve the state of the Bass Harbor Head Light Station's traffic. It was important to take these factors into consideration because ultimately the goal of a reservation system is to enhance the visitor experience.

3.2.5 Residential Experience

In addition to surveys of park visitors, we also conducted surveys geared toward the residents surrounding the Bass Harbor Head Light Station area (*See Appendix B.1*). Our team conducted surveys on the following roads: Lighthouse Road, Arnold Road, Harbor Drive, and McKinley Lane. These surveys focus on how the lighthouse's visitation affects the lives of these residents.

3.3 Data Analysis

This section addresses how we analyzed our collected data. More specifically, we discuss the information we obtained from accessibility trends, dwell time, PAOT, and surveys. Our team formed interpretations following two steps: establishing both vehicular and visitor use patterns and analyzing surveys.

3.3.1 Vehicular Use Patterns

Vehicular use patterns are important to our research and reservation recommendations. While analyzing vehicular data, we determined how many cars accessed the parking lot each day and how many cars passed through Lighthouse Road. In section 3.2, we discussed our data collection methods for the entire project. Methods specific to vehicular use patterns include counting cars manually to validate the car counter and tracking the dwell time of cars at the lighthouse. Our team then used this data to calculate the average time a vehicle stays on-site or near the site and how many cars visited the area during the day. Using that data, we were able to establish the vehicular use patterns for the Bass Harbor Head Light Station. By doing so, we were able to recommend a reservation system that can accommodate the number of cars and their length of stay while still preventing the overcrowding and parking issues that occur without a reservation system.

3.3.2 Visitor Use Patterns

Establishing visitor use trends for the Bass Harbor Head Light Station provided our team with three important pieces of information. First, these patterns established how visitors interact with the site. Second, these patterns outlined how interactions affect the quality of the visitor experience and the surrounding landscape. Third, these patterns helped our team establish a social carrying capacity for the site. Figure 8 outlines the data our team interpreted to obtain visitor use patterns.

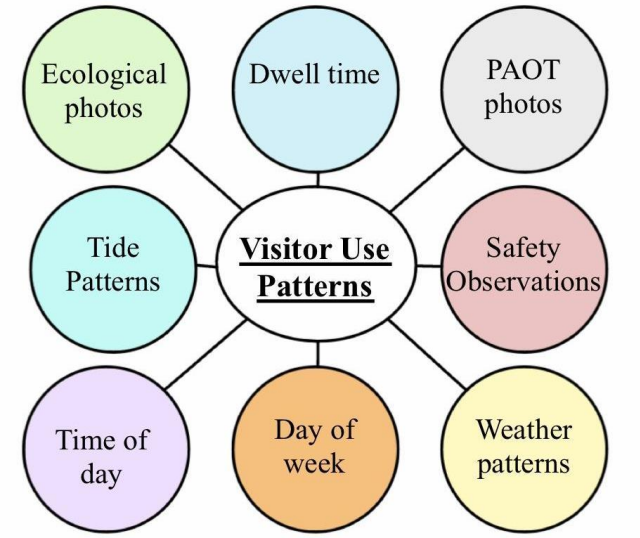

Figure 8: Web chart of data our team will use to establish visitor use patterns

Our team analyzed PAOT photos, dwell times, weather patterns, tide patterns, time of day dependence, and day of the week dependence to determine how visitors interact with the site. To begin, we reviewed PAOT counts for different locations on the site. Our team used this information to determine the most densely populated areas at the lighthouse. Additionally, we analyzed how these counts vary based on weather patterns, tide patterns, time of day, and day of the week. Next, our team recorded the arrival and departure times of each car in the parking lot and used the time-stamped cards to establish an average dwell time for visitors on the site. Our team also compared each time stamp card with the hours people visited. In this way, our team formed interpretations about how dwell time varied based on the time of day.

To analyze how visitation impacts the surrounding environment and the quality of the visitor experience, our team interpreted ecological photos, PAOT photos, and safety observations. After obtaining PAOT photos, our team used a technique that sustainability researcher Robert Manning utilized to define a standard of quality for PAOT and carrying capacity. Our team selected 6 photographs for each viewing area depicting varying PAOT conditions. These 12 photographs can be found under *Appendix C.1*. Next, our team showed these photographs to visitors and asked them to rank the acceptability of each photograph on a scale from -4 to 4 (Manning, 2002). On this scale, 4 corresponds to conditions visitors deemed "totally acceptable," and -4 corresponds to conditions visitors deem "totally unacceptable" (Manning, 2002). The results from these photographs indicate the maximum number of people visitors will tolerate before the average rating drops below zero. In addition, our team compared our safety observations and ecological photos with the PAOT counts to determine the correlation between the number of people on the site, visitor safety, and ecological impacts.

Finally, our team used these visitor use patterns to define a social carrying capacity for the lighthouse. Carrying capacity quantifies roughly how many people the site can accommodate based on factors such as visitor experience, visitor safety, and ecological protection. In the case of our project, we mainly focus on carrying capacity from a visitor experience perspective only. For this reason, any future mention of carrying capacity is that of a "visitor experience carrying capacity."

3.3.3 Analyzing Surveys

Our team analyzed surveys to form interpretations about visitor motivations, visitor satisfaction, visitor safety, and surrounding residential opinion. A useful tool for analyzing qualitative data like surveys is the coding process. Figure 9 outlines the five-step coding process our team used (Schmidt, 2004). This process allowed our team to efficiently transform our surveys into quantitative data. We then used this quantitative data to develop recommendations for the park.

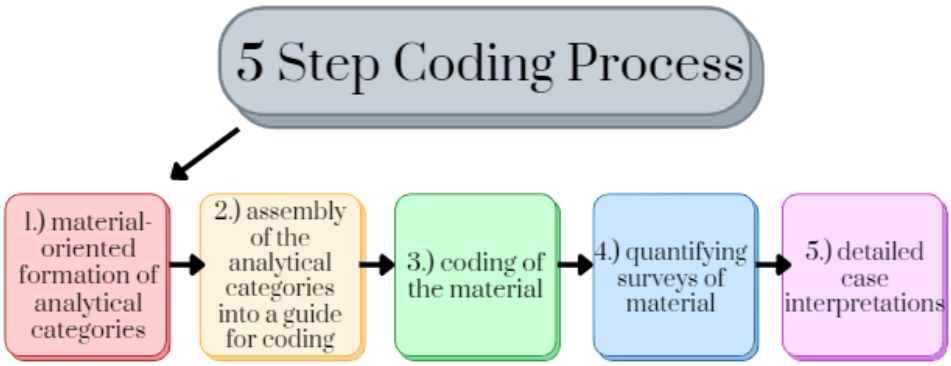

Figure 9: Flowchart of the five-step coding process for semi-structured interviews and surveys

3.4 Reservation System Recommendations

In this section, our team addresses how we planned to use our interpretations to help improve the overall visitor experience. We consolidated all the information we have gathered and analyzed to suggest recommendations for how a reservation system could operate at the Bass Harbor Head Light Station. The SWOT analysis in Figure 10 discusses the potential strengths, weaknesses, opportunities, and threats of a reservation system at the Bass Harbor Head Light Station. We used this chart to consider what potential benefits and detriments certain reservation systems may provide. Recommendations include the following considerations: number of reservations, times of reservations, and alternative solutions.

Figure 10: SWOT analysis of reservation system

3.4.1 Number of Reservations

One of the most important elements of a reservation system is the number of available reservations. To make a suggestion on this quantity, we analyzed visitor and vehicular use patterns. These patterns helped us determine the carrying capacity of the site that also provides the best visitor experience. Then we would use this carrying capacity to calculate the target number of lighthouse visitors. Additionally, we would use the Cadillac Mountain Reservation System model to determine the appropriate number of vehicle reservations for the site.

3.4.2 Times of Reservations

Another important reservation system component is reservation times. Peak visitation hours are times of the day that are naturally more busy than other times of day. Peak times, therefore, may need special systems. These systems could be as simple as preventing visitors from reserving during that peak time again until a few days after their reservation. Finding peak visitation times would help us determine special reservation hours, such as sunrise and sunset.

Additionally, the average dwell time would help us determine if day-long or timed reservations better suited the lighthouse. We determined the average dwell time to understand how long most visitors stay at the site. In the case that visitors spend long periods of time at the lighthouse, we would suggest day-long reservations. With shorter dwell times, we would recommend a reservation similar to the one shown in Figure 11. In this example, visitors can select reservation(s) for the time they would like to arrive at the lighthouse. In Figure 11, the red box would represent a full-time slot where there are no available reservations. The blue represents the times the visitor would be selecting to reserve. The reservation duration is subject to change based on our findings. This system would enable more people to visit the lighthouse on any given day than the day-long reservation.

Start Time	11:00 a.m.	11:30 a.m.	12:00 p.m.	12:30 p.m.	1:00 p.m.
Availability					

Figure 11: Example of a timed reservation system

3.4.3 Alternative Solutions

As previously mentioned, one aspect of the comprehensive visitor management plan may be a vehicle reservation system for the lighthouse parking lot. However, we also considered alternative or supplementary solutions to support this plan. Other solutions we looked into included increasing parking for the site or adding parking attendants to improve the flow of traffic in the parking lot.

3.5 Ethics

This project is an Interactive Qualifying Project, sponsored by Worcester Polytechnic Institute, and is an undergraduate degree requirement. Our project involved the use of surveys that we administered to the visitors of Acadia National Park and residents of Tremont/Bass Harbor. We made it known to those being surveyed that their answers were completely voluntary and that they were not required to answer any questions they feel uncomfortable answering. Additionally, all responses were kept anonymous, and the surveyed visitors were be notified of this. We received our IRB Exemption for our project's use of human subjects for surveys.

3.6 Timeline

To make sure we were able to complete the methodology that we discussed in sections 3.0-3.5 we created a Gantt chart as a general plan for our 7 weeks at the project center. We created two of them, the first as a general plan of what we would do and the second to show what we actually did. Figure 12 shows how we actually spent our 7 weeks at the project center. The blue section of our Gantt correlates to section 3.2, the yellow section correlates to section 3.3, and the purple section correlates to section 3.4.

Task Title	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7
Phase 1: Data Collection							
Get Familiar with the Area							
Set up cameras							
Count Cars (manually)							
PAOT Count+Pictures							
Environmental Photos							
Time Stamp Cards							
Surveys							
Phase 2: Interpretations							
Vehicular Use Patterns							
Visitor Use Patterns							
Analyzing Surveys and Interviews							
Analyzing Photos							
Phase 3: Reservation System Recommendations							
Carrying Capacity							
Peak Visitation Times							
Visitor Response to a Reservation System							
Final Proposal							

Figure 12: Gantt Chart of what we did during the 7 weeks

4.0 Results

The following sections present the data collected for 22 days. This data was collected through a combination of direct observation methods, photographs, surveys, and big data analysis. Relevant sections include traffic pattern, dwell time, PAOT, ecological impact, survey, and residential survey analysis.

4.1 Traffic Pattern Analysis

For our traffic pattern analysis, we tracked the ebbs and flow of visitation to the Bass Harbor Head Light Station. This analysis looked at metrics such as how visitation has increased over the past few years, peak times, and parking accessibility. These patterns were determined by analyzing data on arrival times, turnarounds, queued cars, and parking.

4.1.1 Increased Visitation

As previously mentioned, visitation to Acadia increased dramatically in recent years. However, due to the Lighthouse being only recently acquired by the park, our team felt that it would be useful to look at how visitation has increased at the Bass Harbor Head Light Station specifically. The following visitation data was obtained through the Car Counter on Lighthouse Road. This data was acquired and sent to us by the Friends of Acadia. Our analysis and graphs from the car counter include data compiled from June to October of each year shown. As can be seen in Figure 13, the total visitation for the lighthouse stayed relatively the same from 2018 to 2019. Visitation then dropped dramatically in 2020, by about 30%, likely due to the COVID-19 Pandemic. Visitation then increased dramatically in 2021, by about 70%, likely due to the ownership of the lighthouse being transferred from the U.S. Coast Guard to the park in 2020. Additionally, the overall increase from 2018 to 2021 was 12,112 vehicles—a 17% increase.

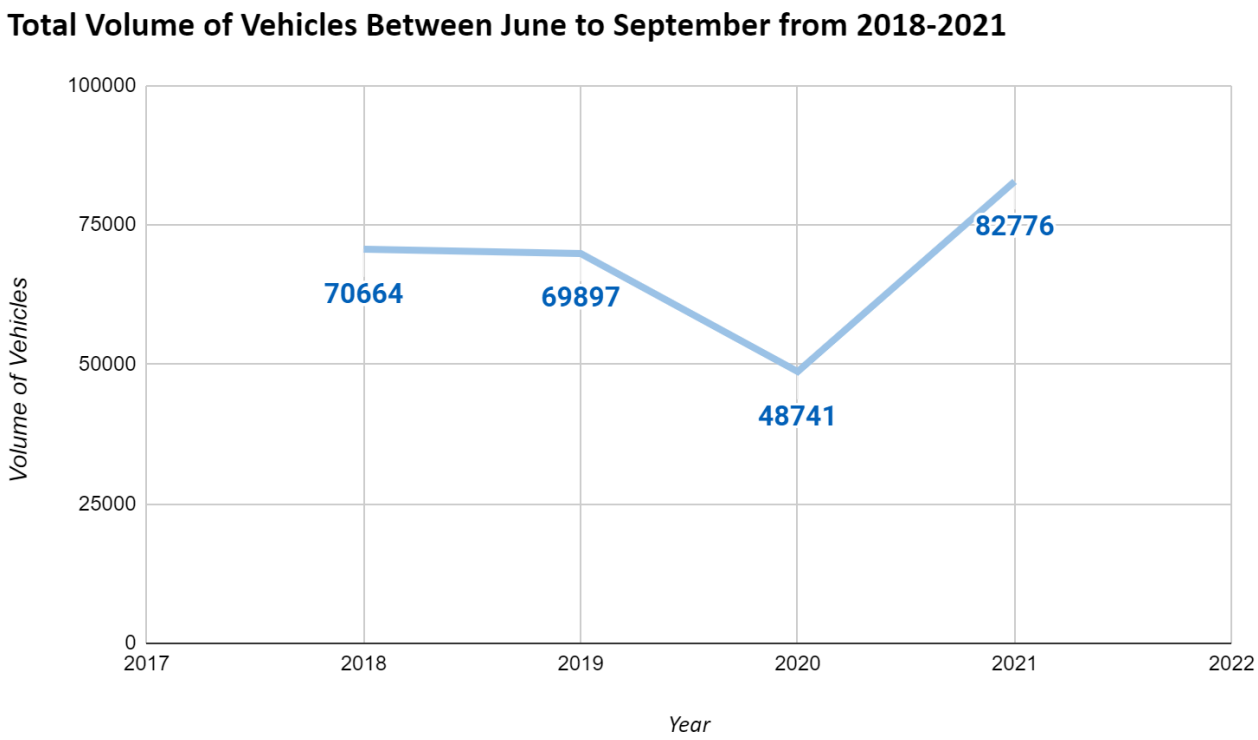

Figure 13: Line chart of vehicles traveling to the lighthouse from 2018 to 2021

Due to these dramatic fluctuations in visitation caused by the transfer of ownership and COVID-19, we believe that the visitation data from 2021 resembles our visitation data the best. Therefore, in the next section, we will only be comparing the 2021 car counter data to our own data.

4.1.2 Peak Times

Peak times are the busiest times at the lighthouse. To determine peak times, data on arrival times, turnarounds, and queued cars were analyzed. This multi-layered analysis aimed to consider all of the visitors that were at the lighthouse, parked or waiting to park, for the determined peak times of the week and the day.

While we looked at peak times, we looked at how they changed for each day of the week. First, we looked at some trends from past years that were collected from Big Data. Figure 14 below shows the fluctuation of visitation at the Bass Harbor Head Light during the years 2019, 2020 and 2021 for each day of the week. As can be seen, each day has similar trends from one year to the next.

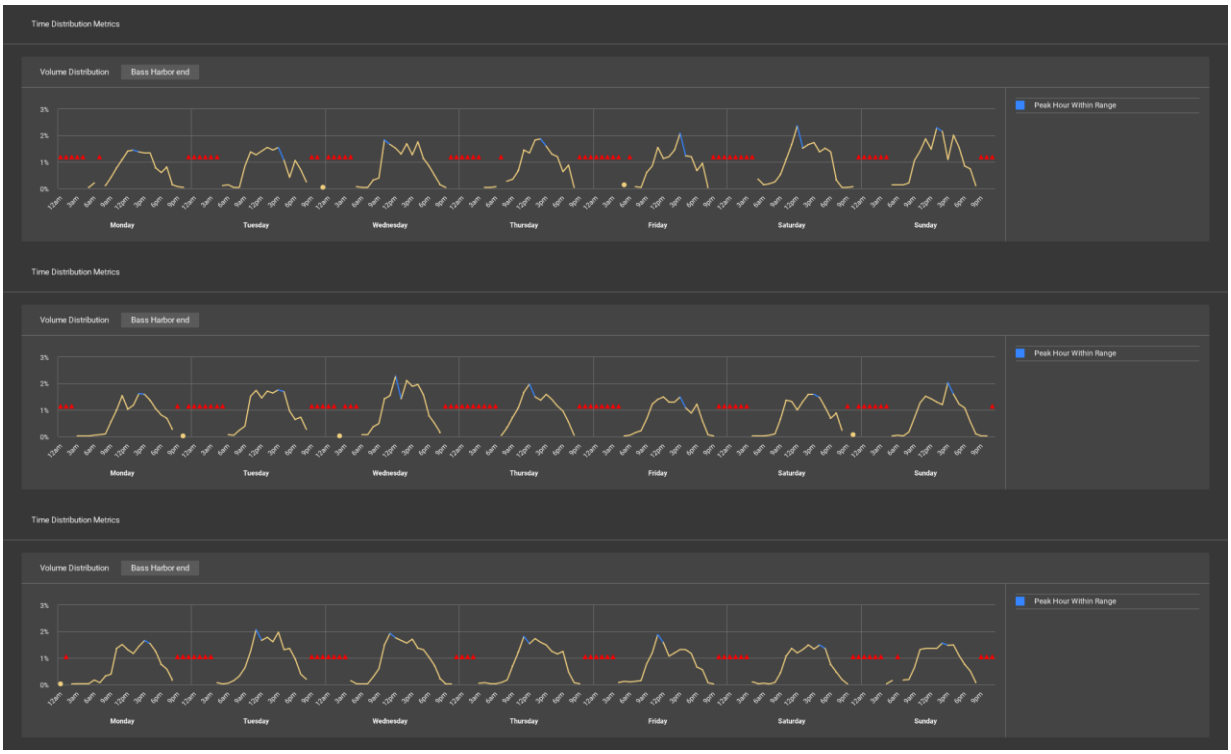

Figure 14: Big Data line charts for day of the week visitation trends from 2019 (top), 2020 (middle), & 2021 (bottom)

We referenced data from the on-site car counter again to compare with our Big Data. The data for 2021 from June to October is shown in Figure 15. This data corroborates Big Data for 2021 shown in Figure 14 for each of the days of the week. As you can see, each day peaks between 12 p.m. and 2 p.m., with the weekdays experiencing more visitors than Friday, Saturday, and Sunday in 2021. This shows that the car counter likely is accurate and enables us to use car counter data to help support our results and recommendations.

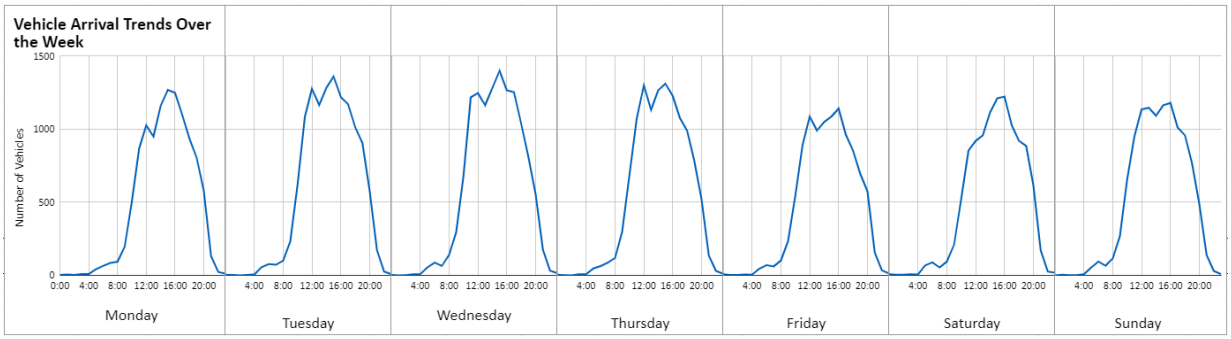

Figure 15: Line chart of 2021 day of the week visitation trends from on-site car counter

Next, we looked at our own data to compare it to Big Data and the on-site car counter. Our data for each day of the week is shown in Figure 16. This data was collected on each day of the week from 9 a.m. to 3 p.m. Due to our limited time on-site, there is only one day's worth of data for each day of the week. As can be seen, this data is corroborated by Big Data and the

on-site car counter. Each day of the week varies slightly; however, they all peak around 1-2 p.m. and dip around lunchtime. You can also see that Friday, Saturday, and Sunday in 2022 had less visitors than weekdays similarly to the on-site car counter data from 2021. However, due to our limited data, we cannot definitively say that this is the case.

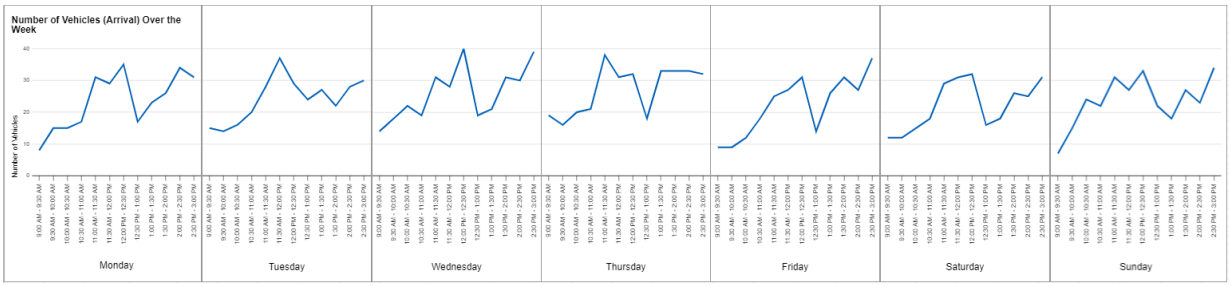

Figure 16: Line chart of 2022 day of the week visitation trends from direct observations

Now to look at the overall daily visitation trends. Here we aim to find the peak times throughout the day. First, we looked at the Big Data graphs shown in Figure 17 for the years 2019, 2020, and 2021. This shows that the Bass Harbor Head Light Station is busy from 10 a.m. to 4 p.m. However, the peak time in 2019 was from 3 p.m. to 4 p.m., from 2 p.m. to 3 p.m. in 2020, and from 11 a.m. to 12 p.m. in 2021.

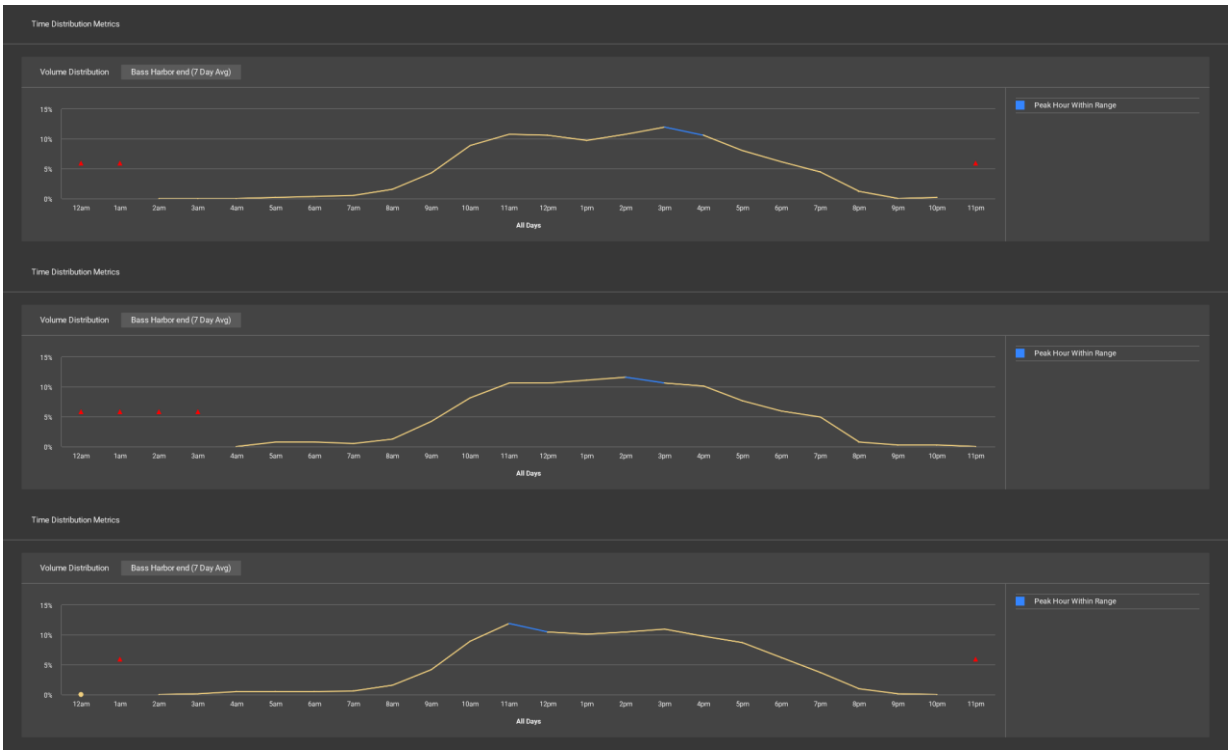

Figure 17: Big data line charts for time-of-day visitation trends for 2019 (top), 2020 (middle), & 2021 (bottom)

We looked again at the data received from Friends of Acadia that was acquired by the on-site car counter in 2021. This time it was viewed over the course of the day. As is displayed in Figure 18, this data corroborates Big Data, showing that the times between 10 a.m. and 3 p.m. are when the Bass Harbor Head Light is the busiest. Additionally, Figure 18 below indicates two distinctive peaks during 2021. The first peak occurs from 10:00 a.m. to 11:00 a.m. The second peak occurs from 12:00 p.m. to 2:00 p.m. This data is useful to compare with the data we collected.

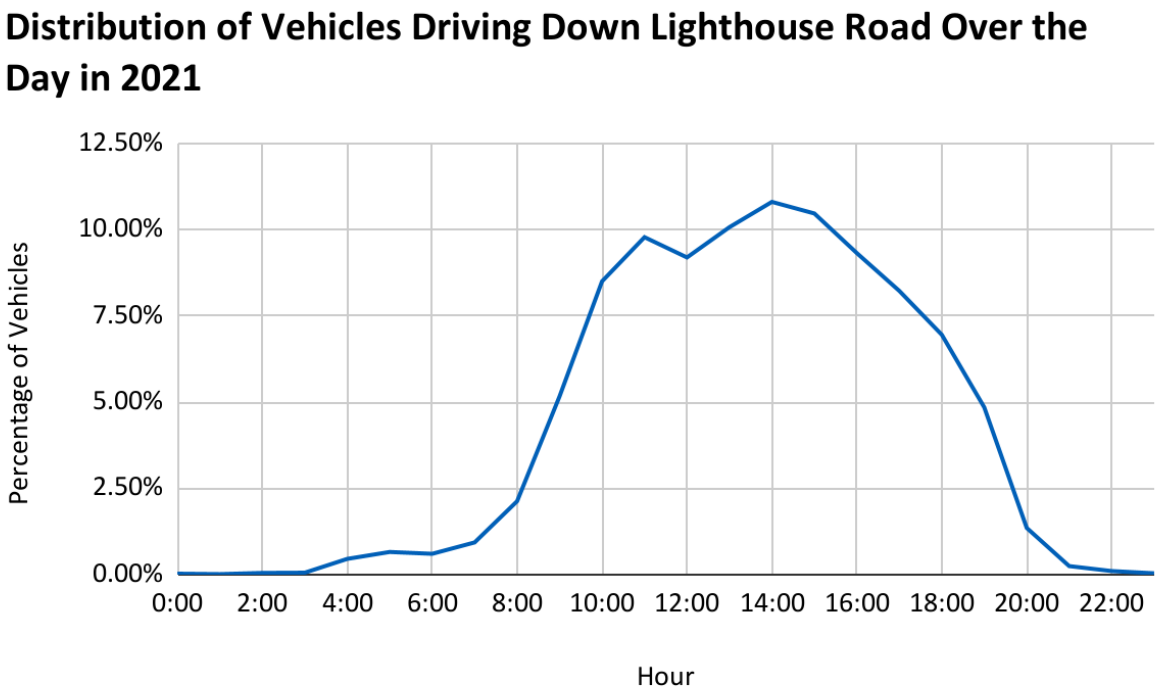

Figure 18: Line chart of 2021 daily trends from the on-site car counter

Now we will look at the data we collected. Figure 19 shows the frequency of arrival times each hour between 9:00 a.m. and 3:00 p.m. This figure shows how arrival times ebb and flow throughout the day. As shown below, our team observed two distinctive peaks. The number of arrivals reaches a relatively smaller spike between 10 a.m. and 11:00 a.m. The number of arrivals seems to decrease between 11:00 a.m. and 12:00 p.m., After 12:00 p.m., the number of arrivals increases again, reaching a maximum between 1:00 p.m. and 2:00 p.m. Additionally, the number of arrivals remains busy until 2:00 p.m. to 3:00 p.m. when it starts to taper off. These two peaks between 10:00 a.m. and 11:00 a.m. and 12:00 p.m. and 2:00 p.m. match the peaks recorded by the car counter in 2021 (Figure 18). This trend seems to indicate the hours between 10:00 a.m. and 2:00 p.m. are peak times at the lighthouse. These trends also corroborate the Big Data seen in Figure 17.

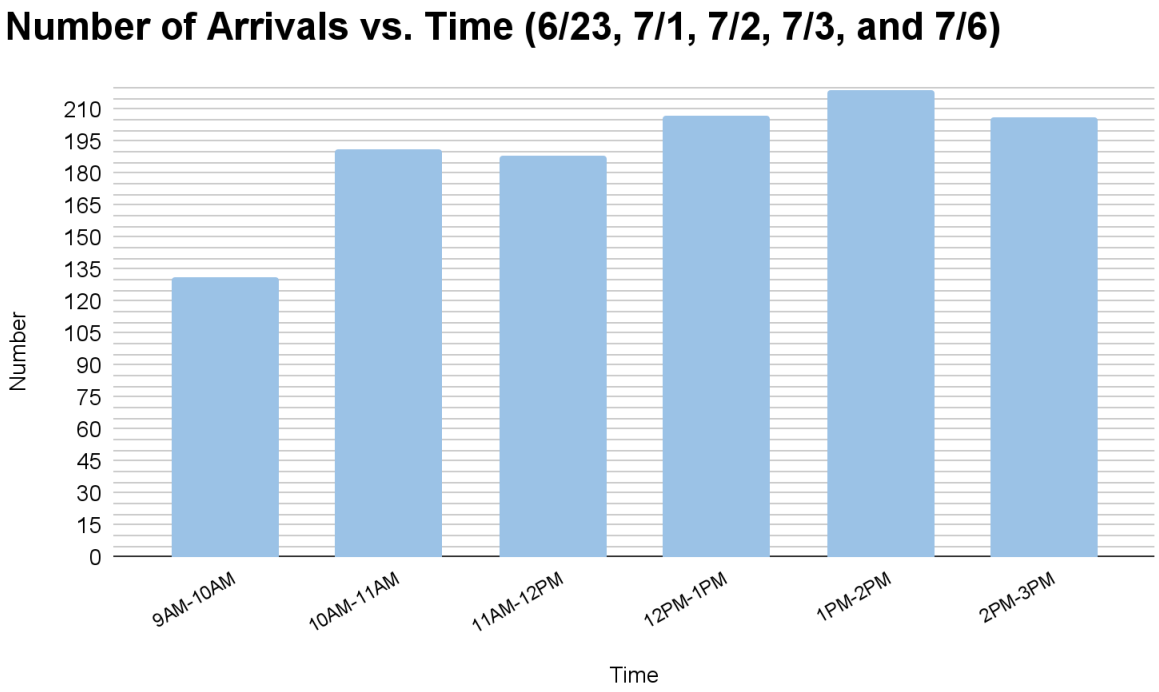

Figure 19: Bar graph of parking lot arrivals from 9:00 a.m. to 3:00 p.m. for 2022

To help illustrate the peak times clearly, looking at arrival times along with turnarounds and the queue of cars is important. By looking at turnarounds, along with the queue of cars, we could further understand the volume of cars trying to park at the lighthouse at different times. This multi-layered analysis is shown in Figure 20 below. This analysis further demonstrates that the peak times at the lighthouse are from 10:30 a.m. to 3:00 p.m.

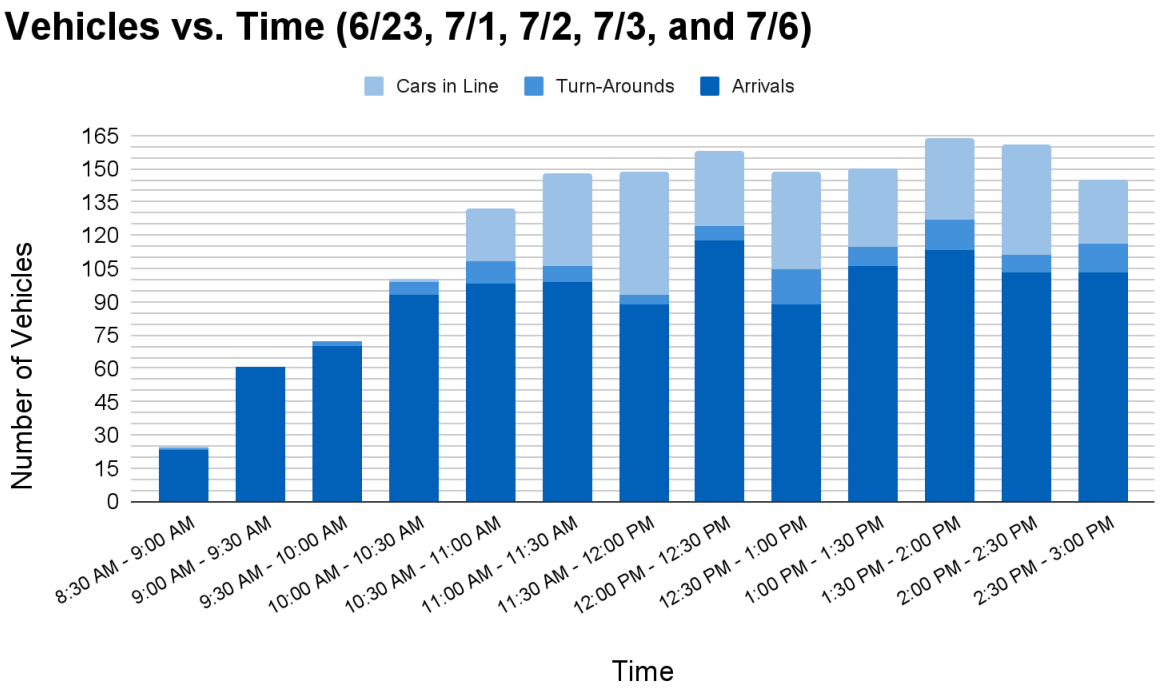

Figure 20: Bar graph of cars parking, turning around, and queuing from 9 a.m. to 3 p.m. for 2022

In addition to these times during the day, we have observed that sunset is also a peak time at the lighthouse. At sunset, visitors park or leave their hazards on, abandoning their car to walk in, aiming to catch the sunset. People at one time (PAOT) counts support this, having seen peak PAOT counts at sunset caused by this influx of visitors from the queued cars.

Figure 21 below shows the multi-layered data analysis on July 2nd, 2022. On this day, it was raining at the Bass Harbor Head Light Station throughout the morning until it stopped at 11:30 a.m. In Figure 21 you can see an increase in visitation at the lighthouse when the weather cleared up. This suggests that inclement weather can impact the peak times throughout the day, with less visitation during the inclement weather.

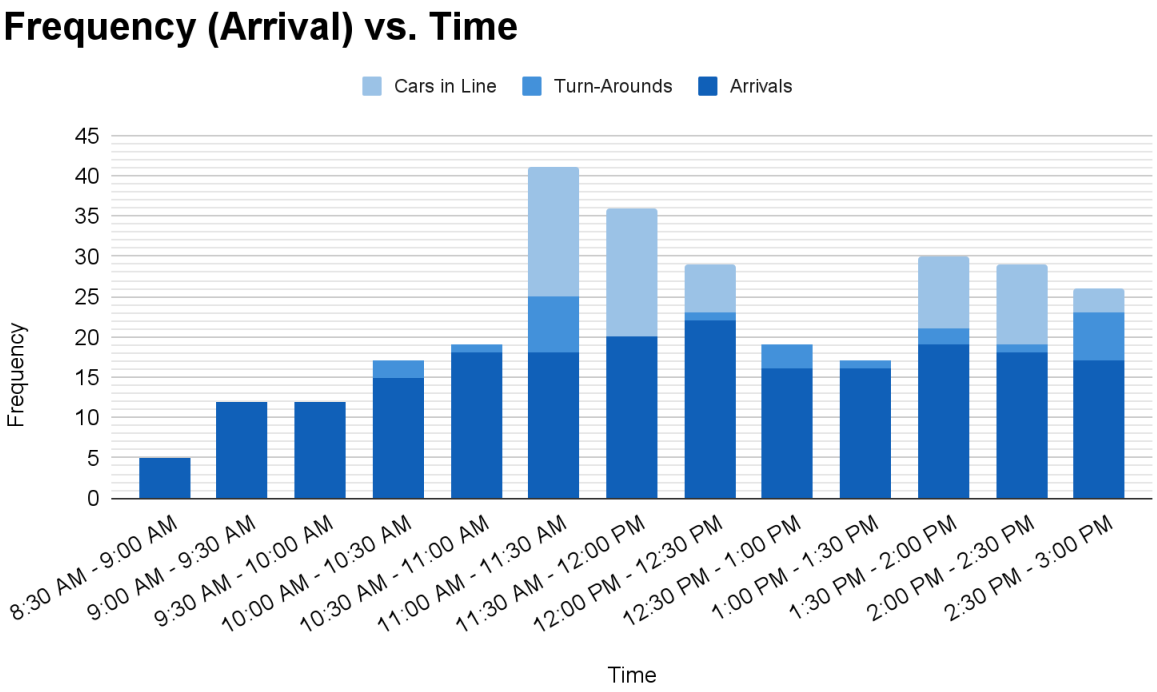

Figure 21: Bar graph of cars parking, turning around, and queuing from 9 a.m. to 3 p.m. on 7/2/2022

4.1.3 Parking Availability

Parking accessibility describes the ability to find parking at the lighthouse. To determine parking accessibility, data on turnaround rates, parking in unmarked spots, cars in the queue, and the usage of handicap spots were analyzed. Our analysis helped us determine the effectiveness of the current parking lot at the lighthouse.

First, we looked at the turnaround rate of vehicles entering the parking lot. This data tracks cars that entered the parking lot and left without parking. This data is important as it demonstrates the lack of accessible parking at the time the turnaround occurred.

Next, we looked at cars parking in unmarked spots. Unmarked spots are the spots that were not clearly marked in the parking lot with lines. This data helped demonstrate limited access to parking as visitors parked where there were no parking lines.

Finally, we analyzed data on the cars in the queue. The cars in the queue represent the number of vehicles that had to wait for a parking spot to open up. This data is important to recognize the visitors that had to wait for parking to become accessible to them.

Once we analyzed all of these data points, we looked at them collectively. Figure 22 below represents them collectively. We found that 68.4% of people are able to access parking upon arrival, leaving 31.6% of visitors to wait in the queue, park in an unmarked spot, or turn around. Of the 31.6% not able to find parking right away, 69.3% found themselves queued up for a parking spot. This shows that the parking lot is not very accessible for visitors.

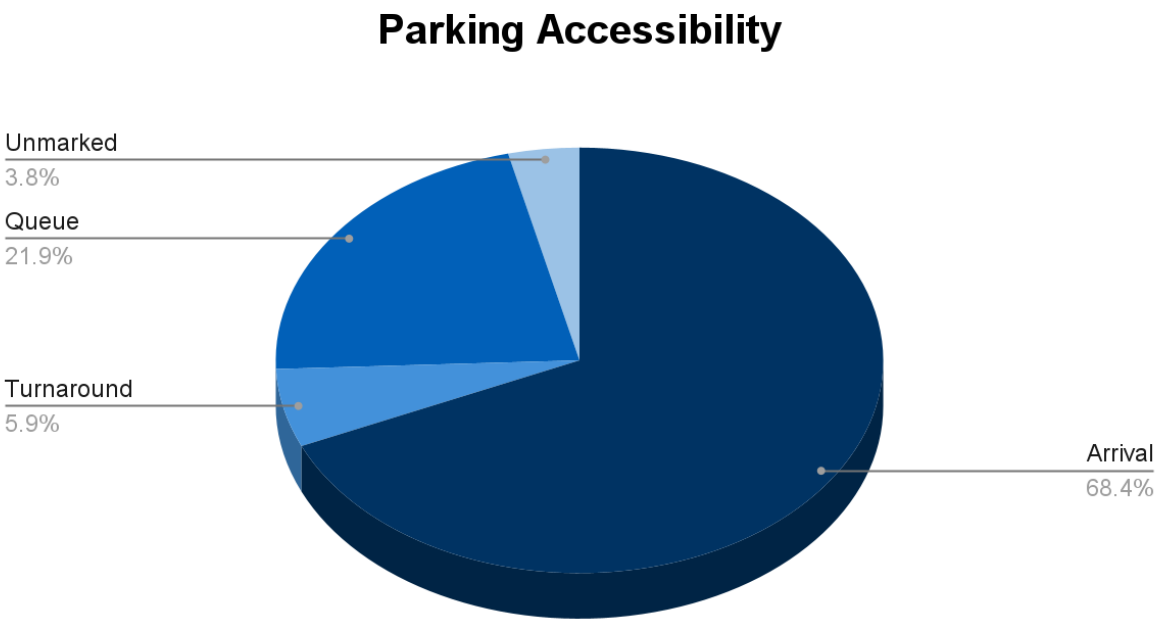

Figure 22: Pie chart of different parking outcomes

4.1.4 Use of Accessible Spots

Out of the 25 spots on the site 3 of the spots are reserved as accessible spots. That means accessible parking spots account for 12% of the parking lot. Our team while on site collected 2,462 dwell times over 15 days and only 59 (2.4%) of those dwell times were vehicles parked in accessible spots (spots 14, 24, and 25). This means that the other 88% of the parking spots are able to be used by any vehicle with or without an accessible parking placard and out of the 2,462 vehicles, 2403 (97.6%) used those twenty-two spots. If you look at the comparison of the percentage of spots used by cars with an accessibility placard versus the percentage of spots available to them and compare it to the percentage of cars who used the remaining spots and the percentage of spots available to them, you can see it is disproportionate. Additionally, throughout our entire direct observation, we only witnessed a one six-minute period when all three spots were full. The accessible spots have a larger supply than demand and the remaining spots have a greater demand than supply.

4.2 Dwell Time Analysis

Our team collected approximately 2,462 valid, vehicular dwell times over 15 days. Figure 23 is a bar graph that divides these dwell times into five-minute bins. The highest proportion, accounting for approximately 14.9% of the data, falls between 21-25 minutes. The next highest proportions fall between 26-30 minutes (14.5%) and 16-20 minutes (13.8%). The shortest dwell time ever recorded was approximately 2 minutes (6/20 and 7/6), and the longest dwell time our team recorded was 4 hours and 1 minute (6/26).

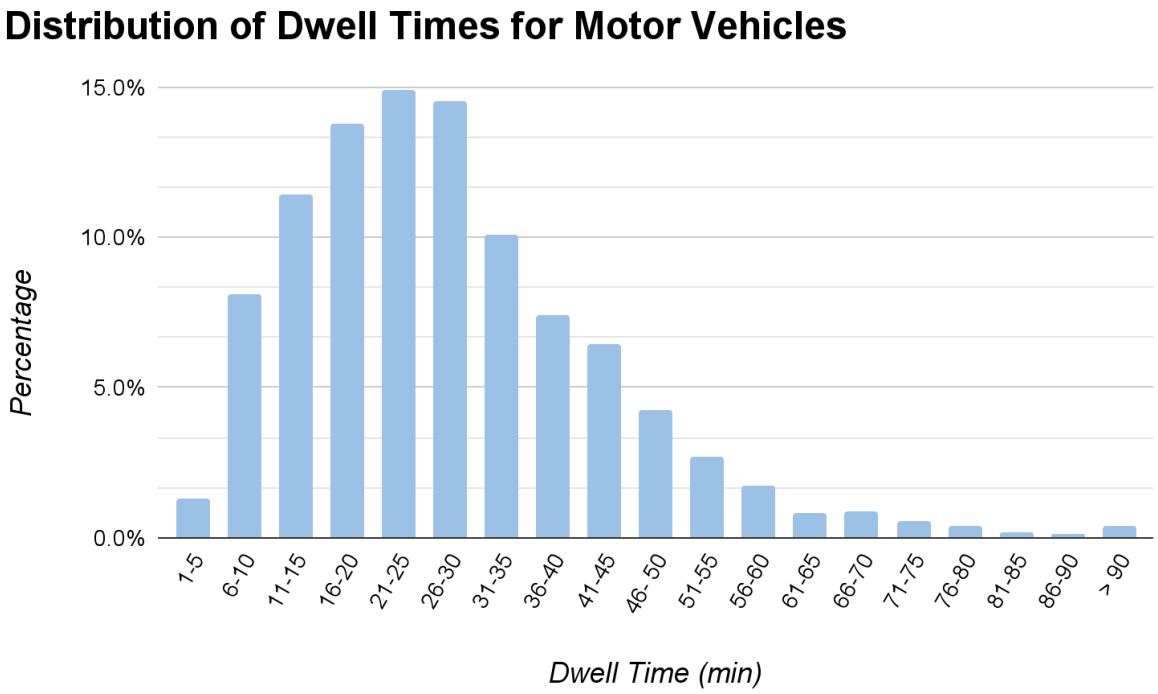

Figure 23: Bar graph of vehicular dwell times in five-minute bins

The bar graph in Figure 23 is also skewed to the right, indicating a large proportion of dwell-times lasting 30 minutes or less and a small proportion of dwell times over 30 minutes. More specifically, as demonstrated in Figure 24, 64.1% of the dwell times recorded were less than or equal to 30 minutes, 32.7% were between 31-60 minutes, and only 3.2% were over an hour.

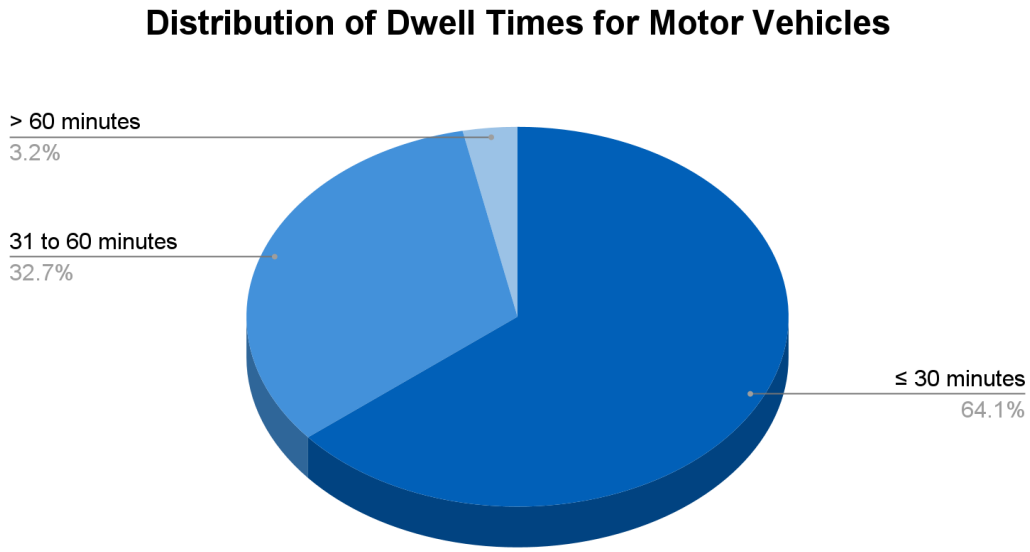

Figure 24: Pie chart of dwell times ≤ 30, [31, 60], and > 60 minutes

Since the bar graph in Figure 23 appears to be skewed right, one would expect the mean dwell time to be larger than the median. In this kind of distribution, the very small percentage of dwell times over 30 minutes pulls the overall average up in duration. With this set of data points, the average is in fact larger than the median. The average dwell time across all days was approximately 28 minutes, while the median dwell time was approximately 26 minutes.

4.2.1 Group Size Dependence

The average dwell time reported in section *4.2* is the average dwell time for vehicles in the parking lot. In this section, our team discusses how dwell time varies based on group size. Additionally, we report the average dwell time for visitors on the site using a weighted average.

Figure 25 plots the average dwell time for vehicles containing between 1 to 7 people. While our team did record group sizes of 8, 9, and 10, we did not include them in this graph. We did not include these groups because we did not observe them in large enough volumes to obtain accurate averages.

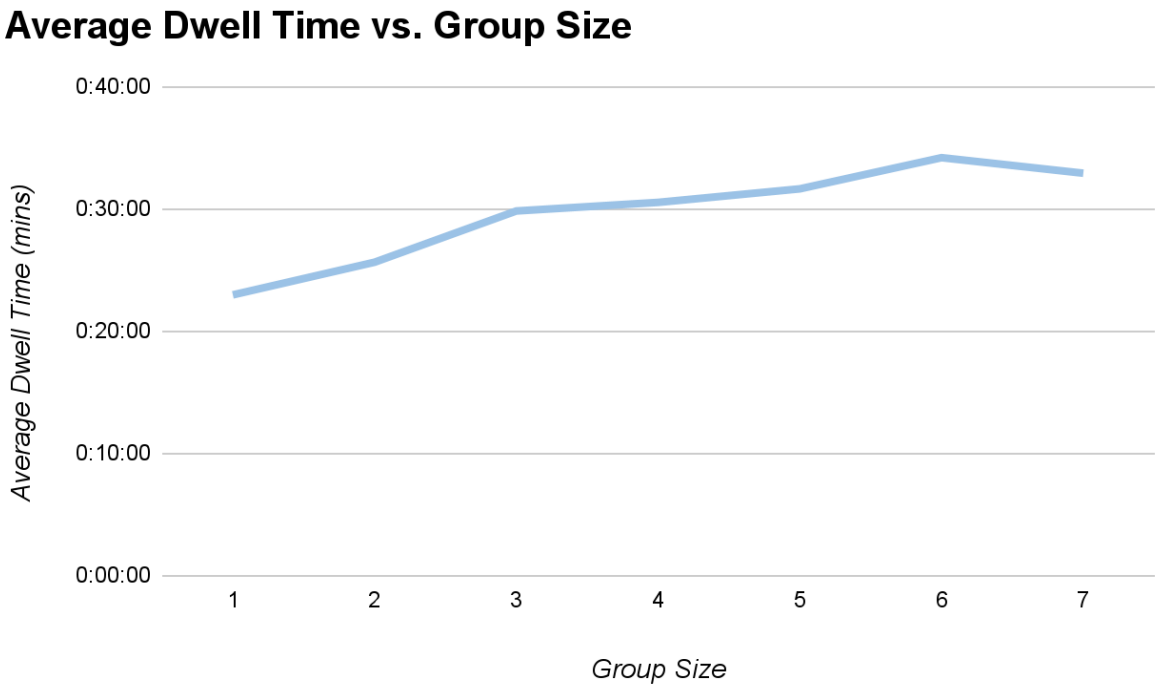

Figure 25: Line graph of average dwell time versus group size

As illustrated above, from 1 to 6 people, the average dwell time increases from 23 minutes to 34 minutes. This is an 11-minute increase in average dwell time. Beyond six people, the average dwell time per group drops to 33 minutes. This finding seems to suggest that dwell time increases with increasing group sizes, for vehicles containing between 1 to 6 people.

To account for the effect of group size on dwell time, our team calculated a weighted average using both the dwell times and group sizes recorded. This weighted average provides an approximate dwell time per person rather than per vehicle. The average dwell time per

visitor is approximately 29 minutes, roughly 1 minute longer than the average dwell time per vehicle.

4.2.2 Time of Day Variability

This section discusses dwell time as a function of the time of day. To account for time-of-day dependence, our team tried to record vehicle data from 9:00 a.m. to 3:00 p.m. daily. We collected data during these times for a total of six days: 6/20, 6/23, 7/1, 7/2, 7/3, and 7/6. Outliers from this pattern are the following nine days: 6/16, 6/18, 6/21, 6/24, 6/26, 6/27, 6/28, 6/29, and 7/7. On 6/16, we recorded data from 9:00 a.m. to 12:30 p.m. On 6/18 and 6/24, we recorded arrivals and departures between the hours of 6:30 to 9:00 p.m. On 6/21, our team recorded data from 9:00 a.m. to 2:30 p.m. On 6/26, we collected data between 7:00 a.m. and 11:00 a.m. On 6/27, we recorded data from 11:00 a.m. to 1:00 p.m. On 6/28 and 6/29, we recorded from 9:30 a.m. to 3:00 p.m. Finally, on 7/7, we recorded arrivals and departures between 10:30 a.m. and 3:00 p.m.

Figure 26 graphs the average dwell time change over the day from the hours of 9:00 a.m. to 9:00 p.m. in hourly blocks. As our team did not collect enough data points between 3:00 - 7:00 p.m., these hours are not plotted. To create Figure 26, we included the data collected on 6/20, 6/23, 7/1, 7/2, 7/3, and 7/6. We also included data from 6/18 and 6/24 to incorporate dwell times around sunset. Additionally, our team also included data from 6/21, 6/28, and 6/29 because we recorded arrivals and departures just 30 minutes short of 3:00 p.m. or just 30 minutes after 9:00 a.m.

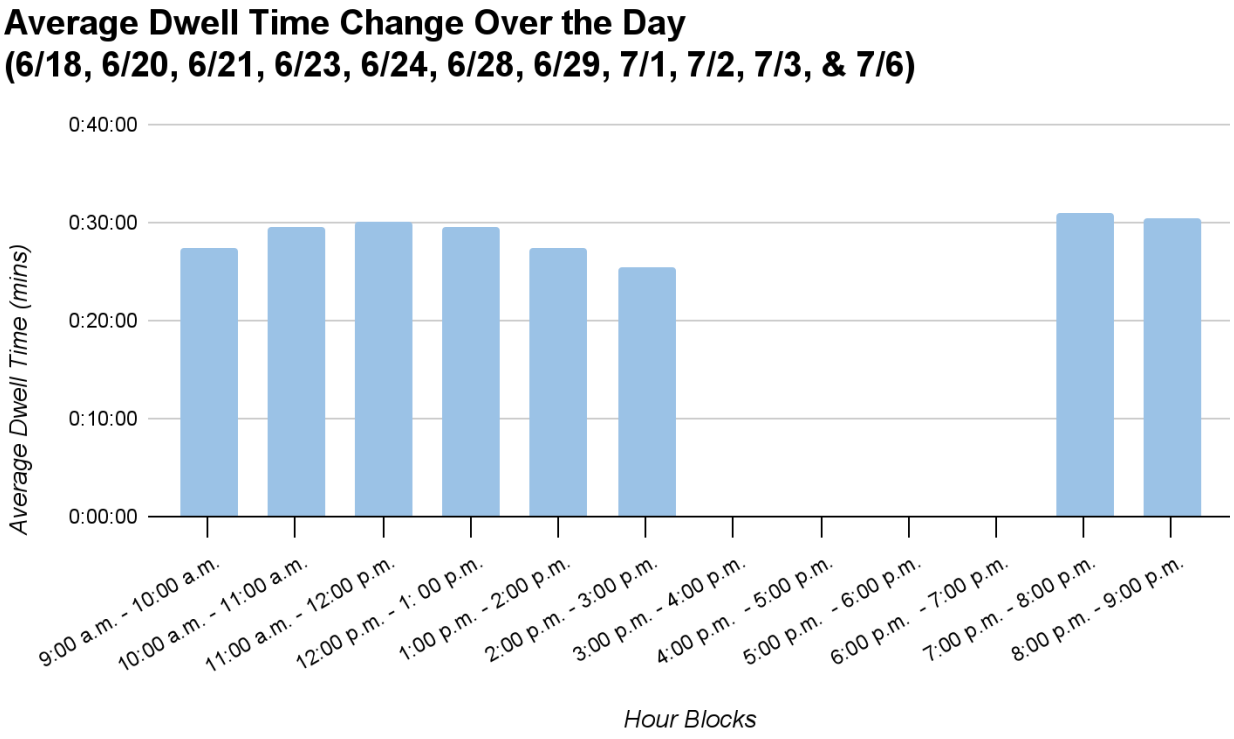

Figure 26: Bar graph of average dwell time change over the day

As shown in Figure 26, the average dwell time increases from 27 minutes at 9:00 - 10:00 a.m. to 30 minutes between 11:00 a.m. and 12:00 p.m. After 12:00 p.m., the average dwell time decreases across the day, dipping to 25 minutes between 2:00 and 3:00 p.m. Additionally, the average dwell time peaks between 7:00 and 8:00 p.m., reaching a value of 31 minutes. This finding seems to suggest that visitors stay on site longer during sunset.

To explore sunset further, our team will look at the dwell time data collected on 6/18 in greater detail. On that date, sunset occurred at approximately 8:23 p.m. Figure 27 plots the distribution of dwell times recorded in five-minute intervals. Unlike Figure 23, no visitors stayed for less than 6 minutes. Additionally, only 55.4% of the visitors recorded stayed for 30 minutes or less, as opposed to the overall frequency of 64.1% (Figure 24). Comparatively, during the hours leading up to and following sunset, there was an 8.7 percentage point increase in the frequency of visitors staying longer than 30 minutes. Additionally, as shown in Figure 28, the average dwell time on this date was 32 minutes, approximately 4 minutes longer than the overall average.

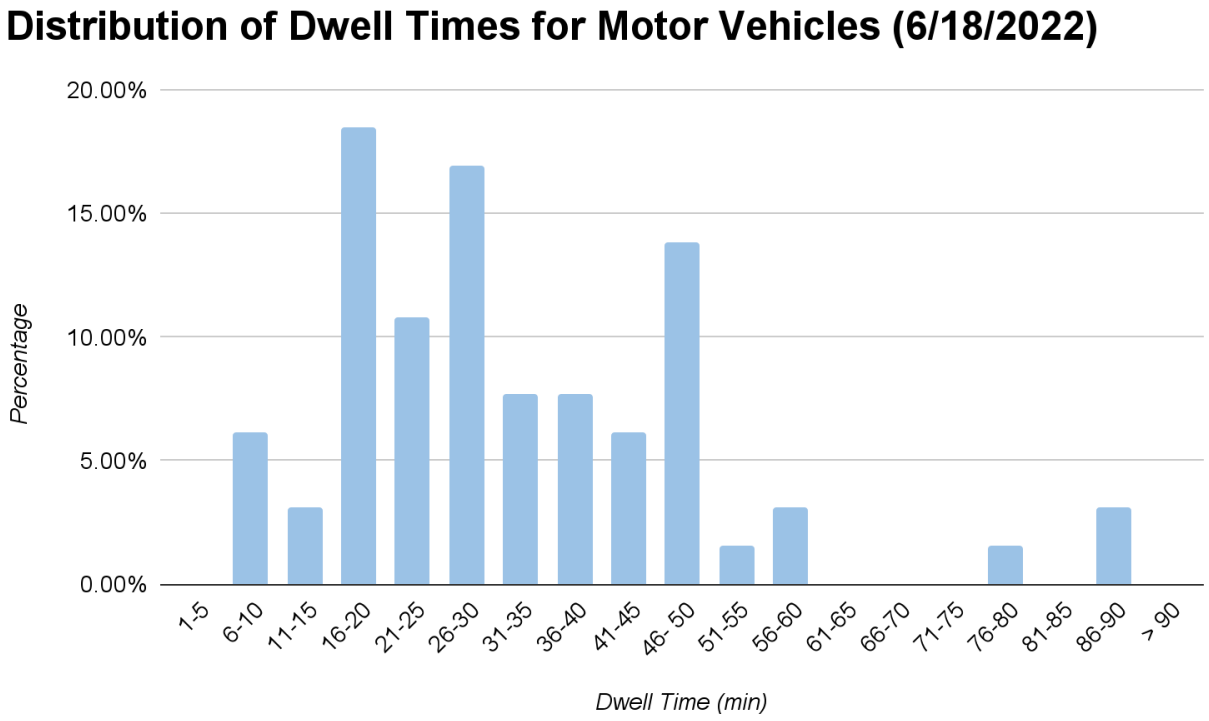

Figure 27: Bar graph of vehicular dwell times for sunset on 6/18/2022

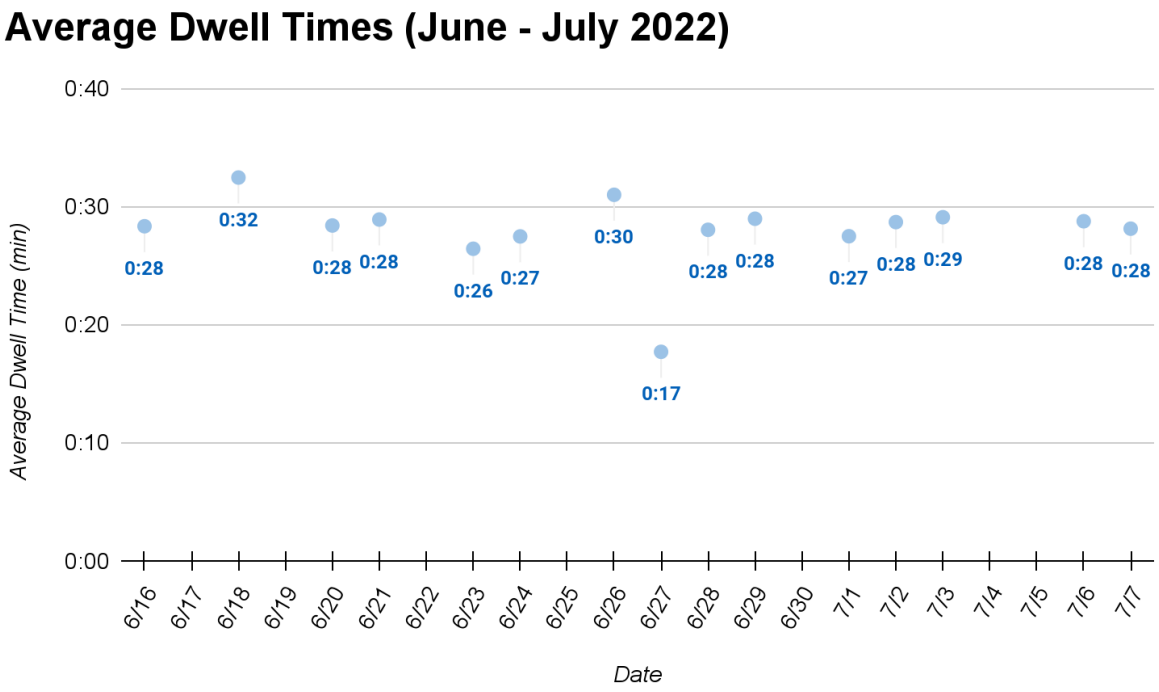

Figure 28: Scatter plot of the average dwell time recorded on each day of data collection

In addition to a longer length of stay during sunset, our team also observed that dwell time varied based on the arrival time within this window. As shown in Figure 29, there was a noticeable decrease in the length of stay as time progressed. In other words, visitors who arrived earlier tended to dwell longer on the site than visitors who arrived closer to sunset. Intuitively this finding makes sense because one would assume that people arriving between the hours of 6:30 p.m. - 9:00 p.m. come to view the sunset. Therefore, visitors who arrive earlier dwell longer on site as they wait for the sun to set. The longest and shortest dwell time recorded further corroborate this finding. On this date, the longest dwell time observed was for visitors who arrived at 7:16 p.m., an hour and 7 minutes before sunset. This group stayed on site for approximately 1 hour and 29 minutes. The shortest dwell time recorded was 8 minutes, for a group that arrived at 8:52 p.m.

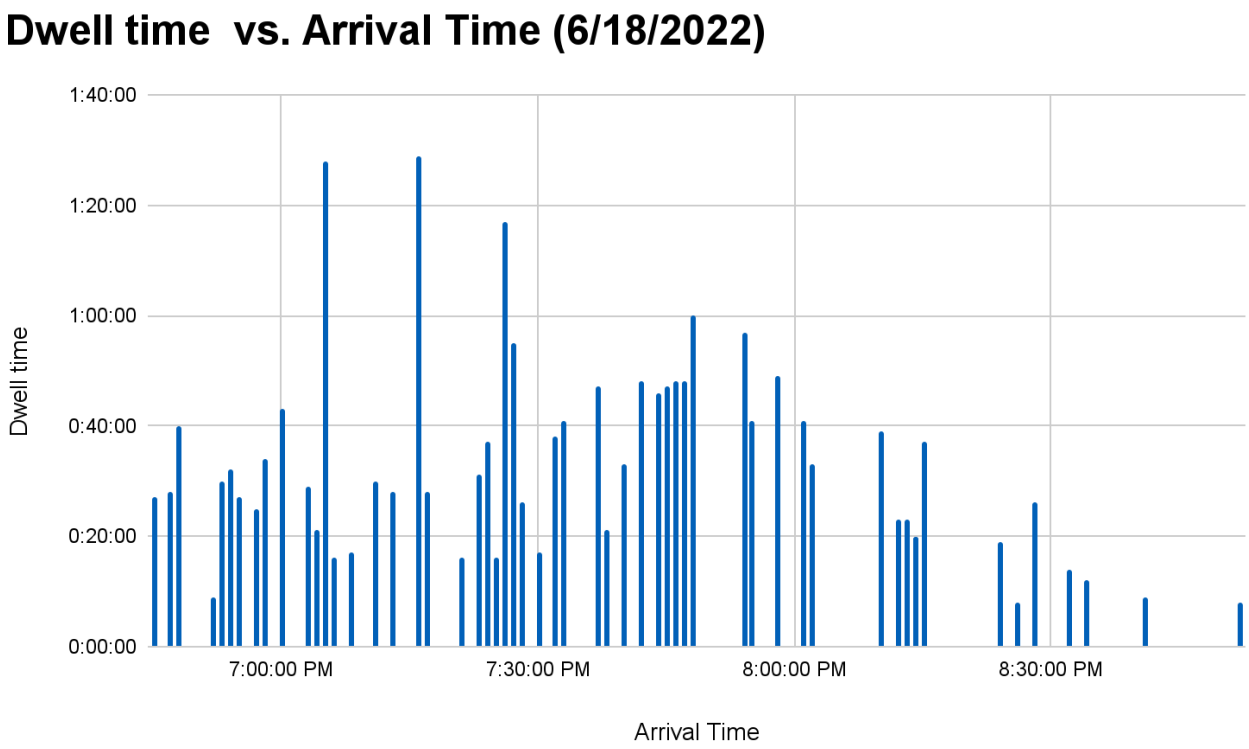

Figure 29: Column chart of dwell time vs. arrival time on 6/18/2022

4.2.3 Weather Dependence

This section discusses dwell time as a function of varying weather conditions. As our team only collected data for 15 days, our discussion of weather dependence is more qualitative in nature. This discussion also focuses on how rain influences length of stay. During our data collection, we observed rain on two occasions: 6/27 and 7/2.

Figure 30 shows the breakdown in the dwell time frequency on the 27th. As shown in Figure 30, the proportion of dwell times lasting 30 minutes or less is significantly larger than in Figure 23. In fact, on the 27th, 84.9% of visitors recorded stayed 30 minutes or less. Compared to the data across all days, this was a 20.8 percentage point increase in the number of visitors staying 30 minutes or less. Additionally, on this day, none of the visitors recorded stayed longer than an hour, which is a 3.3 percentage point decrease from the overall frequency. Additionally, as shown in Figure 28, the average dwell time on the 27th was the shortest dwell time recorded during the 15 days of data collection. On the 27th, visitors stay for an average of

18 minutes, approximately 10 minutes shorter than the overall average dwell time.

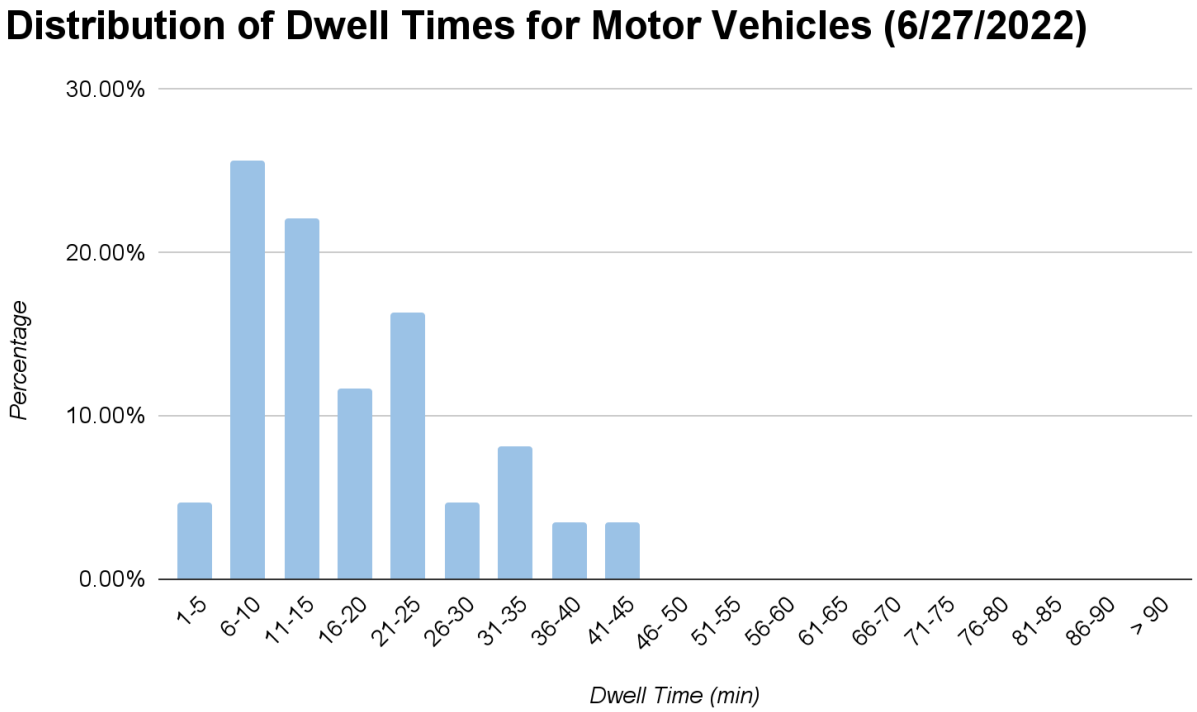

Figure 30: Bar graph of vehicular dwell times for rainy day on 6/27/2022

In addition to a higher proportion of shorter dwell times, our team also observed that the dwell time on the 27th decreased in proportion to when the rain started. On the 27th, the rain began at approximately 12:00 p.m. As can be seen in Figure 31 below, a group's dwell time decreased as their arrival time approached 12:00 p.m.

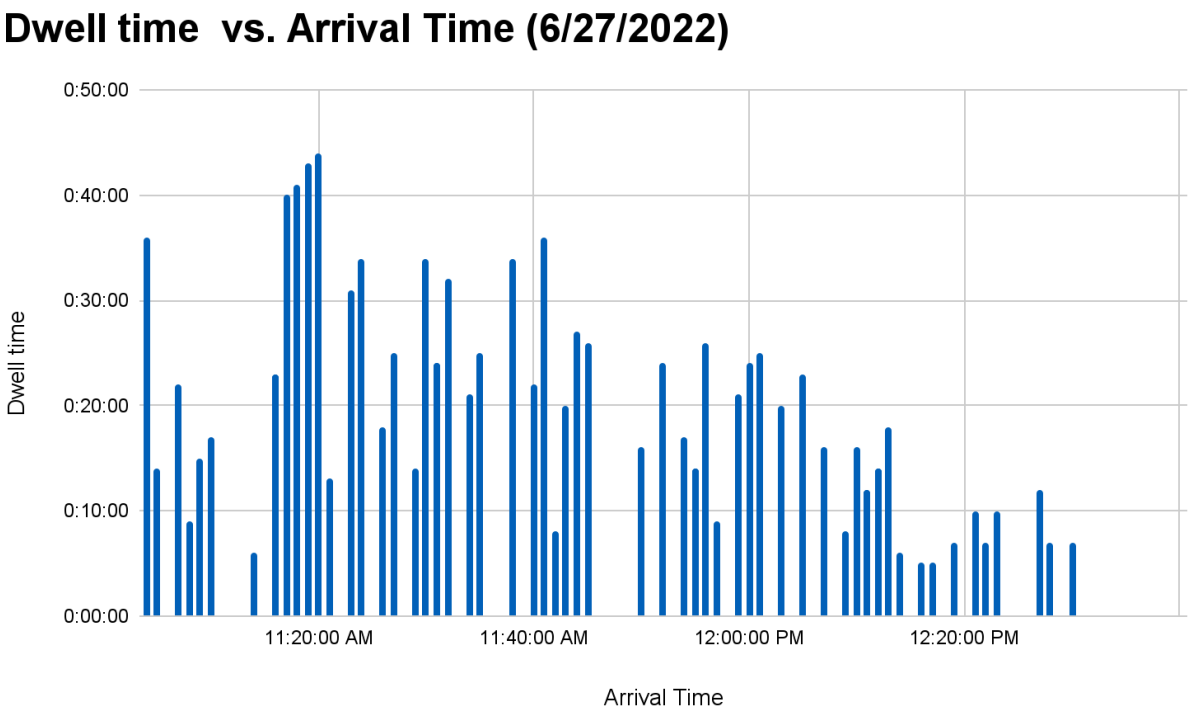

Figure 31: Column chart of dwell times vs. arrival time on 6/27/2022

4.2.4 Variations of dwell time due to other factors

While on site our team made various observations about factors that increased visitors' dwell time that did not have to do with the lighthouse. We noticed that families with smaller children usually had a longer dwell time because of the amount of time it took them to get in and out of the car. Wildlife was another factor that contributed to dwell time. The site would occasionally have deer that people stopped to look at, but the porcupines were usually the larger attraction. At night when people started to arrive, visitors could normally see porcupines in the trees. This would attract crowds of people to stop, look, and take pictures. Sometimes visitors would spend up to 30 minutes observing the porcupines before going to see the lighthouse. Although these observations are qualitative and not quantitative it is important to consider them in our final recommendations.

4.3 PAOT Analysis

As previously defined, PAOTs are the number of people in a specific location at a specific time. Our PAOT analysis observes several aspects of the concept. This includes how the PAOTs vary across different areas of the site, how PAOTs fluctuate across the day, what types of external factors affect PAOTs, how PAOTs are contributed to by group sizes, and finally, how PAOTs contribute to reaching and estimating the site's carrying capacity.

4.3.1 Site Variation

The two most frequently traveled locations at the Bass Harbor Head Light Station are the viewing area directly next to the lighthouse and the rocks at the end of the Bass Harbor

Head Trail. The amount of area that visitors occupy varies between these two locations; therefore, it was important for us to estimate a separate carrying capacity for each. We used multiple cameras to make a distinction between PAOTs at the lighthouse viewing area and the rocky area.

The differences between the two areas were most noticeable during the hours leading up to sunset, which occurred between 8:00 p.m. and 8:30 p.m. in the time we collected data. As can be seen in Figure 32, there is a distinct peak in PAOT on the rocks between the hours of 7:00 p.m. and 9:00 p.m. This peak, although still present in Figure 33 which depicts the same metric only this time at the viewing area next to the lighthouse, is much less distinct from the visitation during the rest of the day than that of Figure 32.

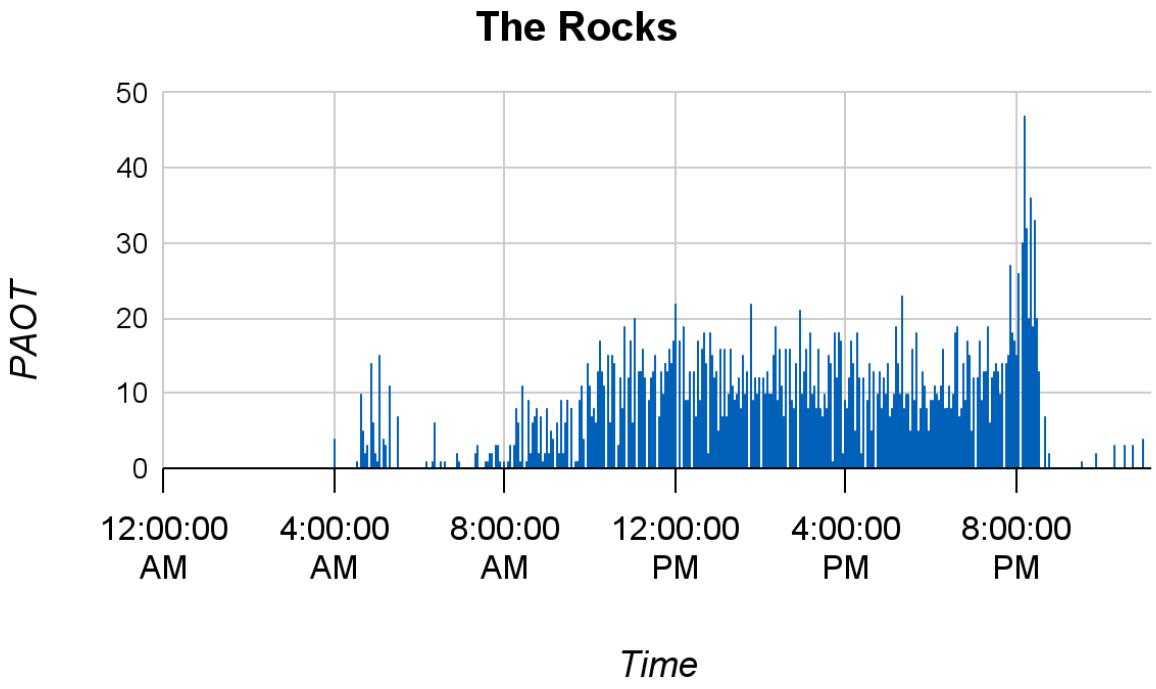

Figure 32: Column chart of PAOTs at the rocks from 6/26/2022 to 7/8/2022

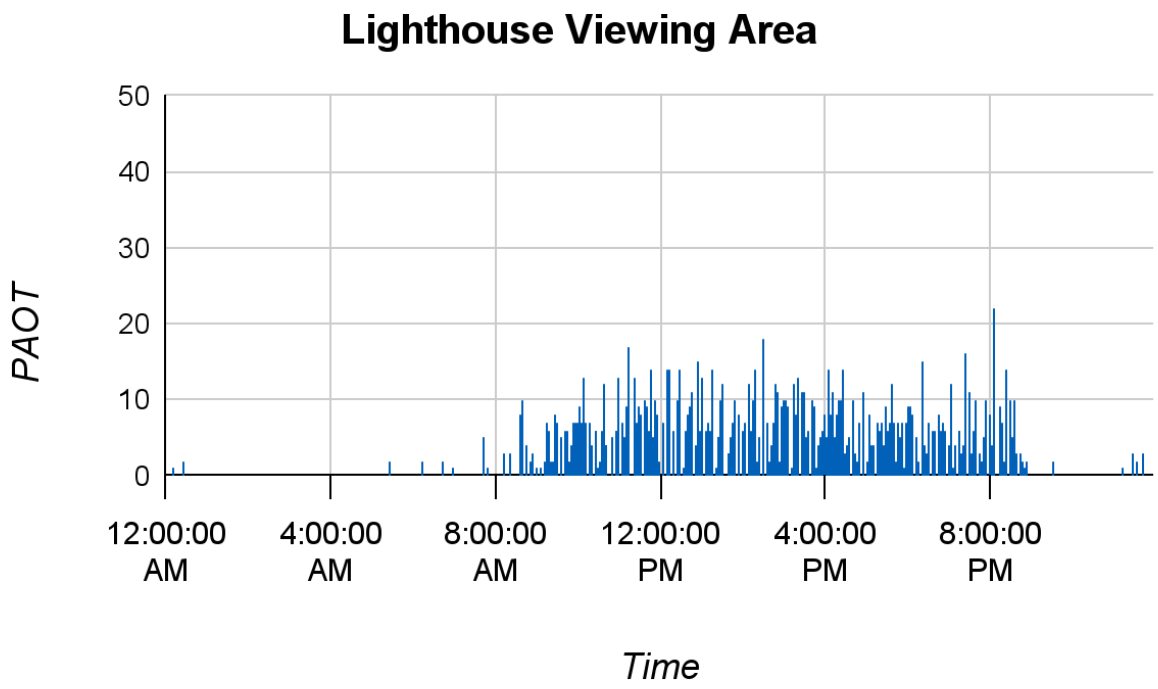

Figure 33: Column chart of PAOTs at the lighthouse viewing area from 6/26/2022 to 7/3/2022

Additionally, as will be discussed in more detail later, we conducted a study at the visitor center.

4.3.2 External Factors

The number of people on this site is influenced by a variety of factors. The most prominent of those factors is the weather. For weather, although most of the days we observed were not rainy so we cannot make any empirical determinations, our team can make some anecdotal observations on how rainy days affect the number of people visiting the site. For example, we recorded that it began raining on the 27th of June at approximately 12:00 p.m. In Figure 34, we can see that after 12:00 p.m., visitation to the rocks was so infrequent that the cameras were unable to pick up a single visitor there until nearly 3:00 p.m.

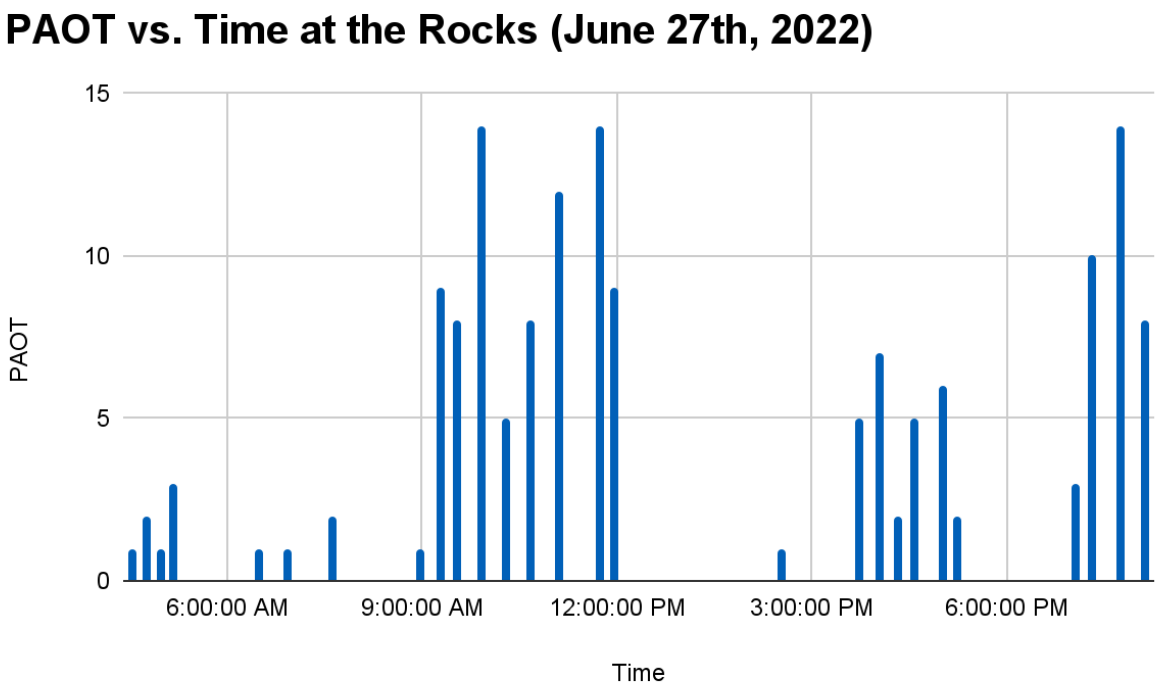

Figure 34: Column chart of PAOTs at the rocks on 6/27/2022

This is similar to the PAOTs within the same time range near the lighthouse. Although it is a bit briefer, there is also a lapse in visitation at the lighthouse viewing area after around 12:00 p.m. as seen in Figure 35.

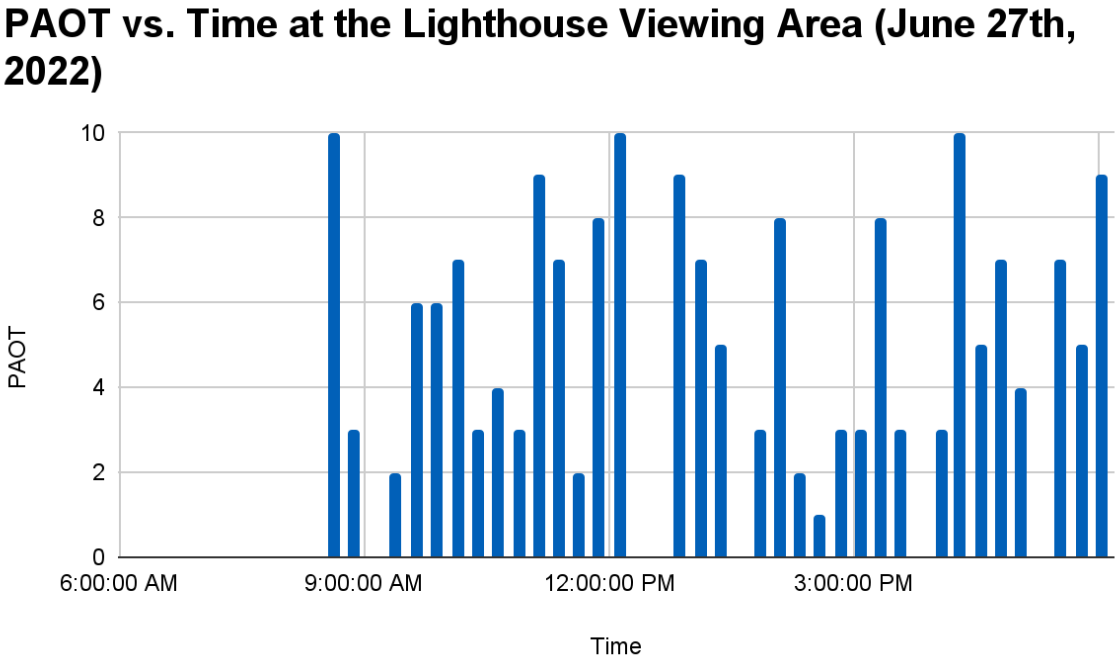

Figure 35: Column chart of PAOTs at the lighthouse viewing area on 6/27/2022

It is important to note that this is not the standard for a clear sunny day. Notice that on the day before—a sunny and clear day—we have Figures 36 & 37 which show how on June 26th, 2022, there is no gap in visitation at 12:00 p.m. at the lighthouse viewing area or the rocks.

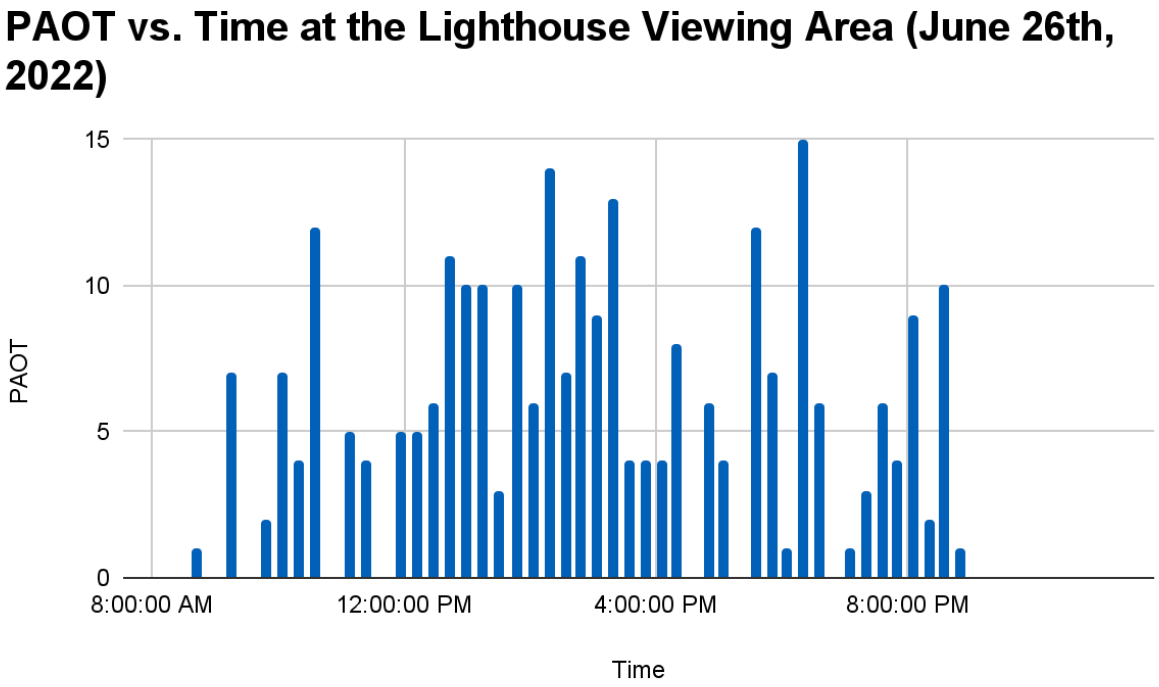

Figure 36: Column chart of PAOTs at the at the lighthouse viewing area on 6/26/2022

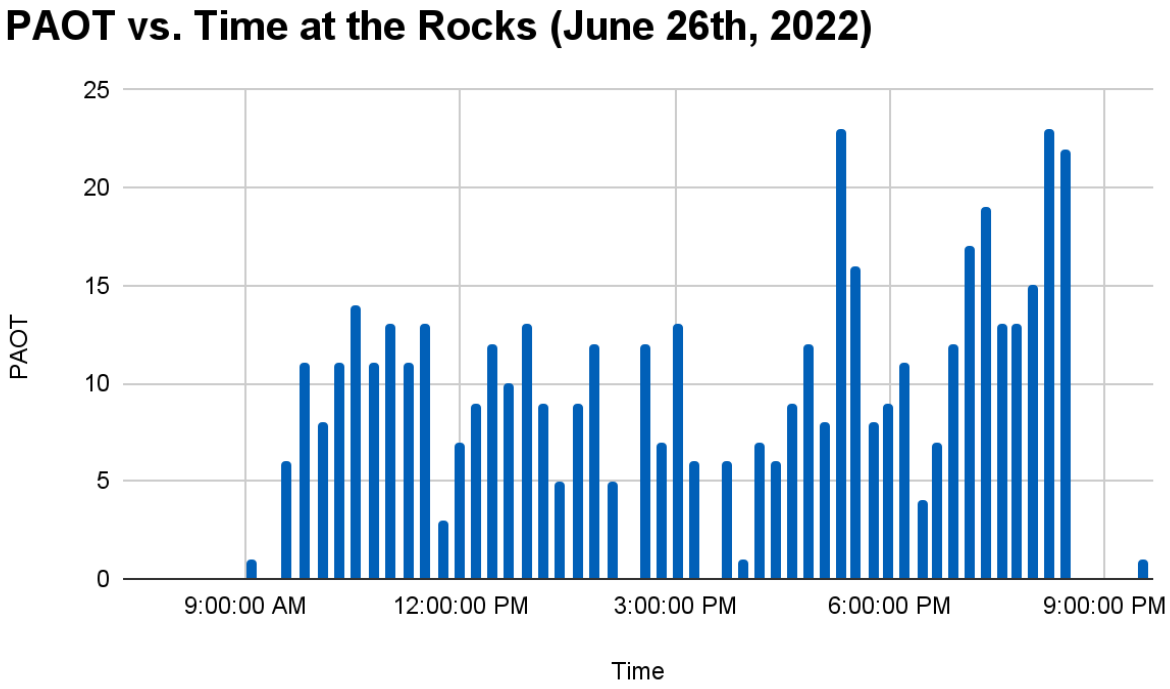

Figure 37: Column chart of PAOTs at the rocks on 6/26/2022

Aside from the weather, we also observed how high and low tide affected how many visitors were on the rocks area since the total accessible area of the rocks is very dependent on the water's elevation. Although we were unable to calculate an exact difference in exposed land area on the rocks between high and low tides, our team instead observed if there was a difference in how many people tended to visit the rocks areas. We used our cameras set up on the rocks to select photographs at the times of high and low tide each day. We then compared the PAOT on the rocks near high tide with the PAOT on the rocks near low tide on separate days where the time of high tide on one day was within 15 minutes of the time of low tide on the other day. Due to how tide patterns match up and the relative brevity of our data collection, we only have six such comparisons. Therefore, the following observations are purely anecdotal and, therefore, are inconclusive. As can be seen in Figure 38 the PAOT counts during high tide are greater than or equal to those of high tide for all compared data points.

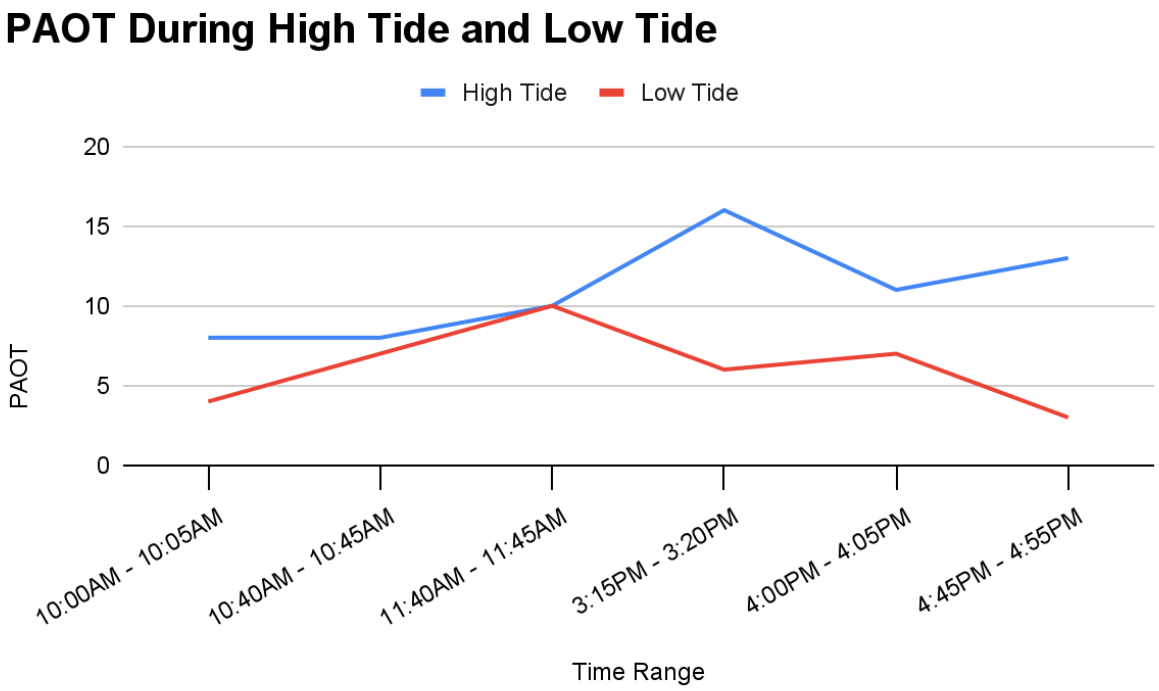

Figure 38: Line chart comparing high tide to low tide PAOTs

Although it may be purely coincidental, Figure 38 would suggest that the number of people visiting the rocks at high tide tends to be greater than that of low tide. If this were to be the case, then this would be crucial to consider when determining a carrying capacity given that there may be both a higher demand to visit the rocks and a lesser area of land for visitors to occupy. These two factors would have compounding contributions toward reaching the carrying capacity during high tide. Therefore, this may be useful to look into for future study.

4.3.3 Group Size (Vehicles)

To get an idea now of how many vehicles the site can accommodate, it is important to acknowledge the average number of people per vehicle parking on the site. This gives a value to the average number of vehicles that can park on the site before the carrying capacity is reached. As can be seen in Figure 39, the most common group size is two, making up 43.9% of

vehicles parking at the lighthouse. Additionally, after collecting 2,279 visitor group sizes, it was found that the average group size was 2.95, which would round to 3 people per vehicle.

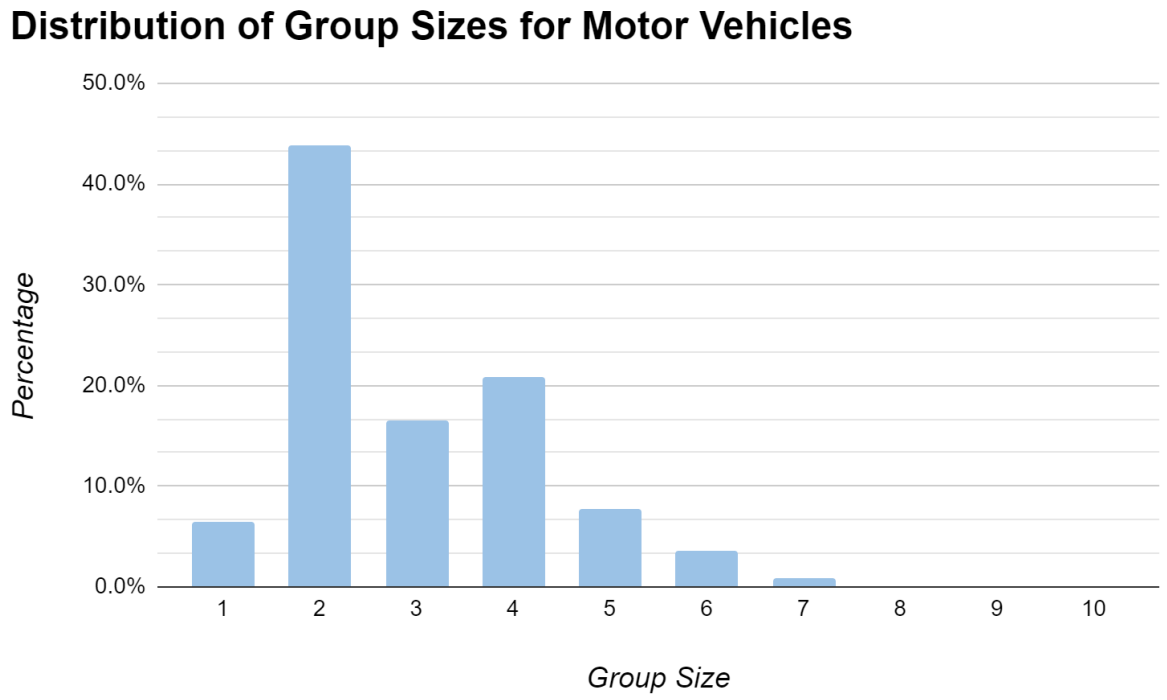

Figure 39: Bar graph of vehicle group size distribution

4.3.4 Visitor Experience and Crowdedness

For our first survey conducted at the lighthouse, we received 172 responses. Among the questions, we asked visitors the two following questions: “On a scale of one to ten, how crowded was the Lighthouse?” and “On a scale of one to ten, how would you rate your overall experience at the Lighthouse?” Using these two questions, we intended to establish a correlation between the visitor experience and crowding. Of the 172 responses, we were able to pair 170 of the crowdedness responses to the overall experience responses of visitors. Plotting these responses, as is seen in Figure 40 we were able to get a trendline with an R^2 correlation of zero. An R^2 of zero for this best fit line would suggest that there is absolutely no correlation between perceived crowdedness and overall visitor experience. This would suggest that the lighthouse has not yet reached a capacity at which the crowdedness becomes detrimental to the visitor experience. To clarify however this data is not conclusive. For this time of year and number of data points, there seems to be no correlation. However, due to our lack of data points for the rest of peak season, along with the fact that many other factors also contribute to calculating carrying capacity, we were unable to determine a concrete number for carrying capacity.

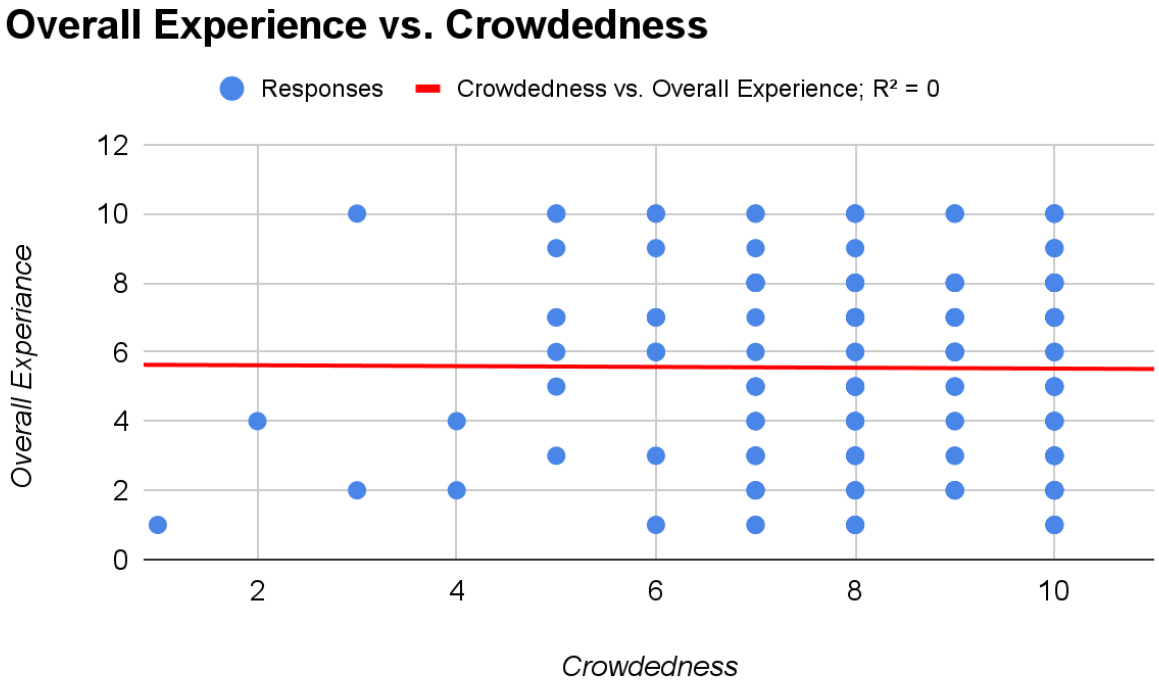

Figure 40: Scatter plot of visitor ratings of crowdedness vs. overall experience

4.3.5 Visitor Experience Carrying Capacity

As previously mentioned, carrying capacity is defined as the maximum number of people a site can accommodate before it becomes detrimental to the visitor experience, visitor safety, and environmental protection of the site. We only looked at the visitor experience. Therefore, we cannot use our data to determine a conclusive number for carrying capacity. Despite this, our group identified a method to determine a possible lower bound on the carrying capacity for the site based on the maximum number of visitors seen on site during times that received an "acceptable" rating (above a seven) for overall experience. This method involved cross-referencing our group size data at times when visitors reported being on site in their survey responses. We examined at the times that each visitor reported they were on site in their survey response and added up the group sizes of all motor vehicles we recorded as being on site at that time. We then took the maximum number of people we found on site that were still considered acceptable. The number we obtained through this method from vehicles only was 77 people.

Additionally, our time-stamped card system kept track of visitors walking, jogging, or biking who were not accounted for in the recorded vehicle group sizes. This included people getting out of cars in line to walk down to the lighthouse. Therefore, the people walking onto the site were considered in this method to calculate this lower bound as they also would have contributed to the PAOT on site. We handed out a total of 320 time-stamped cards and received 296 of them back. Of those 296 cards, 288 of them were considered usable, valid data. Now considering the time when there were 77 people from vehicles on site at one time, there were also 27 visitors who had walked, jogged, or biked onto the site at that same time and day. Using this we get a total value of 104 visitors at one time. Again, this number is not conclusive, however, we believe that it can serve as a theoretical lower bound to the carrying capacity.

4.3.6 The Manning Survey

Our group conducted another survey adapted from the Robert Manning VERP study. From this, we received 96 responses. With these responses we averaged the ratings for each photo and graphed them against the known number of people each photograph contained. As can be seen in Figure 41, the carrying capacity of the viewing area next to the lighthouse is approximately 17 people. Then for the rocks at the end of the trail, Figure 42 depicts a carrying capacity also of approximately 17 people. Despite the large difference in accessible area across the two areas of the site, the carrying capacity seems to be somewhat consistent across each area. This also suggests that the combined carrying capacity of both sites would be approximately 34 people. This does not seem to corroborate the results from our previously mentioned survey since we have observed an average group size of 2.95 and at least 22 spots are occupied at peak hours. This would suggest that approximately 65 people are on site at peak hours, which is over this supposed carrying capacity. This contradicts the first survey which suggested that crowding was not negatively impacting visitor experience. We attribute this to the fact that the crowding survey was distributed at the visitor center where visitors had not necessarily visited the lighthouse specifically. Giving them an altered sense of the actual available space on site. Since these images only look at a portion of the rocks area and the lighthouse viewing area, we considered this value of 34 an isolated statistic. It shows a theoretical carrying capacity at the rocks and lighthouse viewing area only and is not representative of the carrying capacity for the entire site.

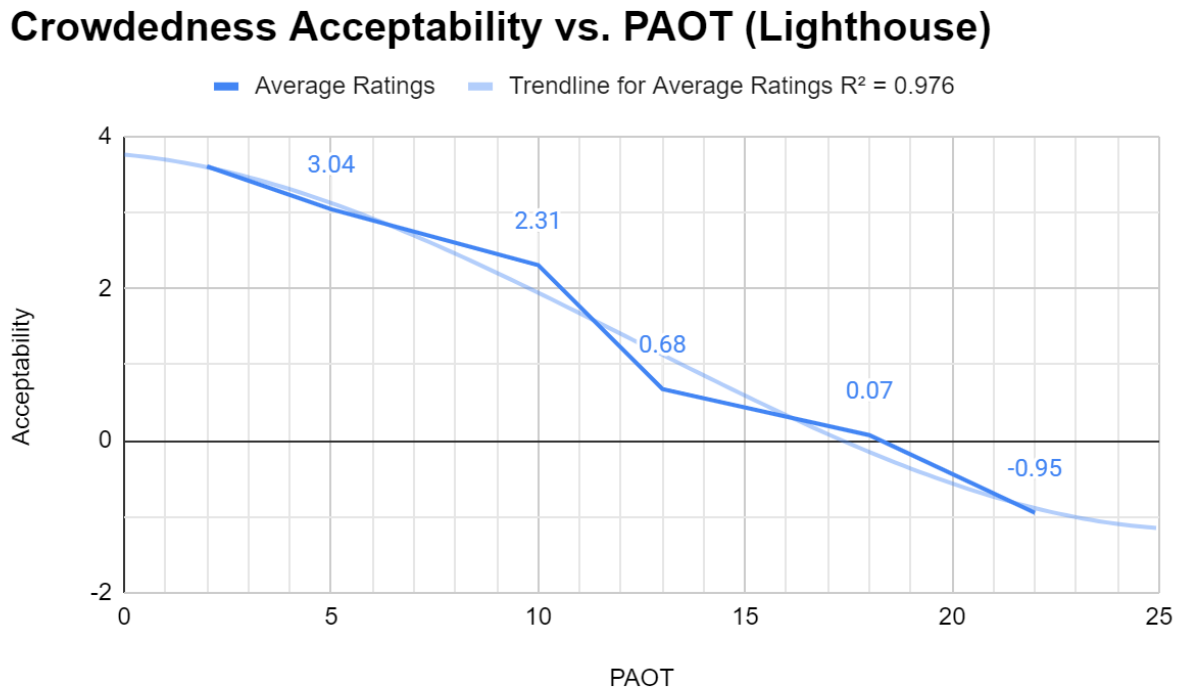

Figure 41: Line chart of crowdedness acceptability vs. PAOTs at the lighthouse viewing area

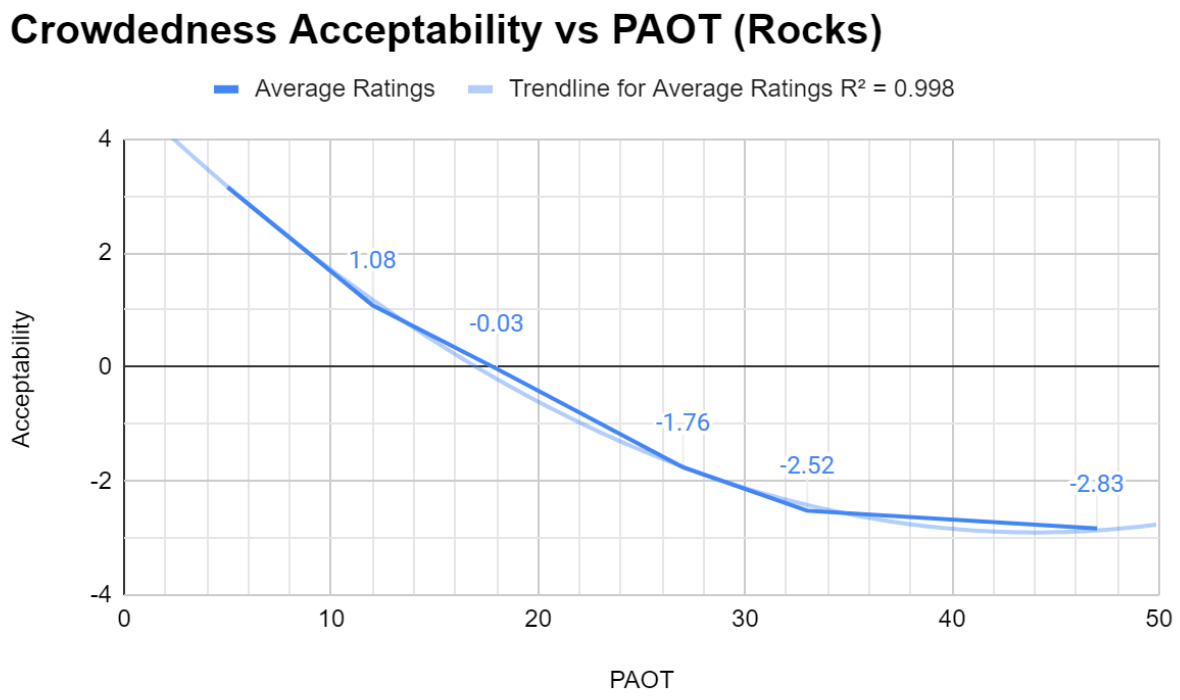

Figure 42: Line chart of crowdedness vs. PAOTs at the rocks

4.4 Ecological Impact Analysis

One of the things our team focused on while observing overcrowding on site was the impact on the environment. We specifically examined the trail to the rocks. Each week we took photos of the trail to compare to the previous weeks. In these photos, we looked for trail widening and damage to the environment surrounding the trail. This analysis was done for 4 weeks, and although we cannot make certain conclusions, we can make observations. From our observations there were no major impacts throughout the 4 weeks. We noticed the park had put up signs regarding illegal trails that had been made, and during our time on site, we never saw those trails being used. The only time people went off of the trails was if they brought their bicycles or strollers down. They would move them off of the path so they could go down the stairs as can be seen in Figure 43. Although this data is not conclusive, the observations we made from collecting these photos helped our group with deciding what some of the smaller recommendations should be which will be discussed in Chapter 5.

Figure 43: Photo of bicycles left along the Bass Harbor Head Light Trail

4.5 Survey Analysis

Our team conducted visitor surveys for 11 days and received 172 responses. In the following sections, we discuss the results of these surveys and provide noticeable trends. Pertinent sections include how visitors discover the lighthouse, the most common forms of transportation to the site, group size distributions, visitor interactions with the site, visitor sentiment around a reservation system, visitor experience, and possible recommendations.

4.5.1 How and Why Do Visitors Come to The Lighthouse?

In this question, "why" refers to how visitors learned about the site. When asked, "How did you find out about the Lighthouse?" The most common answer, representing approximately 23.7% of responses, was the NPS website. In addition to the NPS website, 18.9% of the responses included other websites, such as social media, blogs, an Acadia Facebook group, and Google. After other websites, the next most popular option was word of mouth, with 18.4% of responses. The next highest answer was maps, accounting for 11.4% of responses. The visitor center accounted for 10.1% of responses. Guidebooks, travel books, hiking books, and brochures made up 5.3% of responses. 3.1% of responses indicated visitors who had been to the site before. Information booths accounted for 2.6% of responses. The smallest proportion of responses were people who had lived in the area (or had family who lived in the area) and people staying at nearby campsites, accounting for 1.3% of and 0.9% of responses, respectively. Other answers include the following: a souvenir Lego set of the lighthouse, famous pictures of the park, postcards, magnets, an NPS quarter, YouTube, signs, and a bathroom.

"How" visitors come to the lighthouse refers to their mode of transportation. As shown in Figure 44, an overwhelming majority of respondents, nearly 92.4%, indicated they arrived by car. After cars, the most popular modes of transportation were as follows: 3.5% by bike, 2.9% by foot, and 1.2% by Island Explorer bus.

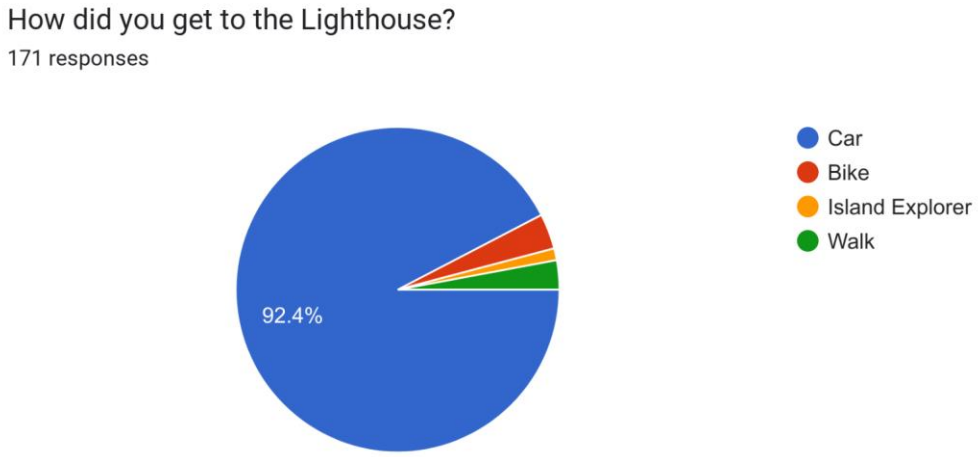

Figure 44: Pie chart of modes of transportation from visitor survey

4.5.2 Group Size

When asked, "How large was your group size at the Lighthouse," 37.6% of respondents selected a group size of two. The next most frequent group sizes were as follows: 4, 5, and 3, accounting for 21.1%, 15%, and 13.5% of visitors surveyed. The smallest group size selected was 1, and the largest group size selected was 16.

These survey results also corroborate the group sizes per vehicle we obtained in section *4.3.3.* Through direct observation, we concluded that 2 was the most common group size. The survey results confirm this finding. Additionally, we concluded that 4 was the next most common group size. The survey results also confirm this finding. While our team recorded more groups of 3 than 5, both appear in the top four most common group sizes in the survey and direct observation results. Additionally, the smallest group size recorded through direct observation matched the smallest group size response in the survey.

While the survey responses confirm some of our team's findings, there are a few discrepancies. For instance, the average group size from the survey was 3.83. This was larger than the average group size derived per vehicle: There are a few explanations for this discrepancy. The responses for the surveys include any type of group: walk-ins, bikers, people from cars, and people from the Island Explorer. One drawback to recording the group size per vehicle is this number does not include the total number of people in a group that arrives in more than one car. Additionally, the group size per vehicle is confined by the size of the car, whereas groups that walk-in or take the Island Explorer do not face that kind of confinement and can arrive in bigger groups.

4.5.3 Visitors' Interaction with The Site

The two interactive locations on the lighthouse site include the paved path to the lighthouse and the Bass Harbor Head Trail to the rocks. To capture visitor interaction with the site, our team asked visitors to indicate whether they visited each location with a "yes" or "no" response. As shown in Figures 45 & 46, the results of the survey indicated that a higher percentage of respondents visited the paved path than the Bass Harbor Head Trail. When

asked, “Did you walk down the paved path to the Lighthouse,” 88.3% percent of visitors indicated “yes.” Whereas, when visitors were asked, “Did you walk down the Bass Harbor Head Trail to the rocks,” only 86.5% answered “yes.”

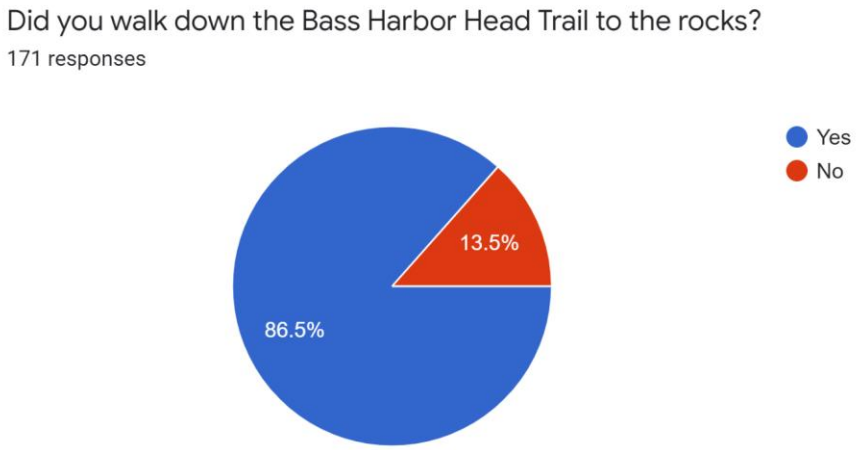

Figure 45: Pie chart of visitor interaction with the Bass Harbor Head Trail from visitor survey

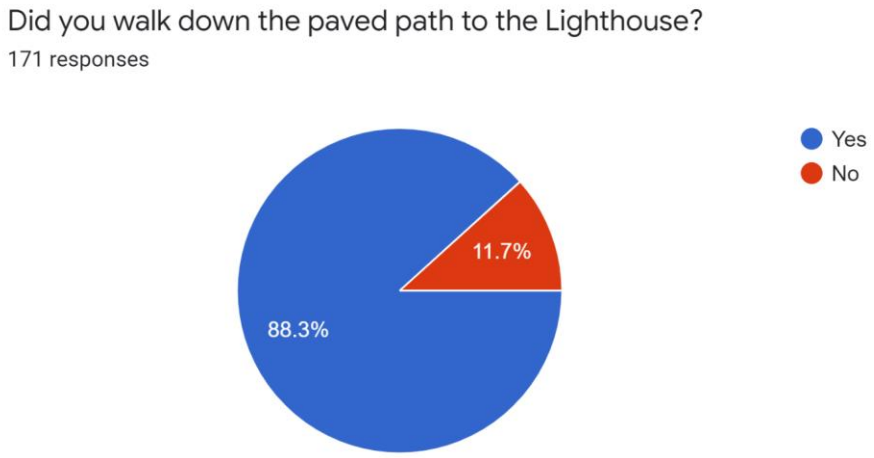

Figure 46: Pie chart of visitor interaction with the paved path to the lighthouse from visitor survey

4.5.4 Visitors Sentiment Around Implementing a Reservation System

In our survey, visitors were asked if they thought the lighthouse would benefit from a reservation system (Figure 47). Through this question, we learned that 36.7% of visitors “agree” or “strongly” agree that a reservation system would benefit the lighthouse. 26.7% of visitors were neutral to the idea that a reservation system would benefit the lighthouse, 36.7% of visitors “disagree” or “strongly disagree” that a reservation system would benefit the lighthouse. This data shows that the number of people who think the lighthouse would benefit

from a reservation system is the same as the number of people who do not think the lighthouse would benefit from a reservation system.

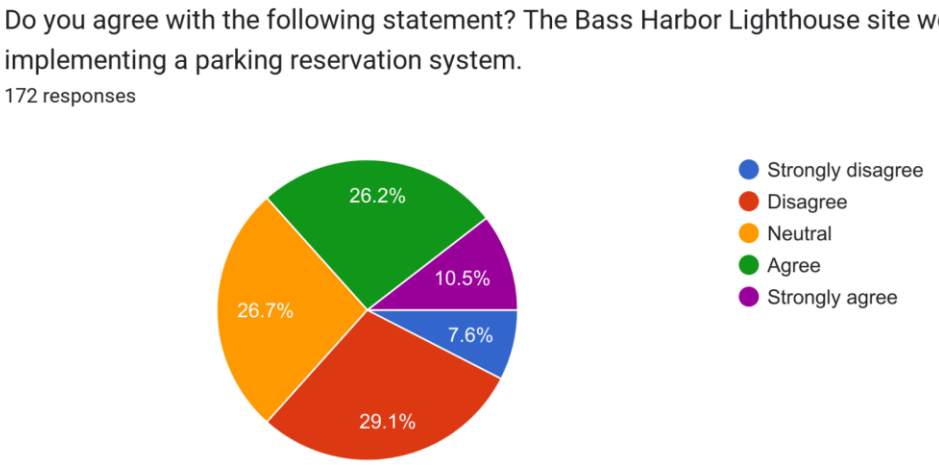

Figure 47: Pie chart of visitors' views on implementing a reservation system from visitor survey

Another question that visitors were asked regarding a reservation system was if they were willing to pay for a parking spot (Figure 48). We got 172 responses and 44.2% said they would not, 36.6% said maybe, and 19.2% said they would be willing to pay.

Figure 48: Pie chart of visitors' willingness to pay for a parking spot from visitor survey

To follow up with the responses in Figure 49, we asked visitors who were willing to pay for a parking spot how much they would be willing to pay. Out of the 172 responses from Figure 49, we got 105 responses for Figure 50. Out of these responses 91.4% said they were willing to pay between $1 and $5, 8.6% said they would be willing to pay $5 and $10, and 0% are willing to pay between $10 and $15.

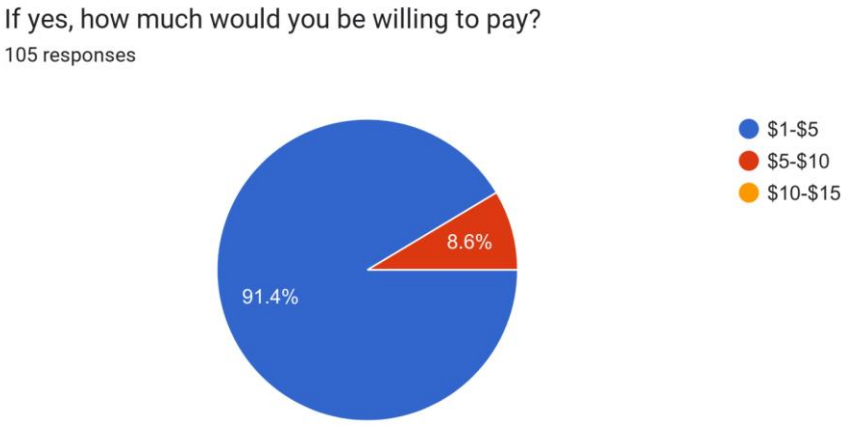

Figure 49: Pie chart of the maximum amount visitors would pay for a parking spot from visitor survey

4.5.5 Visitor Experience

As can be seen in Figure 50, 70.3% of visitors rated their experience an eight or above. This survey helped us see the effects of overcrowding on the visitors at the site. This shows us that even with the overcrowding more than ⅔ of surveyed visitors are still enjoying their time at the lighthouse, with an "enjoyable" experience being a rating of eight or higher.

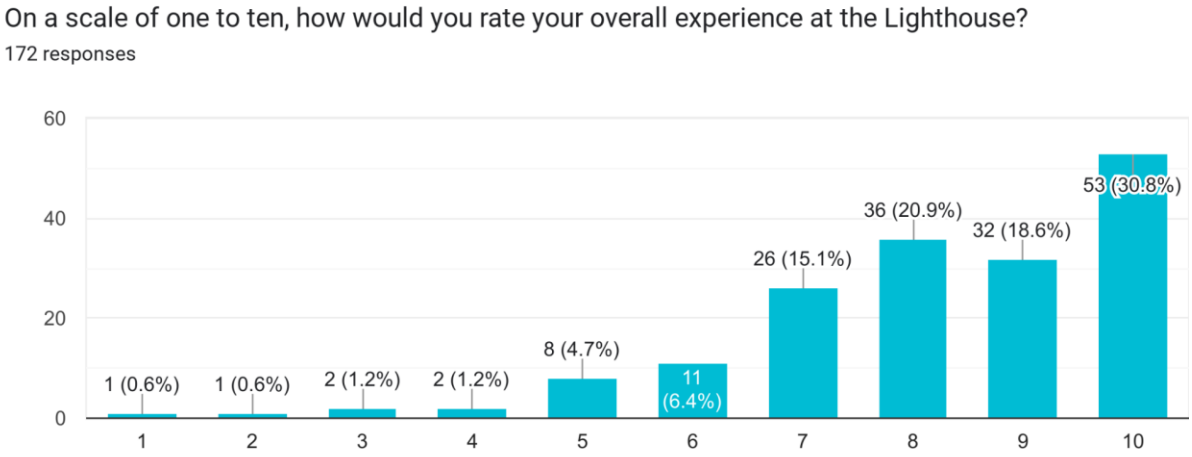

Figure 50: Bar graph of visitors' overall experiences while at the lighthouse from visitor survey

4.5.6 Recommendations from Visitors

At the end of our visitor survey, we gave an option for people to leave additional comments or things they wanted to share about their experience. Only 50 out of the 172 responses contained a response in this section. We coded the responses to see what visitors wanted to mention (Figure 51)

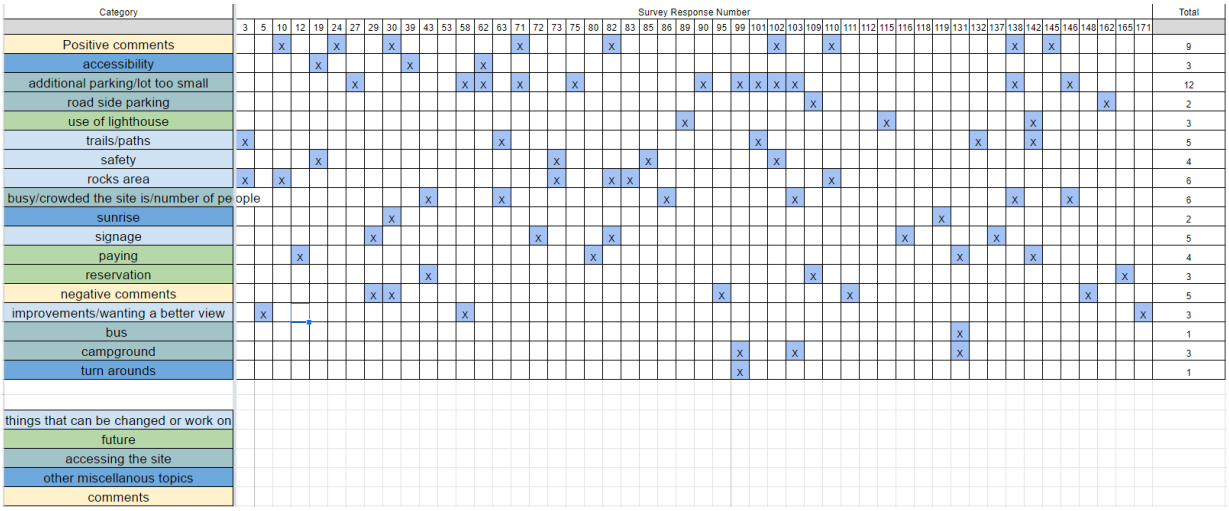

Figure 51: Coding of visitors' comments

After coding the responses, the five major categories that people brought up were positive and negative comments, things that can be changed or worked on, the future of the site, accessing the site, and other miscellaneous topics. As can be seen in Figure 52, 12 of the 50 people who left responses made some sort of comment or reference to the fact that the lot was extremely busy or that the NPS should increase the parking lot size for the lighthouse.

4.6 Residential Surveys

Our team conducted 13 surveys with residents living within the vicinity of the lighthouse. These surveys included residents on Arnold Drive, Lighthouse Road, Harbor Drive, and McKinley Lane. Additionally, our team also conducted a survey with the volunteers who lived in the Keeper's Dwelling during the summer of 2022. These surveys gauged residential use of the lighthouse, impacts of overcrowding on their daily life, and possible recommendations on how to improve the overcrowding at the lighthouse.

4.6.1 Residents Visiting the Lighthouse

This section addresses the residential use of the lighthouse. Out of the 13 residents surveyed, 10 identified that they were permanent residents of Bass Harbor. Six people we talked to expressed visiting the lighthouse 10 times or less per year. Additionally, nine residents said that they do not visit the lighthouse during the summer months because the area is too crowded. When asked, "what time of year do you typically visit the lighthouse," everyone we spoke to identified visiting the lighthouse during the winter or fall. In terms of how residents interact with the site, many identified walking to and from the site. One resident on Harbor Drive said the lighthouse was "nice to walk the dogs to," and another expressed that "[w]e like being close." Similarly, one resident from McKinley Lane touched on the "enjoyment of visiting and knowing we live so close" to the lighthouse.

4.6.2 How Overcrowding Impacts the Residents

Of the 13 residents surveyed, ten of them mentioned that their lives were negatively impacted by the lighthouse's proximity. The two residents that had not experienced any negative effects from the lighthouse were those living on McKinley Lane. This street is further from the lighthouse than any of the other surveyed roads. The other lived on Harbor Drive

which is also further than Arnold Road and Lighthouse Road are from the lighthouse. In turn, this finding supports the notion that living closer to the lighthouse and its crowding has a tangible negative effect on these residents. It is, however, interesting to note anecdotally that, when distributing surveys along McKinley Lane, our group spoke with two different residents who both described that the crowding was particularly bad. They stated that cars would often park along the side of the road and even in some people's driveways on occasion. Regardless, the proximity to the lighthouse undeniably has had an effect on a fair number of the surveyed residents.

After using the survey coding method to categorize the sentiments expressed in these surveys, we found that nine of the residents noticed traffic being particularly worse on or near their street. Two even mentioned that visitors used their driveways to turn around as many as five times a day during peak season. One resident of Harbor Drive mentioned that during past years' peak seasons, "cars park as close to [her] driveway as they can without being in it." These statements, although fewer in number, are especially important to consider due to the importance of maintaining good relations with the residents of the area.

4.6.3 Recommendations from the Residents

While these statements about how the lighthouse affects residents' daily lives are important, it is crucial to also consider their proposed solutions. 10 of the 13 residents were in favor of increasing the number of viable parking spaces, while only two were outwardly opposed to it. Additionally, the idea of implementing a reservation system was supported by nine of the residents and only directly opposed by three of them. This shows that the residents were, in general, in support of taking more action rather than less. Some additional solutions proposed include a shuttle system going to and from the lighthouse and even potentially disabling cars from entering the site, requiring that they take the bus. Other residents supported the further promotion of the Island Explorer as an alternative to increasing parking in light of environmental preservation concerns. Widening Lighthouse Road and adding a shoulder for walking was also an idea proposed. This was suggested in the interest of making Lighthouse Road safer for pedestrians and allowing more room for emergency vehicles to pass through.

5.0 Recommendations

Our team used relevant result quantities such as peak visitation times, average dwell time per group, average group size per vehicle, and carrying capacity to develop several recommendations for the Bass Harbor Head Light Station. The aim of these recommendations is to reduce the congestion of vehicles on the site and facilitate parking while still maintaining the quality of the visitor experience and ecological protection of the landscape. These recommendations include a reservation system, additional parking, and cost-effective options such as traffic control and improved signage.

5.1 Reservation System

In this section, our team presents our recommendations for how to implement a reservation system at the Bass Harbor Head Light Station. Many of our recommendations in this section are based on the Cadillac model referenced earlier in *2.4.3.* More specifically, we discuss reservations per motor vehicle, as well as duration, cost, and availability. Additionally, we explore the possibility of using separate reservation systems for different times of the day, such as sunset.

5.1.1 Reservations by motor vehicle

Our team's first recommendation is to provide reservations per motor vehicle rather than by person. The results from our visitor survey suggest that an overwhelming majority of visitors arrive by motor vehicle. In this sense, the source of congestion on the site is likely due to the number of motor vehicles rather than the number of people biking or walking in. Additionally, many visitors and a few residents we spoke to expressed concern about not being able to walk down to the lighthouse if the park implements a reservation system. We believe only requiring reservations for motor vehicles would help alleviate these concerns.

5.1.2 Timed Entry

As mentioned previously, the reservation system at Cadillac Mountain works on timed entry (National Park Service, 2022g). A timed entry gives visitors a limited window of time to arrive on the site but does not require that they leave until 10 p.m. Additionally, this timed entry varies based on the time of day. During sunrise, visitors have a 90-minute arrival window, whereas, during the day, visitors have a 30-minute arrival window.

Using the Cadillac system as a model, our team also recommends a timed-entry system for the Bass Harbor Head Light Station. While the Cadillac model uses separate systems for sunrise and daytime, we recommend the park look at providing separate reservations during the day and during sunset. As mentioned in section *4.2*, the average dwell time across all days was approximately 28 minutes. This finding seems to support a 30-minute arrival window during the day. As demonstrated in Figure 26, our data indicated a longer dwell time during the hours leading up to and following sunset. While our data suggested that visitors dwell longer, this data is limited in scope, as our team only collected sunset data for two days. While our team suggests providing a longer arrival window during sunset, we also recommend collecting more data points during these hours before determining an appropriate and specific window of time.

5.1.3 Parking and Reservation Availability

Regarding the availability of parking spaces, during the daytime reservation system at Cadillac, the park makes roughly 36% of all parking spots available every 30 minutes. Applying this percentage to the lighthouse parking lot corresponds to roughly 9 available spots every 30 minutes. In addition to the availability of parking spaces, our team recognizes that considerations also need to be in regard to weather. To account for fluctuations in weather, the Cadillac system makes only 30% of reservations available 90 days in advance, opening up the other 70% just 2 days in advance. Given that our team collected dwell time data for a total of 15 days, our discussion of weather was more qualitative in nature. We recommend that future WPI teams and park staff investigate the relationship between dwell time and weather in more detail.

5.1.4 Visitor Receptiveness

Our team also considered how visitors may respond to a future reservation system. As mentioned previously in section *4.5.4*, visitor sentiment seems to be equally divided. In the survey, the percentage of respondents that either agreed or strongly agreed with the future benefit of a reservation system was exactly equal to the percentage of respondents that either disagreed or strongly disagreed (36.7%). Regarding whether visitors will be willing to pay for a reservation, the majority of respondents indicated that they would not be willing to pay. Of the 36.6% that said they might be open and the 19.2% that said they would be willing to pay, no one was willing to pay over $10 dollars. Additionally, an overwhelming majority indicated they would be willing to pay between $1 and $5. The Cadillac system currently charges approximately $6 dollars per reservation. Given the results of our survey, $6 seems to be a reasonable price point for the visitors who are willing to pay for a reservation.

5.1.5 Challenges of Reservation System

Finally, our team will discuss some of the challenges of implementing a reservation system at the lighthouse. The first obstacle is determining where to place the check-in booths on Lighthouse Road. An ideal option would be to place the gates and booths by the intersection of Lighthouse Road and Route 102A. However, this portion of the road is owned by the town rather than the park. Another problem is the narrowness of Lighthouse Road. The road is likely only wide enough to accommodate one booth. This may not seem like an issue given the site's relatively small size. However, only providing one check-in booth may contribute to a long queue of cars on the road. An additional concern is visitors who need to turn around. Again, given the limited width of Lighthouse Road, there really is no room for visitors to turn around if they forget or do not have a reservation. Additionally, our team worries that many visitors may resort to using the driveways along Lighthouse or Arnold Road to turn around, which would be a major disturbance for locals in the area.

5.2 Additional Parking

The results from our data collection clearly demonstrate the demand for more parking at the Bass Harbor Head Light Station. To meet this demand, a solution could be to provide additional parking at the site. We understand that adding additional infrastructure is not ideal for the park, but we wanted to include it as a possibility. Before recommending that the park expand parking, our team determined if the site could accommodate this type of change. In this

section, we discuss a vehicle carrying capacity for the site, a theoretical number of spots we believe the site could accommodate, and a possible location for additional parking.

5.2.1 Vehicle Carrying Capacity

Our team defined vehicle carrying capacity as the maximum number of vehicles a site can accommodate before becoming detrimental to the environment or the visitor experience. To determine a vehicle carrying capacity for the lighthouse, we originally planned to divide the visitor carrying capacity by the average group size per vehicle. This value would tell us how many parking spots the site could accommodate before violating the visitor carrying capacity. However, our team was unable to quantify the visitor carrying capacity. Thus, we cannot determine the vehicle carrying capacity. However, we do know that the vehicle carrying capacity is currently 25 due to the size of the current parking lot.

5.2.2 Number of Additional Parking Spots/No Additional Spots Needed

The number of additional parking spots the lighthouse can accommodate depends on the vehicle carrying capacity. Theoretically, the maximum number of spots in the parking lot should be at or below the vehicle carrying capacity. Since our team could not find a conclusive number for the visitor or vehicle carrying capacities, we cannot determine the exact number of parking spots that can be added at the Bass Harbor Head Light Station

However, the data from our visitor survey can be used to speculate on what the visitor and vehicle carrying capacities might be. As mentioned previously, the results of our survey revealed zero correlation between visitors' perception of crowdedness and their overall experience. While we were not able to quantify the carrying capacity for the site, this finding seems to suggest that from a visitor experience perspective, the carrying capacity was not violated during the times at which visitors filled out these surveys. Following this assumption, our team determined the total number of people on site when each respondent arrived. We did this using both our time stamp cards and dwell time logs. We then selected the response corresponding to the maximum number of people on the site at one time. This corresponded to a response with crowdedness rated at a nine (out of 10) while overall experience was rated an eight (out of ten). During this time, the lighthouse had 104 visitors on the site. With our average group size per vehicle at 2.95, this gives us a theoretical vehicle carrying capacity of 35. This means that our data shows the parking lot at the lighthouse can be increased by approximately ten spots. This increase in parking is also supported by 9 of the 13 residents in the lighthouse area, as well as being mentioned by 12 of 50 of the additional comments at the end of the on-site survey. However, due to our limited time collecting data, as well as our limited data, this number is not conclusive.

5.2.3 How/Where to Add Parking

Additional parking requires using space differently. We have found three different options to expand parking. The first place to add parking spots is within the current parking lot. Another option is to add parking at a nearby quarry off Lighthouse Road. The last location for additional parking is at the Bass Harbor Campground. Each of these locations come with their own benefits and challenges.

The easiest solution is to add parking within the current parking lot. With this option, one possibility is to create two additional spots next to the dumpster at the end of Lighthouse Road. During our on-site data collection, our team noticed many visitors parking in this

location. While these two spots were not marked, this did not cause any major gridlocks or traffic jams. Another option is to open up the reserved spot used for routine maintenance of the bathrooms to visitors, only reserving the spot around the times maintenance comes. This option would be the least costly, however, it only adds a handful of additional spots.

The next location for additional parking is the quarry on the corner of Lighthouse Road and Arnold Road as seen in Figure 52 marked by the red square. This plot of land is already mostly flat. However, there are piles of rocks that would need to be moved before creating a parking lot there. Additionally, the quarry provides space sufficient to accommodate the vehicle carrying capacity of the site. If the park used this location for additional parking, this would likely be the only additional parking the site should need. Also, the quarry is located only three tenths of a mile from the entrance of the lighthouse. This close proximity means visitors would only need to walk 5 minutes to reach the lighthouse.

Figure 52: Map of additional parking locations; Bass Harbor Campground (yellow), quarry (red), Bass Harbor Head Light Station (green), and Lighthouse Road (blue) (Google, n.d.b)

The final location for additional parking is at the Bass Harbor Campground. The campground is located right at the end of Lighthouse Road as seen in Figure 53 marked by the yellow square. This area has limited space to increase parking. This area is served by the Island Explorer bus and is located approximately half a mile from the entrance of the site, equating to a 10-minute walk. Our team believes this location would be the last resort to add parking, especially compared to the previous two, which are likely to be much more cost effective.

Additional parking on its own is not the best solution to this problem. However, additional parking can be supported by a reservation system as well to provide a solid solution that both makes the site accessible to more visitors while also helping to manage crowding at the lighthouse.

5.3 Traffic Control

After a couple of days on site, the team made some observations about the flow of traffic. In the back of the lot is one no parking spot and two accessible spots. From the entrance they are hard to identify, so when the parking lot gets full, cars drive to the back of the lot trying to park in those spots and then realize they cannot. We also noticed that many gridlocks occur in the parking lot due to multiple cars pulling in and out of spaces at once. For a few days, our team decided to see if directing traffic would help, and it did. We were able to direct cars in and out of the lot easily without gridlocks or cars going to spots they cannot park in and having to turn around. This is one solution that could easily be implemented with as few as two employees or volunteers on site. We even had multiple visitors thank us for what we were doing because they had come to the lighthouse before, and it was so much worse when no one was directing traffic.

5.4 Additional Smaller Recommendations

Aside from the main larger recommendations our group proposed, we have considered some less dramatic changes that could still be beneficial to the visitor experience at the lighthouse. These recommendations are made based mainly on general observations, and anecdotal evidence. These are meant to be seen as supplemental toward other larger recommendations.

5.4.1 Accessible Parking Spots

According to the American Disabilities Act (ADA), a parking lot that consists of 25 spots is required to have one handicap spot and one van accessible spot (Mid-Atlantic ADA Center, 2017). The difference between accessible parking spaces and van-accessible spots is that

> Accessible parking spaces are eight (8) feet wide; van-accessible spaces are eleven (11) feet wide. Access aisles for either type of space are five (5) feet wide. These adjacent aisles, which can be shared between two spaces, provide room for individuals to deploy vehicle-mounted wheelchair lifts and/or unload and use mobility devices such as wheelchairs, walkers, etc. An alternate design allows a van-accessible space to be eight (8) feet wide if the adjacent access aisle is also eight (8) feet wide.
> (Mid-Atlantic ADA Center, 2017).

The lighthouse parking lot currently has 25 spots and three of those are handicap spots. Since the site is not very handicap accessible our team noticed that the three handicap spots were not being fully utilized. Instead of having three you could cut it down to one van-accessible spot

and one accessible spot. Although this would only increase the lot by one extra spot it would also guarantee that the parking lot had the correct requirements for the accessible spaces. The number and dimensions of the accessible spots on site are not the only things that could be improved regarding these spots. According to standards,

> Accessible parking spaces must be identified by signs that include the International Symbol of Accessibility. Signs at van-accessible spaces must include the additional phrase "van-accessible". Signs should be mounted so that the lower edge of the sign is at least five (5) feet above the ground. This helps ensure visibility both for motorists and local enforcement officials" (Mid-Atlantic ADA Center, 2017).

Having the spots properly indicated would solve a lot of the confusion we have observed with visitors parking in the accessible spots before they realized that they were. This then causes the vehicles to have to turn around and get back in the line causing more congestion in the lot.

5.4.2 Signage

When collecting dwell time data, we were able to notice some reasons for increased dwell time that did not involve looking at the lighthouse. While our team was collecting data, we witnessed multiple visitors confused on which way to go to see the lighthouse, and some did not know there were two paths. Our team and the volunteers were constantly being asked about where to go and what they would see when they went there. To help address this we recommend installing a sign in the parking lot with a map of the site and showing the two paths visitors can go down. For the path leading to the stairs, the map can also note that the path is not handicap, bicycle, or stroller accessible.

Another signage issue is the operation hours displayed on site. At the beginning of Lighthouse Rd where the park property begins, the sign states the hours of operation are 7 a.m. to dusk but in the parking lot there is a sign that says the hours are 9 a.m. to sunset. We recommend updating these to match the official hours of operation.

5.4.3 Numbering Parking Spots

Similar to the signage issues, there are some improvements that could be made to spot markings that could provide clarity for visitors. One such improvement is placing numbers for each parking space. Our group observed that numbering each of the parking spots has allowed visitors to know which areas are valid parking spots. Many times, we observed visitors driving down to the end of the parking lot thinking that the NPS reserved spot was a valid spot only to find that it was not. However, our group also started using chalk markings to number each parking spot for our own convenience when collecting vehicle dwell times. A latent result of this was that many visitors recognized the numberings and therefore assumed those were all the valid spots and did not always attempt to find invalid parking spots.

Additionally, this could help with the previously mentioned suggestion of traffic control. When our group tested out the method of traffic control, we found that it was much more convenient and clearer to refer to each parking spot by its number. This again allowed for less confusion for visitors in the parking lot and, as a result, an easier time getting cars in and out of parking spots.

5.4.4 Additional Bicycle Racks

Throughout taking the ecological impact photos we did not notice any trail widening; however, we did notice some spots next to the trail leading to the staircase had some spots that

were human made. After further observation, we noticed that bikers were riding down the trail to the rocks, and when they saw the stairs, they would take their bikes off trail and put them to the side as they explored the lighthouse. This behavior was usually caused by the fact that they did not see the bike racks towards the entrance of the lighthouse. A solution to prevent this from continuing to make those human-made patches worse is to put another bike rack next to the trail leading down to the stairs. The park could also put up a sign indicating that no bikes or strollers are allowed down that path since those were the two items most commonly pushed to the side of the trail.

5.4.5 Website Updates

A final suggestion we have is regarding the Bass Harbor Head Light Page for the National Park Service Website. Although the website does set expectations well for visitors, it would be useful to mention a few extra factors that may affect a visitors' decision of when and if they should visit the lighthouse. For one, peak times aside from sunset should be noted. Additionally, the website makes mention of the island explorer not running for 2021. The website should instead be highlighting that the island explorer is now dropping off every hour at the Bass Harbor Campground a half mile away from the lighthouse. With this, it would also be beneficial to provide a map of the most efficient bus routes that lead to the Bass Harbor Head Light. Additionally, this website update may want to include a statement about the accessibility of the site; make it clear that the paved path is steep, and that the rocky area has stairs and jagged rocks making both of them potentially challenging areas for the physically handicapped to traverse.

5.5 Recommendations for Future Teams

Our team was the first IQP team to do work at the Bass Harbor Head Light Station. Although it was an exciting feat to take on, we had no data going into our project. The only data our team had was the data we collected or big data we were given, which means we did not have an extensive amount of data to make concrete conclusions at the end of our project we could only make observations. Our team would recommend that future teams who work on this site continue our data collection methods. By collecting more data similar to ours they would be able to make more concrete conclusions regarding the data since we could not do that as our data was only preliminary. Specifically, we recommend continuing to track how weather affects visitation patterns, develop a method to determine carrying capacity on the site, how tide affects carrying capacity and visitation patterns, and collecting more dwell time data points for days of the week and sunset.

6.0 Conclusion

The goal of our project was to collect a variety of data to help Acadia National Park develop a comprehensive visitor management plan for the Bass Harbor Head Light Station. Given the site's recent addition to the National Park System, our data serves as a baseline for future WPI teams and current NPS staff to track visitor and vehicle use patterns.

During our data collection process, our team used direct observation, photographs, and surveys to quantify these trends. We collected dwell times of vehicles in the parking lot to determine how long visitors spend on the site. Additionally, we recorded the number of people walking or biking onto the site using time stamp cards. To capture the level of crowding on the site, we analyzed photographs from the Bass Harbor Head Trail, the stairs to the rocks, the rocks, and the lighthouse viewing area. Additionally, our team analyzed visitor survey responses to gauge their interaction with the site. We also conducted surveys with residents in the surrounding Bass Harbor community to evaluate how this visitation impacts their daily lives.

After analyzing this data, our team was able to establish several important visitor and vehicle use patterns for the Bass Harbor Head Light Station. Firstly, our team noticed a distinct spike in visitation around the hours of sunset. Additionally, the distribution of dwell times recorded indicate a relatively short length of stay and a relatively quick turnover rate for parking. Additionally, our team observed that more visitors accessed the site via car rather than by bike, foot, or bus. Due to the popularity of motor vehicles and the limited parking on the site, our team also noticed that many cars line up on Lighthouse Road waiting for a spot to open up, generating air pollution from their exhaust and restricting access to the narrow road for pedestrians, cars trying to leave, or emergency vehicles trying to access the site. In regard to carrying capacity, our team was not able to determine a specific quantity for the site; however, the results from our visitor surveys suggest that the carrying capacity is likely not reached with the current size of the lot.

Our team then used these vehicle and visitor use trends to develop a variety of recommendations. The purpose of these recommendations is to facilitate the park in creating a comprehensive visitor management plan for the lighthouse. Recommendations to reduce vehicular congestion included providing traffic control, implementing a reservation system, or expanding parking. Recommendations to improve visitor interaction include providing additional bike racks, updating the lighthouse page on the park website, advertising consistent hours of operation, and adding additional signage for the two paths on the site.

While our data is an important starting point, our team encourages future WPI teams and or park staff to expand the scope of this data collection. We recommend analyzing how varying weather conditions impact visitation patterns. We also recommend developing a method to define the carrying capacity for the site and how this value changes due to the tides. While our team presents some data points for sunset, we also encourage future teams to explore how visitation differs between sunset and the rest of the day.

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Appendix A.1: Survey Questions for Visitors of The Bass Harbor Head Light Station

We are a team of students from Worcester Polytechnic Institute in Massachusetts. We are currently completing a project with the WPI Acadia National Park Project Center. We are conducting this survey to gain insight into how, when, and why visitors of Acadia choose to visit the Bass Harbor Lighthouse. Additionally, we seek to learn how satisfactory your experience at the lighthouse was. Your participation in this survey is voluntary and you may opt-out at any time. If you would like, we would be happy to include your comments as anonymous. If you are interested, a copy of our results can be provided at the conclusion of the study.

(Begin by marking the date and time of the survey)
Questions we ask will include:

1) About what time did you arrive at the Lighthouse
2) How did you find out about the Lighthouse? (Check all that apply)
    a) National Park Service Website
    b) Other Website
    c) Word of mouth
    d) Visitor Center
    e) Information booth
    f) Other_____
3) How did you get to the Lighthouse?
    a) Car
    b) Bike
    c) Island Explorer
    d) Walk
4) How large was your group size at the Lighthouse?
5) Did you walk down the Bass Harbor Head Trail to the rocks?
    a) Yes
    b) No
6) If you answered yes to the above question, on a scale of one to ten, how safe did you feel the Bass Harbor Trail and rocks were?
7) Did you walk down the paved path to the Lighthouse?
    a) Yes
    b) No
8) If you answered yes to the above question, on a scale of one to ten, how safe did you feel the paved path was?
9) On a scale of one to ten, how crowded was the Lighthouse?
    a) | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
10) Do you agree with the following statement? The Bass Harbor Lighthouse site would benefit from implementing a parking reservation system.
    a) | Strongly Agree | Agree | Neutral | Disagree | Strongly Disagree |
11) Would you be willing to pay for a parking spot at the Lighthouse?
    a) Yes
    b) No
12) If yes, how much would you be willing to pay?

a) $1-$5
b) $5-$10
c) $10-$15

13) On a scale of one to ten, how easy was the parking lot to navigate
14) On a scale of one to ten, how would you rate your overall experience at the Lighthouse?
    a) | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
15) You may list any comments or concerns here.

Appendix A.2: Bass Harbor Head Light Station Visitor Survey Responses

This appendix section provides access to the responses from the Bass Harbor Head Light Station visitor surveys. These surveys were administered through Google Forms. In total, our team collected a total of 172 responses. The individual responses are stored in the Google spreadsheet below:

https://docs.google.com/spreadsheets/d/1uq8PsQhGl0XpDj0GNPtOw4Lq88mxq0kCzJehZFcmUjQ/edit?usp=drive_web&ouid=103534588346938512874

Appendix B.1: Survey Questions for Tremont/Bass Harbor Residents

We are a team of students from Worcester Polytechnic Institute in Massachusetts. We are currently completing a project with the WPI Acadia National Park Project Center. We are conducting this survey to gain insight into how, when, and why residents of Tremont/Bass Harbor choose to visit the Bass Harbor Lighthouse. Additionally, we seek to learn how satisfactory your experience living in close proximity to the lighthouse is. Your responses will be used to help us make recommendations to the park to improve the overcrowding issues, visitor experience, and residential impacts of the Bass Harbor Lighthouse site on its surrounding areas. Your participation in this survey is voluntary and you may opt-out at any time. If you would like, we would be happy to include your comments as anonymous.

If you would like to contact us to discuss anything further, please email our alias, gr-bassharborteam22@wpi.edu

Thank you! :)

1. What road do you live on?
2. How long have you been living here?
3. Are you a seasonal or permanent resident here?
4. Annually, how often do you visit the lighthouse?
    a. If you do or have visited the lighthouse, what time of year do you typically visit the lighthouse?
5. How does the proximity of the lighthouse affect your daily life?
6. What changes would you make to improve how the lighthouse operates?
    a. Do you think the site would benefit from a reservation system?
    b. How would you feel if Acadia was to expand parking at the lighthouse?
7. How would you like to see the lighthouse used in the future?
8. Is there anything else relevant to the lighthouse that you would like to mention?

Appendix B.2: Bass Harbor Residential Survey Responses

This appendix section provides access to the responses from the Bass Harbor residential surveys. These surveys were administered through Google Forms. In total, our team collected a total of 13 responses. Residents who filled out these surveys reported living on the following roads: Lighthouse Road, Harbor Drive, Arnold Road, and McKinley Lane. The individual responses are stored in the Google spreadsheet below:

https://docs.google.com/spreadsheets/d/1zkRlwjb7ihu0s4Is9GKc6dpd2Rt3mhBFlQZv5z8Nulw/edit#gid=2094023831

Appendix C.1: Crowding Survey Questions Adapted from Manning Study

We are a team of students from Worcester Polytechnic Institute in Massachusetts. We are currently completing a project with the WPI Acadia National Park Project Center. We are conducting this survey to gain insight into the levels of crowding at the Bass Harbor Lighthouse. Your participation in this survey is voluntary and you may opt-out at any time. TO AVOID ANY BIAS, PLEASE DO NOT RETURN TO A PREVIOUS QUESTION ONCE IT HAS BEEN ANSWERED. Thank you! :)

(*Question Order is Randomized*)

1. On a scale of -4 to 4 how acceptable is the crowding in this photo? (*See Appendix C.1.1*)
    a. -4 | -3 | -2 | -1 | 0 | 1 | 2 | 3 | 4
2. On a scale of -4 to 4 how acceptable is the crowding in this photo? (*See Appendix C.1.2*)
    a. -4 | -3 | -2 | -1 | 0 | 1 | 2 | 3 | 4
3. On a scale of -4 to 4 how acceptable is the crowding in this photo? (*See Appendix C.1.3*)
    a. -4 | -3 | -2 | -1 | 0 | 1 | 2 | 3 | 4
4. On a scale of -4 to 4 how acceptable is the crowding in this photo? (*See Appendix C.1.4*)
    a. -4 | -3 | -2 | -1 | 0 | 1 | 2 | 3 | 4
5. On a scale of -4 to 4 how acceptable is the crowding in this photo? (*See Appendix C.1.5*)
    a. -4 | -3 | -2 | -1 | 0 | 1 | 2 | 3 | 4
6. On a scale of -4 to 4 how acceptable is the crowding in this photo? (*See Appendix C.1.6*)
    a. -4 | -3 | -2 | -1 | 0 | 1 | 2 | 3 | 4
7. On a scale of -4 to 4 how acceptable is the crowding in this photo? (*See Appendix C.1.7*)
    a. -4 | -3 | -2 | -1 | 0 | 1 | 2 | 3 | 4
8. On a scale of -4 to 4 how acceptable is the crowding in this photo? (*See Appendix C.1.8*)
    a. -4 | -3 | -2 | -1 | 0 | 1 | 2 | 3 | 4
9. On a scale of -4 to 4 how acceptable is the crowding in this photo? (*See Appendix C.1.9*)
    a. -4 | -3 | -2 | -1 | 0 | 1 | 2 | 3 | 4
10. On a scale of -4 to 4 how acceptable is the crowding in this photo? (*See Appendix C.1.10*)
    a. -4 | -3 | -2 | -1 | 0 | 1 | 2 | 3 | 4
11. On a scale of -4 to 4 how acceptable is the crowding in this photo? (*See Appendix C.1.11*)
    a. -4 | -3 | -2 | -1 | 0 | 1 | 2 | 3 | 4
12. On a scale of -4 to 4 how acceptable is the crowding in this photo? (*See Appendix C.1.12*)
    a. -4 | -3 | -2 | -1 | 0 | 1 | 2 | 3 | 4

Appendix C.1.1: Survey Photograph (Lighthouse with 2 People)

The following photograph was used in our survey administered at the visitor center.

Appendix C.1.2: Survey Photograph (Lighthouse with 5 People)

The following photograph was used in our survey administered at the visitor center.

Appendix C.1.3: Survey Photograph (Lighthouse with 10 People)

The following photograph was used in our survey administered at the visitor center.

Appendix C.1.4: Survey Photograph (Lighthouse with 13 People)

The following photograph was used in our survey administered at the visitor center.

Appendix C.1.5: Survey Photograph (Lighthouse with 18 People)

The following photograph was used in our survey administered at the visitor center.

Appendix C.1.6: Survey Photograph (Lighthouse with 22 People)

The following photograph was used in our survey administered at the visitor center.

Appendix C.1.7: Survey Photograph (Rocks with 5 People)

The following photograph was used in our survey administered at the visitor center.

Appendix C.1.8: Survey Photograph (Rocks with 12 People)

The following photograph was used in our survey administered at the visitor center.

Appendix C.1.9: Survey Photograph (Rocks with 18 People)

The following photograph was used in our survey administered at the visitor center.

Appendix C.1.10: Survey Photograph (Rocks with 27 People)

The following photograph was used in our survey administered at the visitor center.

Appendix C.1.11: Survey Photograph (Rocks with 33 People)

The following photograph was used in our survey administered at the visitor center.

Appendix C.1.12: Survey Photograph (Rocks with 47 People)

The following photograph was used in our survey administered at the visitor center.

Appendix C.2: Crowding Survey Responses

This appendix section provides access to the responses from the crowding surveys. These surveys were administered through Google Forms at the visitor center in Bar Harbor. In total, our team collected a total of 98 responses. The individual responses are stored in the Google spreadsheet below:

https://docs.google.com/spreadsheets/d/1CFHULwS3J5G7mUDzO2UM9kahZ09k4PKoiQ0w75Z4fWU/edit#gid=792348098

Appendix D: PAOT Photographs

As part of our methodology, our team placed seven trail cameras at different locations at the Bass Harbor Head Light Station to record photographs every 15 minutes. These cameras were placed at the following locations: the lighthouse viewing area, the Bass Harbor Head Trail, the stairs to the rocks, the rocks, and the entrance of Lighthouse Road. To capture the rocks viewing area, our team used a total of two cameras. Wet then used the photographs from these cameras to obtain PAOT and car counts. These photographs were stored in Google Drive under folders for each location. Additionally, the photographs for each location are further divided based on date. The link below provides access to all the photographs obtained during our data collection process:

https://drive.google.com/drive/folders/1Czy3FfVDPqU1J5f49EYn9Xtn8Qjfa8Fj

Appendix E: PAOT Counts

As part of our methodology, our team placed seven trail cameras at different locations on the Bass Harbor Head Light Station site to record photographs every 15 minutes. These cameras were placed at the following locations: the lighthouse viewing area, the Bass Harbor Head Trail, the stairs to the rocks, the rocks, and the entrance of Lighthouse Roads. To capture the rocks viewing area, our team used a total of two cameras. We used the photographs from these cameras to obtain PAOT and car counts. These counts were logged in the Google spreadsheet below:

https://docs.google.com/spreadsheets/d/1NyeQi9UGXzqb8jYqQOGTaf2Ef5FiBnT5fGpGc8fipiw/edit?usp=drive_web&ouid=103534588346938512874

Appendix F: Lighthouse Road Car Counter Data

This appendix section provides access to the car counter data on Lighthouse Road. Our team received this information from Friends of Acadia. The car counts are stored in Google spreadsheets according to the year and directionality. Our team received data from 2018, 2019, 2020, and 2021. In terms of directionality, southbound refers to vehicles traveling inbound towards the site, and northbound refers to vehicles traveling outbound away from the site. These counts can be accessed using the link below:

https://drive.google.com/drive/folders/1LIQEMDCKv8svlB8r36QSNx362FHFy9Ea

Appendix G: Dwell Time Datasheets

As part of our methodology, our team recorded the dwell times of vehicles in the parking lot. During our data collection process, we assigned each parking spot a number between 1 and 25. We then marked the arrival and departure times of vehicles based on the number of the spot they parked in. The diagram below shows the numbering system our team used:

(Google, n.d.c)

In the diagram above, spots 14, 24, and 25 are handicap accessible parking spots. During our data collection process, our team logged dwell times in Google spreadsheets. The spreadsheet below represents the dwell time data collected by parking spot number: https://docs.google.com/spreadsheets/d/1BgWNsnpo9MoCiZdUO3TWAoXNDuMmVlUpAFrHUG2UIp0/edit?usp=drive_web&ouid=103534588346938512874

After collecting these dwell times, our team also organized this data by date rather than parking spot number. The link below provides access to a Google spreadsheet of the dwell times broken down by date of data collection: https://docs.google.com/spreadsheets/d/17EI5A8c9ekRdA5YCZE96T9ObEVjfM6CAPaioBbx0O8M/edit

Appendix H: Cars in Queue Data Sheet

During our data collection process, our team observed queues of cars on Lighthouse Road when the parking lot filled to capacity. As part of our data collection process, we recorded the number of cars in this lineup roughly every 15 minutes. This data was logged on the Google spreadsheet linked below:

https://docs.google.com/spreadsheets/d/1d0w3Xk37lddfTf9SP4Z7f5xfgu40MDksfoHEwU39Hv0/edit#gid=0

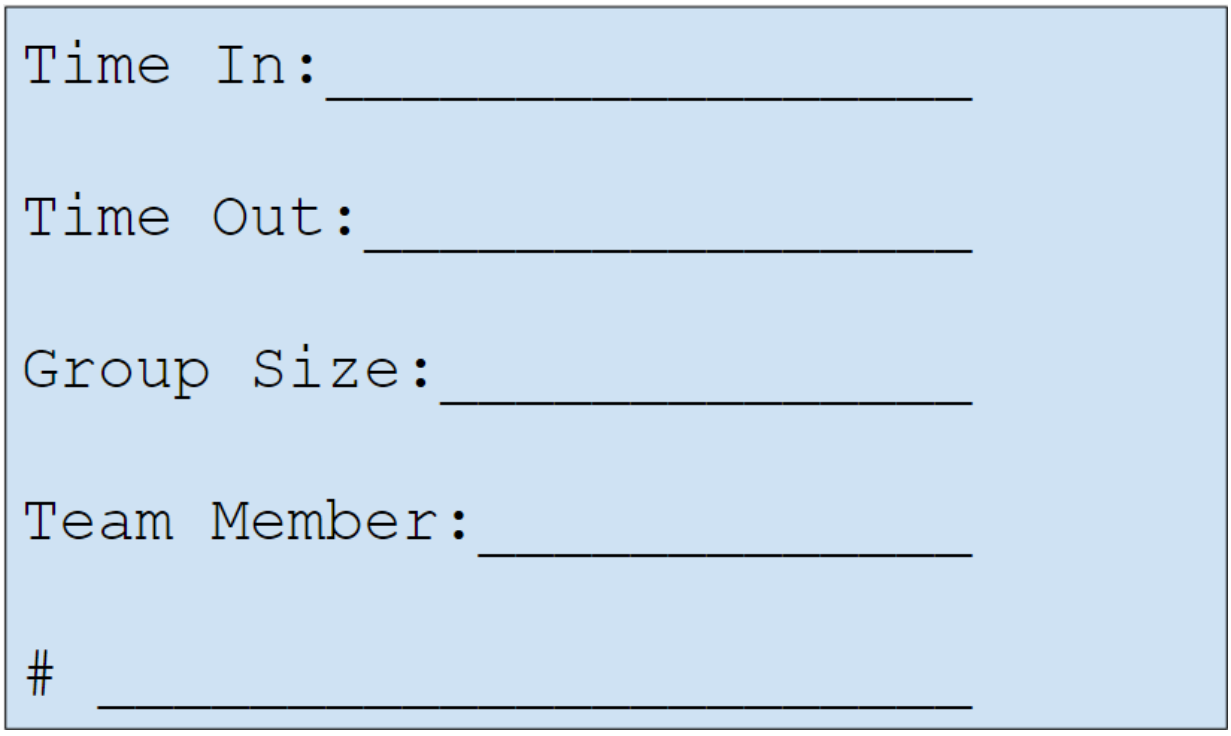
Appendix I: Turnarounds Data Sheet

During our data collection process, our team observed a high frequency of vehicles pulling into the lot to turn-around, particularly at busy times. As part of our data collection process, we recorded the times we observed these turnarounds. This data was logged on the Google spreadsheet linked below:

https://docs.google.com/spreadsheets/d/1gQ_vOXmgfVgV3s1hW-urQTFHz8ywfgsZJHiOaoNoEBU/edit#gid=0

Appendix J: Time-Stamp Card

We handed out "time-stamp" cards to visitors walking or biking to the site with the time they arrived written on the "Time In" line, and the visitor's group size on the corresponding line. The team member handing out the card initialed it on the "Team Member" line and marked down the number of cards they had handed out on the "#" line to keep track of the card return rate. When the visitor returned the card as they left the site, their departure time was marked on the "Time Out" line.



Appendix K: Ecological Impact Photos

During our data collection process, our team took photos of the Bass Harbor Head Light Trail every week for four weeks. The purpose of these photos was to document if there was any alarming damage done to the trail while our team was on site. These photos were filed by week in the Google drive below:

https://drive.google.com/drive/folders/1lv224da4UCIf-7xYRYJ7Kb42nhjcLs7N?usp=sharing