Preparing for the Implementation of a Vehicle Reservation System in Acadia National Park

An Interactive Qualifying Project
submitted to the Faculty of
WORCESTER POLYTECHNIC INSTITUTE
in partial fulfilment of the requirements for the
degree of Bachelor of Science

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Report Submitted to: Professors Frederick Bianchi and Derren Rosbach

Abstract

Due to vehicle congestion becoming an issue in recent years, Acadia National Park is implementing a vehicle reservation system. To properly implement the system, the park required additional data on vehicle behavior in the Ocean Drive corridor. Our project entailed gathering the necessary data by utilizing trail cameras to observe vehicle parking patterns in the parking lot along Ocean Drive. By analyzing these images, we were able to accurately determine the average length of stay in the individual parking lots as well as the average length of stay in the Ocean Drive corridor. With this data, in addition to refinements to the policies of the reservation system which we developed, Acadia National Park should be better equipped to successfully implement their parking reservation system.

Acknowledgements

We would like to thank Professors Bianchi and Rosbach for their wonderful assistance and guidance throughout the project. We would also like to thank John Kelly and Adam Gibson for providing us information and for acting as our liaisons to Acadia National Park. We also wish to thank Acadia National Park for providing us the opportunity to work on such an important project. We appreciate how flexible everyone was with the COVID-19 pandemic creating many obstacles for the project.

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Executive Summary

Overcrowding has been an increasingly dire issue for national parks during the past decade. Being the most densely visited national park, Acadia National Park in particular has been severely afflicted. Stemming from this, the most popular areas of the park (e.g. Cadillac Mountain, Jordan Pond House, Ocean Drive) have suffered from congestion in their parking lots. To resolve the issue, Acadia National Park is implementing a vehicle reservation system in Cadillac Mountain and Ocean Drive.

Our project is intended to provide additional data on parking behavior in the Ocean Drive area in anticipation of the reservation system's implementation. It also serves as a proof of concept for using trail cameras to collect data on parking behavior throughout Acadia National Park. By using the data collected during our project, the park can optimize the reservation system. Our objectives for the project are to:

1. Compare Acadia's proposed vehicle reservation system to systems at other national parks and provide recommendations on how it can be improved or expanded upon.
2. Gather data on and analyze the parking behavior of vehicles along Ocean Drive.
3. Provide proposals and recommendations on how an expansion of our observation methods can be used to evaluate the effectiveness of the vehicle reservation system as well as expand it to other areas of the park.

We placed trail cameras in six parking lots along Ocean Drive, as well as one at the entrance and exit of the strip of road. We used photos taken at one-minute time intervals in the parking lots to determine how long individual vehicles were staying parked at each lot. We used

motion triggered photos at the entrance and exit of the Ocean Drive Corridor to determine how long vehicles were staying in the area. We also attempted to track vehicles between the parking lots using these cameras, but due to the COVID-19 pandemic we did not have enough coverage with the cameras and were unsuccessful.

We collected our data into various spreadsheets and calculated average lengths of stay for vehicles in each parking lot. We also did this for Ocean Drive as a whole and for Ocean Drive during four different time periods throughout the day. We then created charts showing the distribution of these lengths of stays in thirty-minute intervals.

Finally, we developed recommendations for how to adjust the policies of the vehicle reservation system to account for the findings of our research. We also developed recommendations on how to improve our observation and tracking methods, as well as how these methods can be utilized in the future.

1. Introduction

The US National Park System has been dealing with a significant increase in visitors over the past decade. This increase in visitors has led to overcrowding in parks across the county, leading to mass erosion of infrastructure, damage to protected environments, and negative effects on visitor experience. It is projected that overcrowding will only worsen in the coming years, so parks are racing to discover the best methods of managing the situation (Bergstrom, J. C., Stowers, M., & Shonkwiler, J. S., 2020). This has been particularly problematic in Acadia National Park, which is one of the most visited parks in the nation despite its relatively small size. Popular areas of the park, such as Cadillac Mountain, Ocean Drive, and Jordan Pond House, suffer from heavy congestion during peak months.

Acadia National Park, initially founded in 1901 and officiated as a national park in 1916, was established to protect parts of Mount Desert Island in order to preserve it for future generations (History of Acadia, 2017). The park preserves about half of Mount Desert Island, many adjacent smaller islands, and part of the Schoodic Peninsula on the coast of Maine. Acadia National Park works closely with the Schoodic Institute, a non-profit organization centered around the preservation of Acadia's natural resources. Through private philanthropy, Schoodic Institute leverages NPS investment to create a greater impact for science, education, and conservation. Efforts are complementary to and coordinated with Friends of Acadia (Partnership with Acadia National Park, 2020). To assist in managing the overcrowding situation, both Acadia National Park and the Schoodic Institute have reached out to outside parties.

Previous IQP groups from Worcester Polytechnic Institute have worked with Acadia National Park to aid in determining how to deal with overcrowding. A 2017 IQP group studied possible methods of limiting vehicle traffic in the park and recommended setting up a reservation system and a two-way gate system to deal with the traffic (Cosmopulos, E., Gaulin, J., Jauris, H., Morrisseau, M., & Quevillon, E., 2017). Later, a 2018 IQP group developed a multi-step phase-in plan for a parking reservation system for highly congested areas at both Acadia National Park and Glacier National Park (Callahan, E., Hand, A., & Oates, D., 2018). The National Park Service signed off on a Final Transportation Plan in 2019 to manage overcrowding in Acadia National Park (Transportation Plan, 2019). The plan primarily entails the reconstruction of several parking lots as well as the introduction of a parking reservation system for the most congested areas of the park.

Our project goal is to assist Acadia National Park with the implementation and testing of the proposed parking reservation system. To achieve this goal we will: Review the proposed reservation system, and benchmark its efficacy against other reservation systems in place at other parks; gather data on and analyze the parking behavior of vehicles along Ocean Drive; to provide proposals and recommendations on how an expansion of our observation methods can be used to evaluate the effectiveness of the vehicle reservation system as well as expand it to other areas of the park. If all of these objectives are completed, the proposed reservation will be better prepared for its initial implementation in October 2020. The better the system performs, the better Acadia National Park will be able to manage overcrowding.

2. Background

2.1 The National Park Service

Conservation efforts by the United States of America began in earnest with the Act of March 1, 1872, when Congress established Yellowstone National Park. Yellowstone and subsequent national parks and monuments were administered by the Department of the Interior, with no specific agency in control. On August 25, 1916, President Woodrow Wilson signed the Organic Treaty, which established the National Park Service (NPS) as a federal bureau under the Department of the Interior that took over responsibility for the national parks and monuments under the Department's jurisdiction. A huge step towards truly making a national system of parks came with an Executive Order in 1933 from President Franklin D. Roosevelt that transferred control of 56 national parks and monuments from the Forest Service and the War Department to the NPS.

The NPS currently handles over 84 million acres spread across over 400 distinct areas throughout the United States and its territories. New additions to the NPS tend to now be through acts of Congress, and in fact, the creation of national parks can only be done in this manner. However, the Antiquities Act of 1906 granted the President the authority to proclaim new national monuments on land currently under federal jurisdiction. Congress usually asks the Secretary of the Interior for recommendations on possible additions to the NPS, and the Secretary is advised by the NPS Advisory Board. The NPS Advisory Board is composed of private citizens, and it also provides counsel on policies for managing the NPS (Quick History of the National Park Service, 2018).

2.2 Acadia National Park

2.2.1 History of Acadia National Park

What is now known as Acadia National Park was initially purchased by Hancock County Trustees of Public Reservations, founded by George B. Dorr in 1901 as a way to preserve the land so that the public may appreciate it for years to come. In 1916 the land was transferred to the federal government and officiated as Sieur de Monts National Monument by President Woodrow Wilson. As George Door continued to obtain land for the park, he was established as the first superintendent of the newly named Lafayette National Park in 1919. The name was changed once again to Acadia National Park in 1929, and now protects over 47,000 acres of land for the public to visit (History of Acadia, 2017). Popular destinations at the park, and therefore the areas most affected by congestion, include Cadillac Mountain, Jordan Pond House, and Ocean Drive.

2.2.2 Cadillac Mountain

Cadillac Mountain is the tallest mountain along the east coast of the United States at a height of 1,530 feet, and the first place in the country to view the sunrise due to its location and elevation. It was renamed in 1918 after the French explorer Antoine Laumet de La Mothe Sieur de Cadillac, who owned the land for some time during the French colonization of the area, where it had previously been known as Green Mountain. From 1883 to 1890, the mountain hosted a railroad that led to the top of the mountain. (Hartford, G. A., 2001. Cadillac Mountain)

Figure 2.1 Sunrise at the summit of Cadillac Mountain

2.2.3 Jordan Pond House

Jordan Pond House is a restaurant in Acadia National Park that overlooks Jordan Pond. Originally a farmhouse built by the same Jordan family the pond was named after, the house was transformed into a restaurant in the late 19th century due to the popularity of Jordan Pond for summer vacationers. The restaurant was later bought by John D. Rockefeller Jr, who donated it to the NPS in 1940. The original building was consumed by a fire in 1979, but was rebuilt and reopened by 1982, and has remained one of the most popular places to visit in Acadia National Park. (Park History, n.d.)

Figure 2.2 Jordan Pond House (Jordan Pond House Restaurant, December 18, 2019)

2.2.4 Ocean Drive

Ocean Drive is the road that runs alongside the Ocean Path, from Sand Beach to Otter Point. Sand Beach, at the start of Ocean Drive, is a small beach with sand composed of small bits of seashells. Further down the road is Thunder Hole, named for the sound the waves make as they crash into the inlet, reaching up to 40 feet in the air. Even further down the road is Otter Cliff, one of the highest Atlantic cliffs. Just off the shore is The Spindle, the location where Samuel de Champlain’s ship crashed in 1604, the area eventually becoming known as “New

France”. (Hartford, G. A., 2001. Otter Cliff in Acadia, Sand Beach in Acadia, Thunder Hole in Acadia)

2.3 Liaisons and Sponsors

2.3.1 Abraham Miller-Rushing

Since July 2010 Dr. Miller-Rushing has been working as a Science Coordinator for the National Park Service at Acadia National Park in partnership with the Schoodic Institute. Mainly, he coordinates and facilitates science projects going on in and around Acadia National Park. He is also helping to build a research and citizen science program in partnership with the Schoodic Institute. He runs 1 of the 18 research learning centers in national parks across the country. (Miller-Rushing, 2020)

2.3.2 Adam Gibson

Adam Gibson is an environmental sociologist with extensive experience in socio-ecological research. His research focuses on social carrying capacity in parks and protected areas, behavior change strategies, public perceptions of climate change, place attachment, ecosystem service assessment and valuation, and recreation user conflicts. For the National Park Service, Adam Gibson is responsible for developing an applied social science research program including research associated with visitor experiences, visitor satisfaction, visitor perspectives, and socioeconomic monitoring. He conducts interdisciplinary, cross-divisional projects to apply scientific information to planning and management in order to improve decision-making and understanding of visitor experiences. (Gibson, 2020)

2.3.3 Schoodic Institute

Schoodic Institute is a nonprofit environmental organization that works on solving environmental issues in collaboration with Acadia National Park. Their mission is to "[pursue] collaborative solutions to critical environmental challenges through discovery and learning.". They do this by providing funding to the park for research, professional development and training, and citizen science; helping the NPS achieve its own goal of protecting and preserving the park for future generations. (About Schoodic Institute, 2020) (Partnership with Acadia National Park, 2020)

2.3.4 Friends of Acadia

Friends of Acadia is a private nonprofit organization established to help preserve Acadia National Park. The organization accomplishes this through channeling private donations to conservation and preservation projects in the park, sponsoring volunteer groups in Acadia and the surrounding region, and monitoring legislation and planning activities for the park (Our Partners, 2020). In recent years, Friends of Acadia has put more emphasis on dealing with the ever-growing issue of overcrowding in the park.

2.4 Overcrowding

National parks continue to be a popular destination for tourism. In 2019 alone, over 327 million people visited national parks in the United States, compared to only 293 million in 2014 (Visitation Numbers, 2020). While more people enjoy scenic views and fresh air, commodities not available in our ever-urbanizing society, the carrying capacity of national parks has largely stayed the same. When national parks are founded, they are not designed to accommodate the volume of visitors they experience today. Unfortunately, an increase in visitation in recent years has led to some significant issues. Overcrowding at national parks is such a significant issue because it not only does overcrowding pose a risk to the environment, as the increased visitor traffic resulting in accelerated erosion and breakdown of infrastructure; it negatively affects the visitor experience. Maintaining and repairing infrastructure, as well as assuring that the parks' ecosystems are not affected has become an expensive endeavor for all national parks.

2.4.1 Overcrowding in Acadia National Park

Acadia National Park, one of the most popular national parks in the New England area, offers opportunities for locals and tourists to enjoy many attractions, such as hiking, cycling, observing wildlife, and unparalleled views. In the past ten years, visitation has steadily increased for Acadia National Park, with around 2.08 million visitors in 2008, but 3.54 million visitors in 2018, a 74% increase in only a decade. As a result, overcrowding has become a significant problem for the park. Unfortunately, the park cannot accommodate the increased number of vehicles in its parking lots and on its park roads, especially during peak visitor hours. Simply put, there is not enough space for the number of vehicles in the park because the parking lots were not designed to handle the capacities they are currently forced to endure. Consequently, visitors to Acadia National Park often spend too much time searching for parking spaces, or they do not find a spot at all. While roadside parking is available at some locations, such as along Ocean Drive on Park Loop Road, some roads become too narrow, leading to a risk of traffic accidents (Traffic Safety on Acadia National Park Roadways, 2019). Additionally, the increase in vehicular traffic has led to an increase in roadkill, impacting the ecosystem of Acadia National Park.

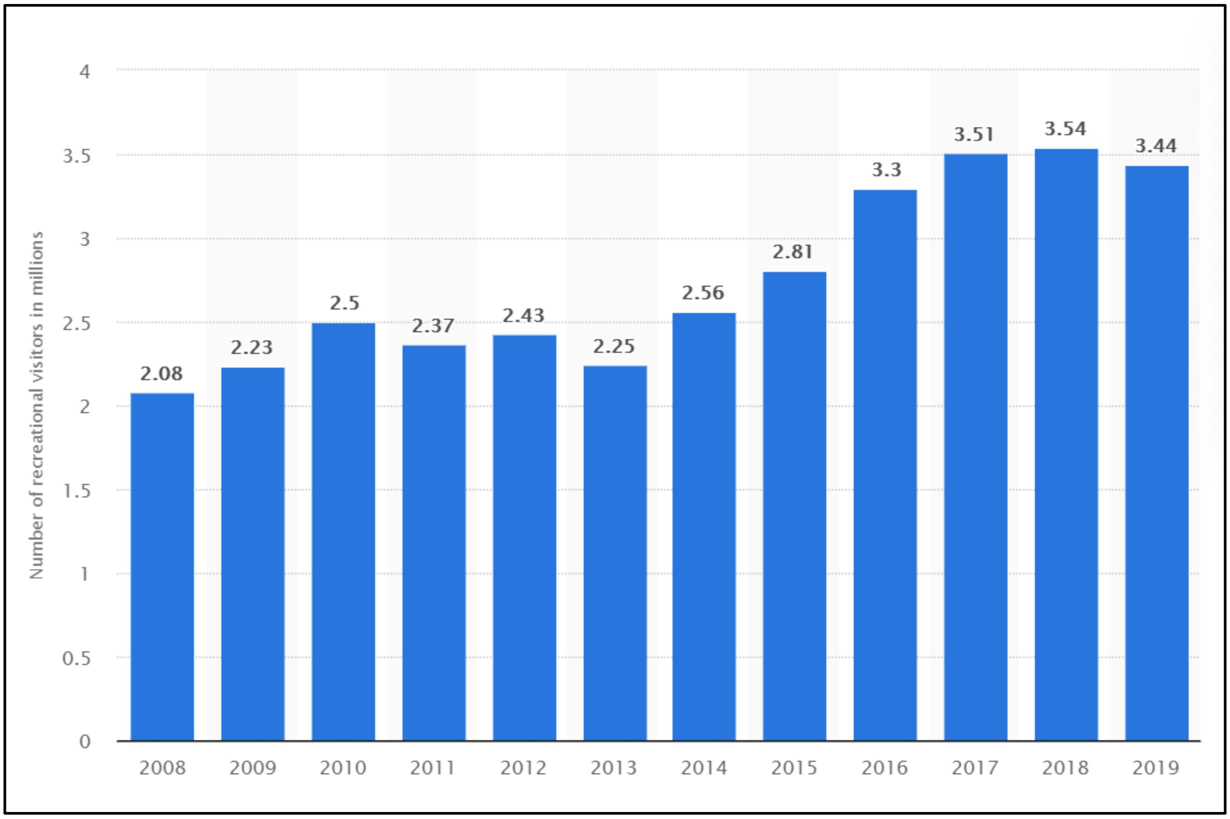


Figure 2.3: Number of Recreational Visitors to Acadia National Park from 2008 to 2019 (in millions)

2.4.2 Results of Overcrowding

Overcrowding negatively affects both economics and the environment. As the number of tourists increases, vandalism and littering incidents increase. Some travelers would like to carve their name or paint graffiti on the plant or historic structure, which is extremely difficult and high cost to remove and repair, and sometimes it cannot be restored to its former condition. Littering is especially dangerous to the ecosystem. Also, overcrowding not only leads to damage to the national parks but an increase in dangerous conditions. It is more likely that visitors will head onto less-maintained paths and areas to avoid highly crowded areas and may encounter unsafe terrain or dangerous fauna and flora. Some of these areas may be under-explored, meaning visitors can easily get lost due to lack of a map and loss of cell signal, which also hampers potential rescue efforts.

2.5 Reservation Systems

2.5.1 Reservation Systems in National Parks

The idea of implementing reservation systems at national parks, or any park, has been in place for many years due to overcrowding increasing in parks. Prior to Acadia National Park, many national parks have implemented some form of a reservation system. Haleakalā National Park on Hawaii’s Maui island, Rocky Mountain National Park in Colorado, and Great Smoky Mountains National park in Tennessee have all recently implemented their own. In general, to purchase a reservation in any system, one usually calls a number or visits a website in advance. For some locations, reservations need to be made one year in advance.

2.5.2 Reservation System at Haleakalā National Park

Since February 1, 2017, visitors at Haleakalā National Park who wish to view the sunrise at Haleakalā Summit must obtain a reservation in advance. The reservation is made at recreation.gov, and they are available online up to sixty days in advance, while a small number of last-minute tickets are released online two days beforehand. Additionally, a visitor may only purchase one sunrise reservation per three-day period. (Park Successfully Implements Sunrise Reservation System, 2017)

Figure 2.4. Visitors gather to view the sunrise at a summit of Haleakalā National Park

2.5.2.1 Reservation and Entrance Fees at Haleakalā National Park

A park entrance fee is required along with a reservation to enter the park for sunrise viewing. An entrance fee ranges from $15 to $45 depending on vehicle or group while a reservation only costs $1.00 per vehicle (Fees and Passes, 2020). An entrance fee, purchased at the entrance to the park, is good for three days, starting on the date of first entry, while a sunrise reservation is only valid from 3:00 AM to 7:00 AM on the date specified on the reservation. The online inventory of reservations renews at 7:00 AM every day but often sells out within fifteen minutes. (Haleakalā Sunrise Reservations, 2019)

2.5.3 Reservation System at Rocky Mountain National Park

Rocky Mountain National Park, reservations can be made for campgrounds and wilderness camping. While no reservations are required to enter the park, staying overnight in the park in a campground or wilderness requires a permit in advance. Like Haleakalā, a reservation can be made at recreation.gov. This specific reservation system started recently; Wilderness Campsite Reservation Requests started March 1, 2020. Reservations for a campsite are available six months in advance and range from $30 in the summer to $20 in the winter at some sites. (Permits and Reservation, 2017).

Figure 2.5. Congestion at Rocky Mountain National Park

2.5.4 Acadia National Park Reservation System

Acadia National Park began working on a solution to visitor congestion in 2016. During these preliminary stages of looking for a solution, Acadia National Park consulted students from Worcester Polytechnic Institute who were working on their Interdisciplinary Qualifying Project (IQP) at Acadia National Park. A 2017 IQP group began with studying possible methods of limiting vehicle traffic in the park and would recommend setting up a reservation system and a two-way gate system to deal with the traffic (Cosmopulos, E., Gaulin, J., Jauris, H., Morrisseau, M., & Quevillon, E., 2017). A 2018 IQP group analyzed the possibility of increasing accuracy regarding vehicle parking information in the park through the use of a phone tracking application, in order to properly track vehicles in Acadia National Park (Nadeau, G. T., Charbonneau, J. L., Caltabiano, J. P., & Fischler, M. A., 2018). Another 2018 IQP group conducted further work on a GPS tracking application, as well as gathered additional data on visitation to Cadillac Mountain and Jordan Pond House. They would develop a multi-step phase-in plan for a parking reservation system for highly congested areas at Acadia National Park and Glacier National Park (Callahan, E., Hand, A., & Oates, D., 2018).

To reduce overcrowding, Acadia National Park considered four options to address visitor congestion:

Option A, "No Action"	The park will continue as per usual.
Option B	The park would address the congestion issues by establishing a parking reservation system at five of the attractions in the park; Cadillac Mountain, Sand Beach, Thunder Hole, Jordan Pond House, and Sieur de Monts.
Option C	The park would take Option B one step further by establishing a timed entry vehicle reservation system during the busiest times of the year for Ocean Drive Corridor, Cadillac Summit Road, and the Jordan Pond House North Lot; with plans to add additional Island Explorer routes, additional parking lots, and reconstructing the parking situation along Park Loop Road if necessary.
Option D	The park would focus on managing only Park Loop Road by managing the number of vehicles through a set of exit-only and entry gates, as well as a timed entry system to the road during the busiest months.

Ultimately, Acadia National Park and the National Park Service signed off on a Final Transportation Plan in 2019 to manage visitor congestion in the park (Transportation Plan, 2019). The plan roughly follows Option C; The plan primarily entails the introduction of a vehicle reservation system for the most congested areas of the park, namely Cadillac Mountain Summit Road, Ocean Drive corridor and Jordan Pond House parking lot. The reconstruction of several parking lots is planned for later in the future after the parking reservation system is fully implemented.

2.6 Remote Cameras

A remote camera is a camera that is either remotely operated or automatically takes photographs or videos. They are commonly used in areas where the photographer cannot be physically, or just to gather photos from additional angles. They are popular in sports and wildlife photography due to being capable of remote function. They can be triggered to take photos or videos through various means, including a self-timer or a motion sensor.

Camera traps, also known as game or trail cameras, are a subset of remote cameras commonly used by hunters and wildlife surveyors. They are designed to function for longer periods of time outdoors and are thus more durable and weatherproof than other remote cameras. They always possess either motion detectors or infrared sensors that act as triggers to take photos of or begin filming wildlife.

Figure 2.6 Wildlife camera mounted on tree

3. Methodology

To address the significant increase in visitation in recent years, Acadia National Park prepared a plan to handle the current situation and plans on starting the implementation of parts of this plan in October 2020 (*Acadia National Park Final Transportation Plan / Environmental Impact Statement*, 2019). The park will be running a pilot of the reservation system at Cadillac Mountain and Ocean Drive in October 2020 for two weeks and will be fully implemented for these areas in 2021. The park hopes that the system can be expanded to other congested areas, primarily the Jordan Pond House area. Our project goal was to provide information for, and evaluation of, Acadia National Park's proposed vehicle reservation system. Our primary objectives in this project were as follows:

1. To compare Acadia's proposed vehicle reservation system to systems at other national parks and provide recommendations on how it can be improved or expanded upon.
2. Gather data on and analyze the parking behavior of vehicles along Ocean Drive.
3. To provide proposals and recommendations on how an expansion of our observation methods can be used to evaluate the effectiveness of the vehicle reservation system as well as expand it to other areas of the park.

3.1 Reviewing the Reservation System Proposal

Acadia National Park's reservation system is being built on recreation.gov, which is where other parks including Haleakala, Rocky Mountains, Yosemite, and Great Smoky Mountains have their systems. All of these were developed by Booz Allen Hamilton, a management and information technology consulting firm. Acadia National Park desired additional input on their proposed vehicle reservation system, so our first objective was to review the proposal and identify conditions that have not yet been considered. We accomplished this by benchmarking the proposal against similar systems at other national parks.

3.1.1 Benchmarking

Through researching other national and state parks with parking reservation systems, we identified some aspects we consider important to address in the proposed system at Acadia National Park. This data was compiled into a spreadsheet that allowed us to compare the proposed reservation system to the other systems parks have implemented, providing us insight on what considerations the proposed system should account for. Other parks whose systems we researched included Haleakala National Park, Muir Woods National Monument, Great Smoky Mountains National Park, Yosemite National Park, Bruce Peninsula National Park, Ha'ena State Park, Baxter State Park, and Rocky Mountain National Park. All of these parks had suffered from over-congested parking lots and implemented vehicle reservation systems to address the issue. Aspects of these systems that we looked at include:

- When are reservations made (how far in advance reservations can be made)
- How are reservations made
- Reservation period (how long the reservation lasts)
- Reservation Cost
- Verification (how does the park verify reservations)
- When/where is the reservation valid
- Weather (can someone get a refund for bad weather)
- What happens when a vehicle has no reservation
- Cancellation Fee

- Company behind the reservation system
- Restrictions on vehicles
- Parking options (are there different options for different types of vehicles)
- Who is required to make the reservation
- Parking and Entry available at the same time
- Is roadside parking available

3.2 Gathering Data on Parking and Factors for Length of Stay

Overcrowding at parking lots at Cadillac Mountain, Ocean Drive, and the Jordan Pond House area in Acadia National Park is the primary reason for this project. Our liaisons at the park expressed a need for more parking data on the parking lots along Ocean Drive, as this area had proven more complicated to understand compared to the parking lot at Cadillac Mountain. Cadillac Mountain only had one parking lot to gather data on, and visitors primarily only went to the mountain for views from the park's highest point. Ocean Drive proved more difficult to gather data on due to there being multiple parking lots spread across a larger area in addition to a variety of attractions there such as Sand Beach or Thunder Hole. The proposed parking reservation system is planned to involve Ocean Drive, so having better parking data should allow the system to be more accurately tailored to manage overcrowding in this area. Therefore, our second objective was to gather data on and analyze parking behavior of vehicles along Ocean Drive.

Figure 3.1 Map Showing Cadillac Mountain, Ocean Drive, and Jordan Pond House in relation to one another https://acadiamagic.com/Park.html

3.2.1 Observations

To accomplish our second objective, we observed the behavior of vehicles along Ocean Drive. These observations were done remotely via nine trail cameras strapped to trees at various locations along Ocean drive. Seven of these cameras took time-lapse photos while two took pictures when triggered by motion detection. The time lapse photos, each being a 3-megapixel (MP) picture, were taken at 1-minute intervals, while the motion capture cameras took a photo directly after it was triggered and an after-photo was taken five seconds after the initial photo.

Figure 3.2 AKASO Trail Camera (left) and Spypoint Force 20 (right)

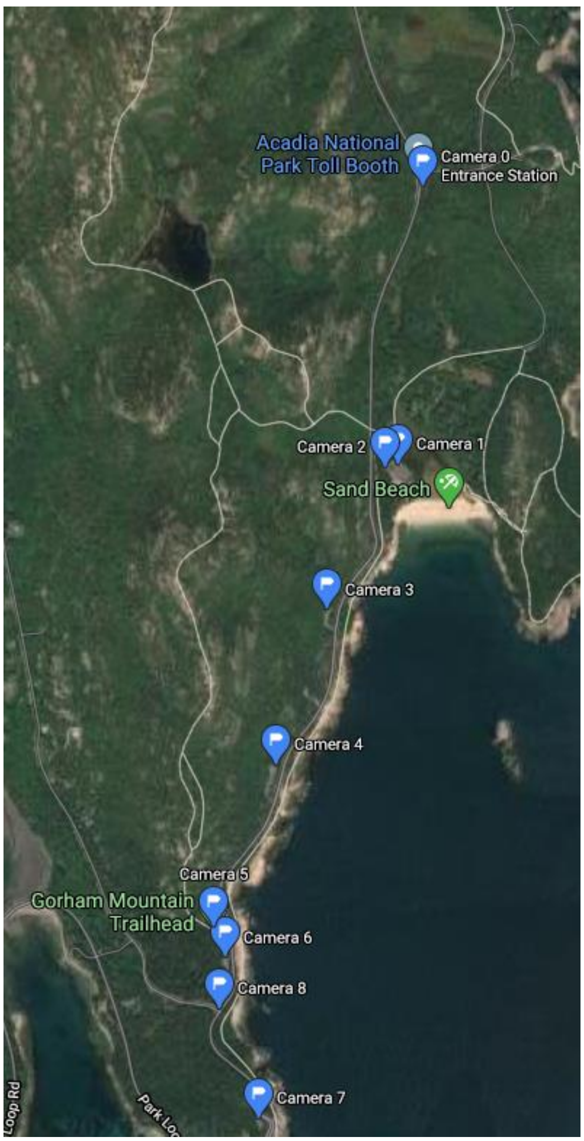


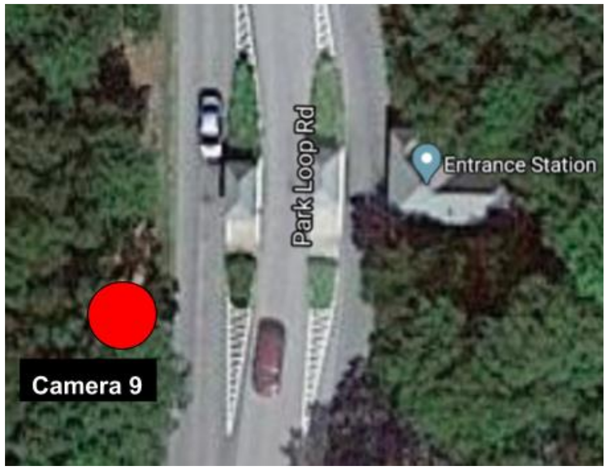
Figure 3.3
Location of cameras on Ocean Drive

The observations involved the use of 9 trail cameras: two AKASO trail cameras and seven Spypoint Force 20 trail cameras. Both cameras had a time-lapse function with photo timestamps including the time, date, and temperature. Both cameras also had motion detection capabilities and ran on 8 AA batteries. The AKASO cameras were chosen because they had adequate picture quality in addition to a built-in time-lapse function with adjustable intervals for taking photos. Compared to similar cameras, they were reasonably priced as well. Additionally, our professors already had seven Spypoint Force 20 cameras in stock. Although the AKASO camera was newer and had slightly better functionality, the Spypoint Force 20's was deemed adequate for the purposes of our project. Thus, it was decided that only two new AKASO cameras were required.

Due to the COVID-19 pandemic, only one of the project advisors, professor Frederick Bianchi, was able to be on-site for the project, so he oversaw setting up the cameras and uploading the photos taken from the trail cameras. Professor Bianchi set up the cameras on trees in the various locations along Ocean Drive, with a map of these locations shown below.

The first parking lot is the Sand Beach parking lot, the largest parking lot in the Ocean Drive Area. Cameras 1 and 2 were located at different halves of this parking lot due to its enormity. This lot allowed access to Sand Beach as well as the start of the Ocean Path, a trail that extended down to the bottom of Otter Peninsula. Camera 3 was located at the looped lot southwest of Sand beach that granted access to another entrance to the Ocean Path. Camera 4 was located at the Thunder Hole lot, which was located next to Thunder Hole, a popular attraction where waves crashing against cliffs sound like roaring thunder. Camera 5 was located at the Gorham lot, which provided access to the Gorham Mountain Trail as well as to Ocean Path and Monument Cove. Camera 6 was located at a smaller lot south of Gorham, which was the closest lot to Boulder Beach. Camera 7 was at the Otter Cliff overlook lot, which allowed access to the Otter Cliff overlook and the Otter Cliff rock climbing area. Camera 8 was located at the intersection of Park Loop Road and Otter Cliff Road, which is the only other entrance into the Ocean Drive Corridor. Camera 9 was located at the Sand Beach Entrance Station north of Sand Beach, which is where people pay to enter the Ocean Drive Corridor.

With the cameras continuously taking photos, Professor Bianchi was required to take the data from the cameras twice a week, usually on Monday and Thursday of each week. Professor Bianchi would take out the MicroSD cards from the cameras, download the photos to his computer, return the cards to the cameras, and go to an off-site location to upload the newest set of photos to a Dropbox. When each photo set was uploaded to the Dropbox, the students would download the photos to their personal computers. From there the photos were analyzed by the students.

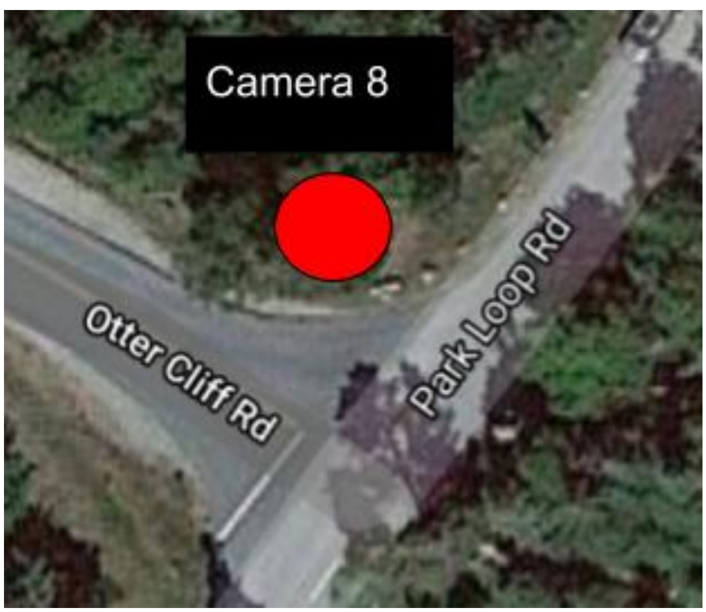



Camera 3
Park Loop Rd


Camera 4


Gorham Mountain
Trailhead
Camera 5


Camera 6

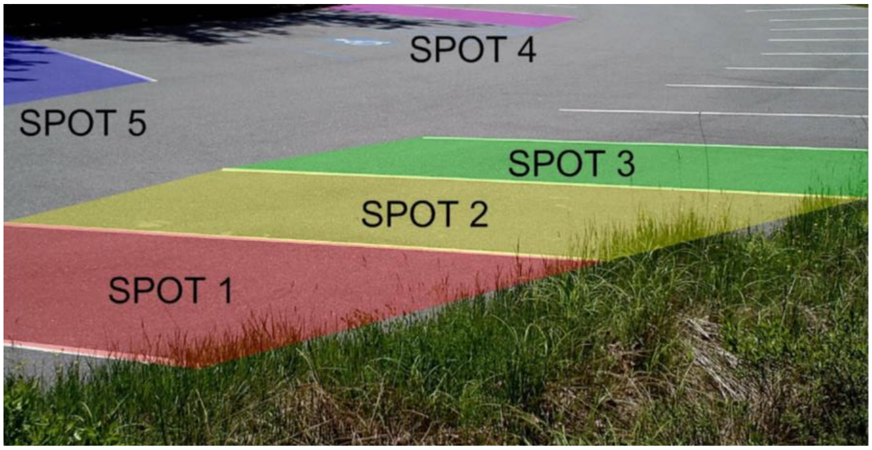

Camera 8
Otter Cliff Rd
Park Loop Rd

Figures 3.4-3.11 Images of the Sand Beach Entrance Station, the parking lots, and the intersection, as well as where the cameras are located

3.2.1.1 Length of Stay

A major objective for the project was to gather data on the length-of-stay of visitor vehicles at different parking lots along Ocean Drive. By analyzing the photos from Cameras 1-7, we were able to gather a sample of data on visitor length of stay at each parking lot. There were thousands of photos and hundreds of vehicles in each camera's set of photos each day, so to make gathering data manageable for a 4-person group to comb over manually it was decided that only a small sample of the vehicles would be analyzed. For each camera, several parking spots were chosen to be focused on (these spots are shown in Figures 3.12 to 3.18), and a person assigned to that camera would only need to focus on vehicles in those parking spots. For Camera

3, due to the low number of vehicles visiting the parking lot, a group of parking spots in the back of the picture were chosen collectively as Spot 6 since there would usually be only 1 vehicle in this section of the parking lot. For Camera 7, there were usually vehicles closest to the camera blocking the view of vehicles behind them, so for this Camera up to 5 visible vehicles would be focused on at a time, ignorant of specific parking spaces. The group set up a Google Spreadsheet for each camera, and each spreadsheet had a column for the date, weather, temperature, time, and one column for each spot being monitored for that camera (Camera 1's spreadsheet is shown in Figure 3.19). Data was recorded whenever the date, weather, or the occupancy of a spot changed. For weather, it was recorded if it was sunny, cloudy, or rainy/foggy; spots were recorded as full, empty, not visible, or swapped (when vehicles swapped in a spot between photos).


SPOT 4
SPOT 5
SPOT 3
SPOT 2
SPOT 1


SPOT 4
SPOT 3
SPOT 5


SPOT 4
SPOT 5
SPOT 6

Figures 3.12-3.18 Images of the parking lots and the parking spaces chosen for observation

	Key: S = Sunny C = Cloudy R = Rain			Key: F = Full E = Empty NV = Not Visible						
Date	Weather	Temperature (F)	Time	Spot 1	Spot 2	Spot 3	spot 4	spot 5	spot 6	spot 7
6/15/2020	S		6:30 AM	Empty	empty	empty	empty			
Avg length of stay: 95 minutes			6:31 AM							
		69	9:40 AM			full				
		69	11:01 AM			empty				
		68	11:57 AM				full			
		66	12:14 PM		full					
		71	12:46 PM				empty			
		73	1:05 PM				full			
		73	1:08 PM	full						
		78	2:23 PM		empty					
			2:39 PM				empty			
		75	3:12 PM	empty						
Lengths of time cars stayed: 49, 79, 94, 124,129										
6/16/2020	s		6:30 AM	empty	empty	empty	empty	empty	empty	empty
Avg length of stay: 95.94			6:31 AM							
		68	10:09 AM			full				
		69	10:47 AM		full					
		68	11:07 AM					full		
		68	11:11 AM				full			
		68	11:25 AM							full

Figure 3.19 Example from the Camera 1 Google Sheet

For our analysis of this data, we used the arrival (Figure 3.20) and departure (Figure 3.21) times of vehicles to calculate how long they were parked in a spot. We then calculated the average length of time vehicles were parked for the areas covered in each camera, for each day. We then looked at how this average changed for a parking lot based on what day of the week it was and what the weather was like.

Figure 3.20 Photo of a vehicle first appearing in Sand Beach on Camera 1

Figure 3.21 Photo where the vehicle is gone

3.2.1.2 Travel Patterns

In addition to determining the length of stay at various parking lots, Acadia National Park also wanted data on the length of stay of vehicles in the 1.7-mile-long Ocean Drive corridor. Additionally, it was determined that tracking the vehicle parking patterns across all the parking lots along Ocean Drive was also required. To determine the average length of stay of vehicles on the Ocean Drive corridor, cameras 8 and 9 were used together to gather the necessary data. The process of tracking an individual vehicle was as follows: An easily identifiable vehicle was chosen from camera 9, as shown in Figure 3.22. The time and date were recorded from camera 9 for the entrance of the vehicle to Ocean Drive. When the vehicle showed up at Camera 8, as shown in Figure 3.23, the time and date was recorded in a spreadsheet (shown in Figure 3.24 with the example vehicle's information highlighted). With this method, the vehicle's entrance and exit time on Ocean Drive was recorded and the length of stay was calculated from there. This was done using photos from July 1 and July 7-9.

Figure 3.22 Photo from Camera 9 showing a vehicle entering Ocean Drive through the Sand Beach Entrance Station

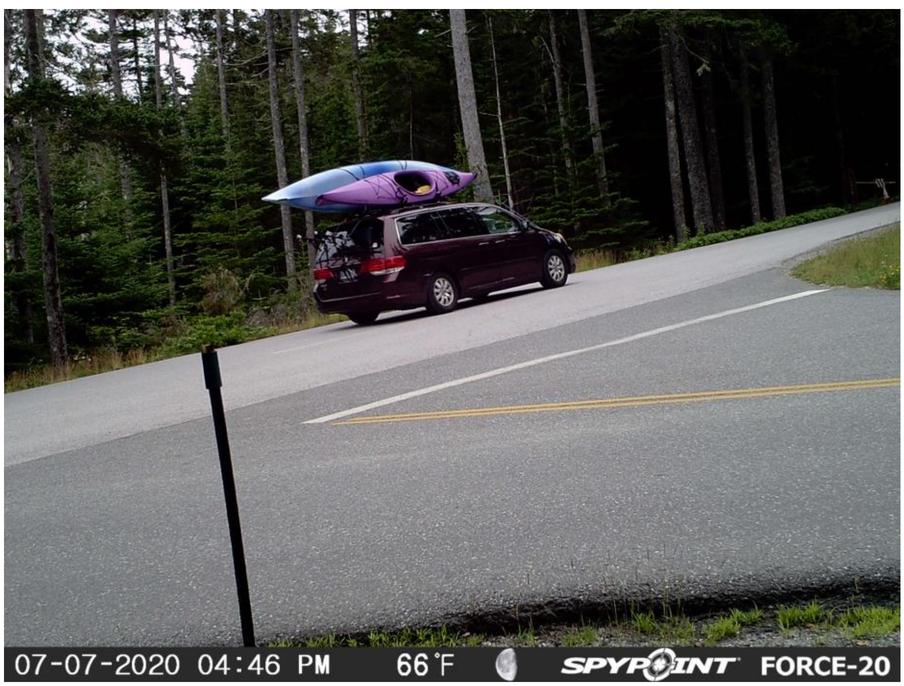


Figure 3.23 Photo from Camera 8 showing the vehicle exiting Ocean Drive at the intersection

Date	Weather	Temperature	Description	Camera 9 Time	Camera 8 time	Time in Ocean Drive (min)
		75 enter	brown kia four door	12:06 PM	2:14	155
		73 enter	light blue mustang	12:16 PM		
			black pickup rack in back something yellow in the bed four door	12:12 PM		
		73 enter	dark pickup truck ford, massachusetts plates, three canoes, Y B R, in the bed, wooden 'rack"	12:20 PM	2:48	148
		69 enter	dark blue convertable maine plate one passenger has a sunhat	12:48 PM	1:28 PM	40
		75 enter	rental rv, 800rv for rent on the side, cruise america.com on the front, ford, mainly white	11:29 AM		
		73	Red pickup. FTX sticker/logo on the side of the bed	12:58	3:30	152
			Red suv bike on top	1:09	5:54	285
		73	Blue jeep with stuff exposed in back	1:25	1:30	5
		69	Black VW, NY plate, liime green frame bike on top	1:36	1:40	4
		73	Black honda minvan with two bikes on back	1:37	6:26	289
		69	green/blue gmc van/rv	1:38	1:43	5
		73	black honda suv two yellow/orange kayaks on top	1:47	6:53	306
			white ford rv	1:55	6:04	249
		69	greenish GMC bus	2:03	5:52	229
			silver Chevy 4-door pickup truck, with bikes in bed	3:03 PM	3:27 PM	24
			blue jeep, black trim, bikes on back bike rack	3:14 PM	5:04 PM	110
			plum van, two kayaks on top (smaller light purple one, larger light blue and white one)	3:22 PM	4:46 PM	84
			red Ram pickup truck, with black trim on bottom and white words on tires	3:47 PM	4:27 PM	40
			long red sedan with 3 windows per side, gray line along side, gray top container	4:16 PM	6:21 PM	125
			red Jeep, black trim	4:19 PM	4:24 PM	5
			old, blocky plum long chevy with long windows at rear sides	5:21 PM	6:22 PM	59
			tall red pickup truck (high suspension)	6:08 PM	6:11 PM	3

Figure 3.24 Part of the tracking Google Sheet, with the enter and exit times of the vehicle from Figures 3.22 and 3.23 boxed

Camera 1 enter	camera 1 exit	Camera 2 enter	Camera 2 exit	Camera 3 enter	Camera 3 exit	Camera 4 enter	camera 4 exit
							12:40
		12:20	1:54				
		1:06	?				
						2:50	3:06
						1:40	2:04
3:38 PM	4:57 PM						
		3:34 PM	4:48 PM				
4:25 PM	4:37 PM						

Figure 3.25 Part of the tracking Google Sheet, with the times the same vehicle entered and exited Sand Beach boxed

We then took the cars chosen for tracking, and identified, if possible, which parking lots they went to on that day using the photos from Cameras 1 through 4 (photos of the example vehicle in parking lots are shown in Figures 3.26 and 3.27). We did not track vehicles using cameras 6 and 7 because the professors had already taken them down, and we could not use camera 5's photos because its battery was dying and had not been replaced. From here, we determined the percentage of vehicles going through Ocean Drive that stopped at a parking lot, as well as how likely a vehicle that parked in one lot was to also park in another. We specifically checked for the percentage of vehicles that parked at Sand Beach first and then other parking lots later in the day.

Figure 3.26 Photo of the vehicle when it first appeared on Camera 2 at Sand Beach

Figure 3.27 Photo of the vehicle leaving Sand Beach on Camera 2

3.3 Providing Proposals on the Expansion of using Cameras

Acadia National Park's vehicle reservation system is intended to begin at Cadillac Mountain and Ocean Dive, and eventually be expanded into other congested areas of the park. The park had intended for the Jordan Pond House area to be included in the system, but they were unable to gather enough data on the area to properly set up policies for it. Therefore, the third objective of this project is to provide proposals on how to improve and expand the use of cameras for gathering parking data in order to both assess the efficacy of the reservation system and acquire the necessary information to implement the system in additional park areas.

Throughout the project, we came up with and tested various methods of using the trail cameras to gather data on the Ocean Drive area. For each of these methods, we took note of which ones failed and why. For those that failed due to current limitations, we determined what would be necessary to make them work properly and the benefits of using these methods over those that we were already using. We took the methods we developed during the project and determined how they could be continued by future groups or by Acadia. Additionally, we used the knowledge we gathered about the methods and determined how they could be used to assist in adapting the reservation system to the Jordan Pond House area.

Initially, we had planned to make use of a company called Parquery to assist in analyzing the photos we gathered. We had also planned to observe different sets of parking areas over the course of 4 weeks, so that all the parking lots could be observed in their entirety using multiple cameras. This would involve taking a week's worth of photos, then transferring the photos out of the SD cards at the end of the week while moving cameras to new parking lots.

Due to the Covid-19 pandemic, we were unable to be on-site, and had to shift our strategy. We would take photos of all the parking lots, which meant all of them except for Sand Beach would only use one camera and only cover part of the lots. We would also be transferring photos every few days and observing the lots for multiple weeks in order to make up for the smaller sample size of data per lot. This would mean shifting the cameras, which would affect Parquery's results. It was decided that we would have to do the analysis of the photos on our own, which meant further reducing the sample size of vehicles to observe. The previous method had its merits, and we went over the benefits it had over the method we were led to use, as well as what would be needed to use this method for future endeavors involving camera observations.

During the project, we came up with several ways of potentially tracking vehicles between the different parking lots along Ocean Drive. For each method, we discussed its feasibility as well as any potential shortcomings they had. When we came to the conclusion that a method would be unfeasible, we adjusted it and repeated the process. We made note of which methods worked and which did not, so that we could pass on this information to future projects that would utilize cameras in the park.

4. Results and Analysis

In this chapter, we discuss the results of our work on Ocean Drive. This includes the data gathered by observing vehicles in the individual parking lots along Ocean Drive as well as the data gathered by observing vehicles at the entrance and exit of the Ocean Drive corridor. Additionally, we discuss the shortcomings of our attempt to track vehicles as they stopped at various parking lots along the corridor. This chapter also contains our discussion of the policies outlined in Acadia National Park's vehicle reservation system.

4.1 Vehicle Length of Stay in Parking Lots along Ocean Drive

At the start of the project, we obtained vehicle parking data in six parking lots along Ocean Drive. First, we calculated the average length of stay for the ten days we were collecting data on the parking lots (June 15 to June 24). Next, we began comparing these averages to determine if weather and temperature affected them. Unfortunately, we noticed that these factors did not have a predictable effect on the length of stay, which is evident in Figure 4.1. There was no single day where all of the parking lots' lengths of stay acted the same, and each parking lot acted drastically different from one another except for Sand Beach and Otter Cliff. June 24th was a cool rainy day, with the worst weather of the 10 days. Not only did that day not have the lowest length of stay for any of the parking lots, it also had several parking lots see an increase compared to days with fairer weather. Therefore, we were unable to produce results that showed a predictable effect of weather and temperature on the length of stay in the parking lots.

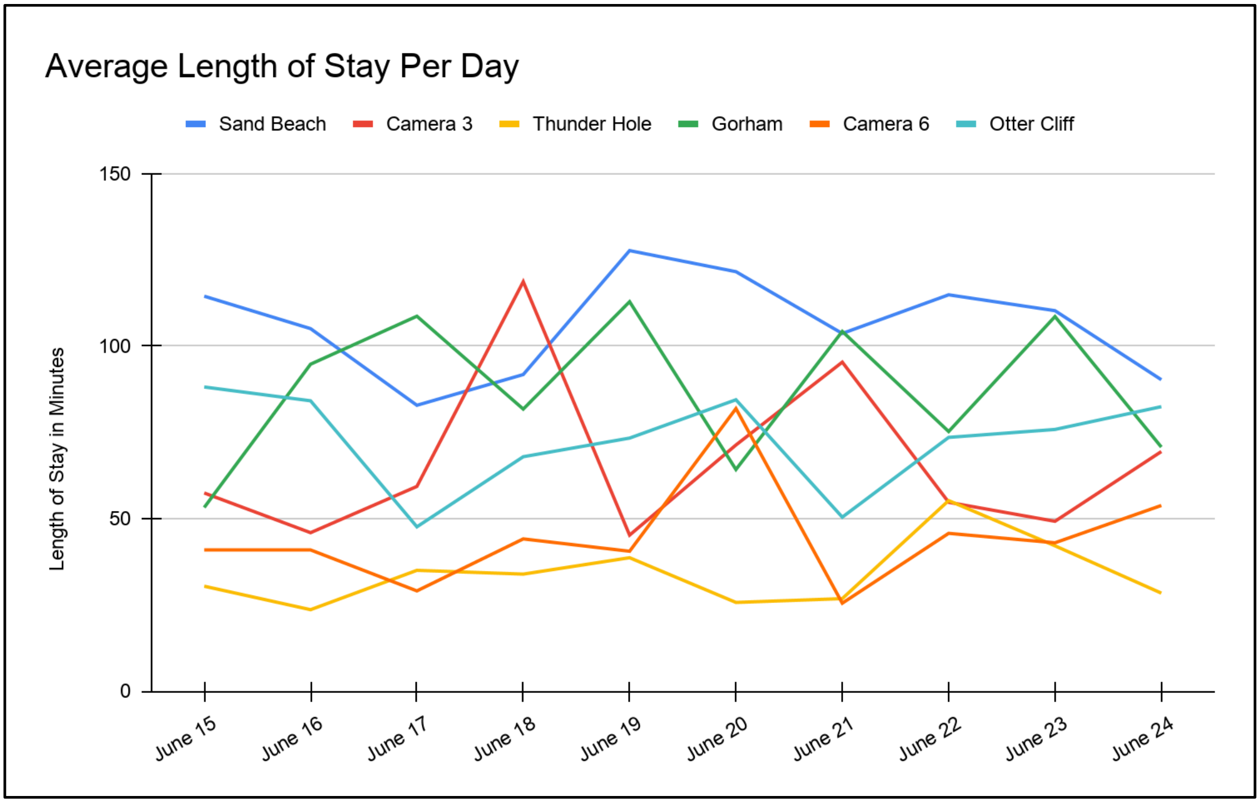


Figure 4.1 Graph of the Average Length of Stay per Day for 6 parking lots, sampled from June 15th to June 24th

	Average Length of Stay (minutes)							
Date	Sand Beach	Camera 3	Thunder Hole	Gorham	Camera 6	Otter Cliff	Weather	Temp. (high)
June 15	114.50	57.50	30.50	53.30	41.00	88.20	Sunny	71° F
June 16	105.10	46.00	23.70	94.80	41.01	84.20	Sunny	75° F
June 17	82.90	59.40	35.10	108.70	29.14	47.70	Sunny	71° F
June 18	91.80	118.70	34.00	81.80	44.20	68.00	Sunny	79° F
June 19	127.70	45.30	38.75	112.90	40.63	73.40	Sunny	84° F
June 20	121.60	71.40	25.80	64.30	81.95	84.50	Sunny	88° F
June 21	103.70	95.40	26.90	104.30	25.58	50.50	Partially Cloudy	64° F
June 22	114.90	54.80	55.30	75.30	45.81	73.60	Partially Cloudy	76° F
June 23	110.30	49.30	42.20	108.60	43.08	75.90	Sunny	70° F
June 24	90.30	69.50	28.50	70.80	53.88	82.50	Rainy	69° F

Figure 4.2 Table showing the average length of stay for each parking lot, as well as the weather and highest temperature

We had also planned to determine how the day of the week affected the length of stay of vehicles in the parking lots. However, after a week into the project, we built up a backlog of photos to analyze. We made the decision to limit our data for this part of the project to ten days; we felt that ten days was a large enough sample size for analysis. Consequently, we were unable to determine if the day of the week produced a noticeable effect on the length of stay of vehicles.

We originally planned on conducting surveys on visitors to better understand the factors that contributed to their length of stay in the various parking lots. Unfortunately, the COVID-19 pandemic forced the project to be conducted remotely, and we came to the decision that conducting surveys remotely would not be feasible. Thus, no concrete data was collected on the factors that affected visitor length of stay; we could only speculate on the factors behind visitor parking behavior in the parking lots.

4.1.1 Results of Analysis

Once we had calculated the average length of stay for the observed vehicles in each parking lot, each vehicle was grouped into a length of stay interval based on their length of stay. It was determined that thirty-minute time intervals best displayed the distribution of vehicles' length of stay on Ocean Drive. For each parking lot, with data shown in Appendix A, a pie chart was made using Google Sheets which visualizes the distribution of length of stay for all the vehicles that were tracked in the ten-day window. The last time interval in each pie chart varied depending on the distribution of vehicle length of stay (240+ for Sand Beach parking lot versus 180+ for Camera 3 lot).

4.1.1.1 Sand Beach Parking Lot

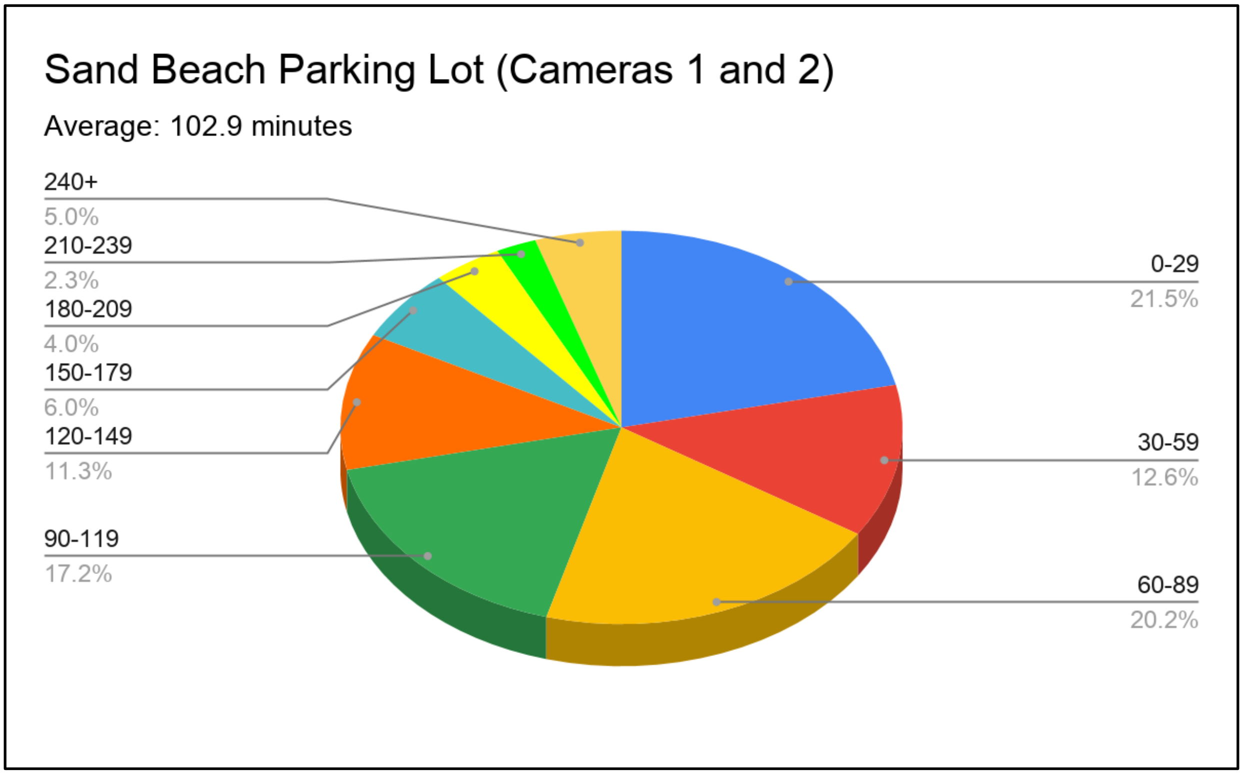


Figure 4.3 Pie Chart showing the Distribution of Length of Stay for Vehicles in the Sand Beach Parking Lot

From the data represented in Figure 4.3, the 0-29 interval had the highest percentage of vehicles (21.5%). We speculated that this was due to many people stopping at Sand Beach just to take a restroom break, look at Sand Beach, and/or to take a short break from driving. This data also shows a dip in the number of vehicles that stayed between 30 and 59 minutes when compared to the intervals around it. There is an increase in the number of vehicles parked for 60 to 89 minutes as well as 90 to 119 minutes, which is likely due to visitors staying at the beach or going on the Ocean Path trail. The average length of stay at Sand Beach was 102.9 minutes.

4.1.1.2 Camera 3 Parking Lot

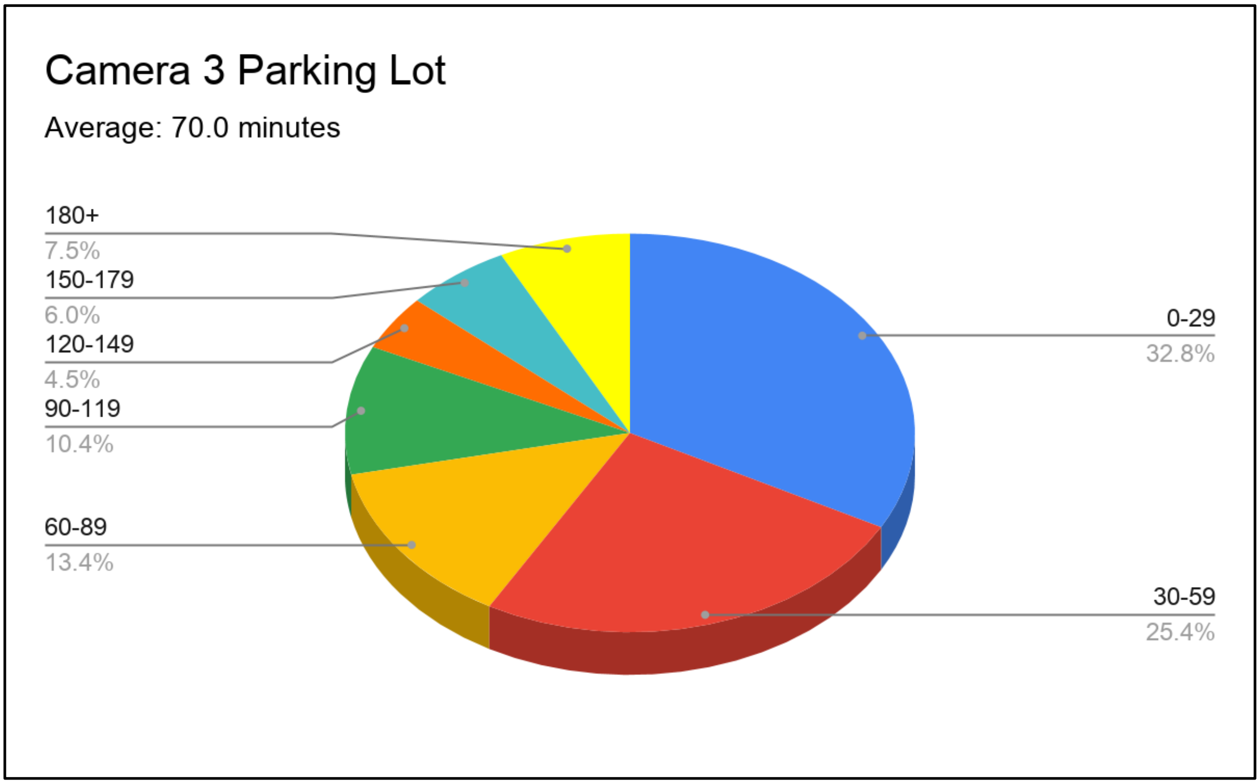


Figure 4.4 Pie Chart showing the Distribution of Length of Stay for Vehicles in the Camera 3 Parking Lot

Using the data represented in Figure 4.4, we speculated there are significantly more vehicles parked for under a half an hour compared to Sand Beach due to there being less time-consuming activities near the parking lot. The only points of interest are an entrance to the Ocean Path and access to the Sand Beach Overlook. The average length of stay at this parking lot was lesser than at Sand Beach, being only 70.0 minutes.

4.1.1.3 Thunder Hole Parking Lot

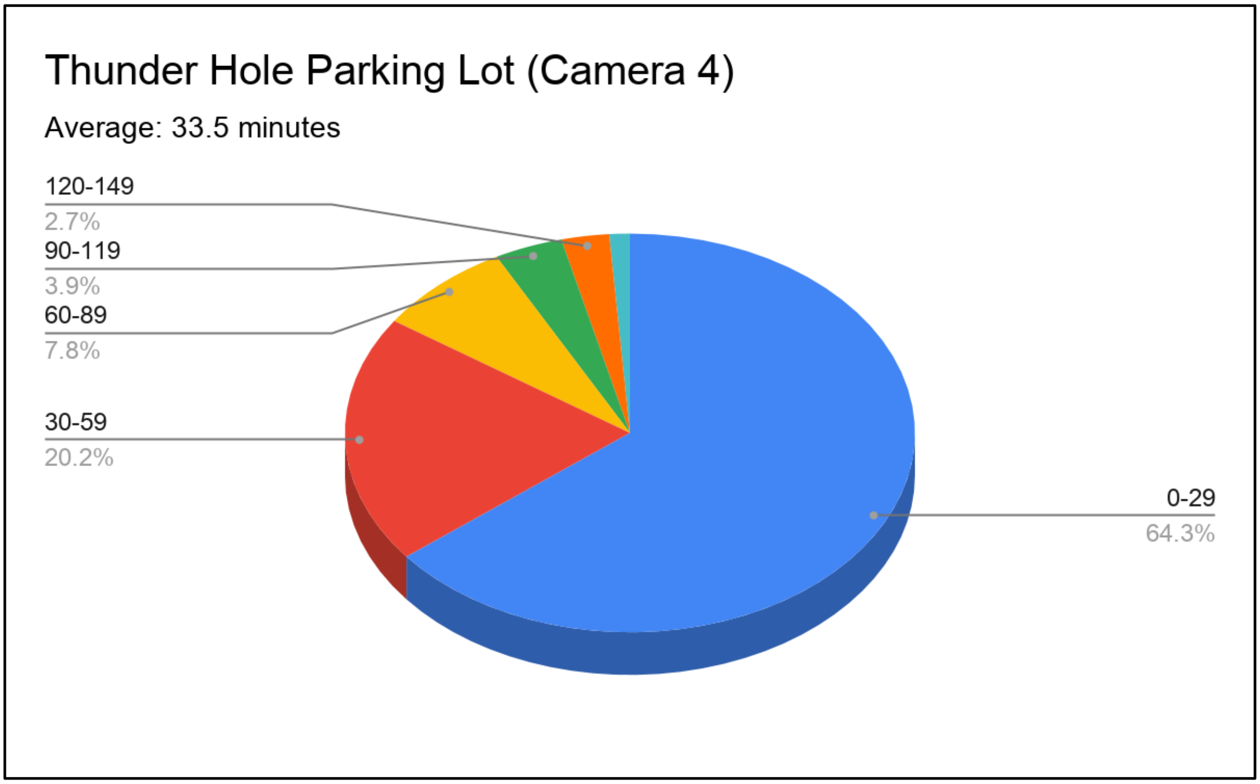


Figure 4.5 Pie Chart showing the Distribution of Length of Stay for Vehicles in the Thunder Hole Parking Lot

Based on the data represented in Figure 4.5, it was apparent that vehicles parked at Thunder Hole for relatively short periods of time, with an average length of stay of 33.5 minutes. We speculate this is due to the main point of interest by this parking lot being Thunder Hole, which can be easily appreciated in less than half of an hour.

4.1.1.4 Gorham Mountain Parking Lot

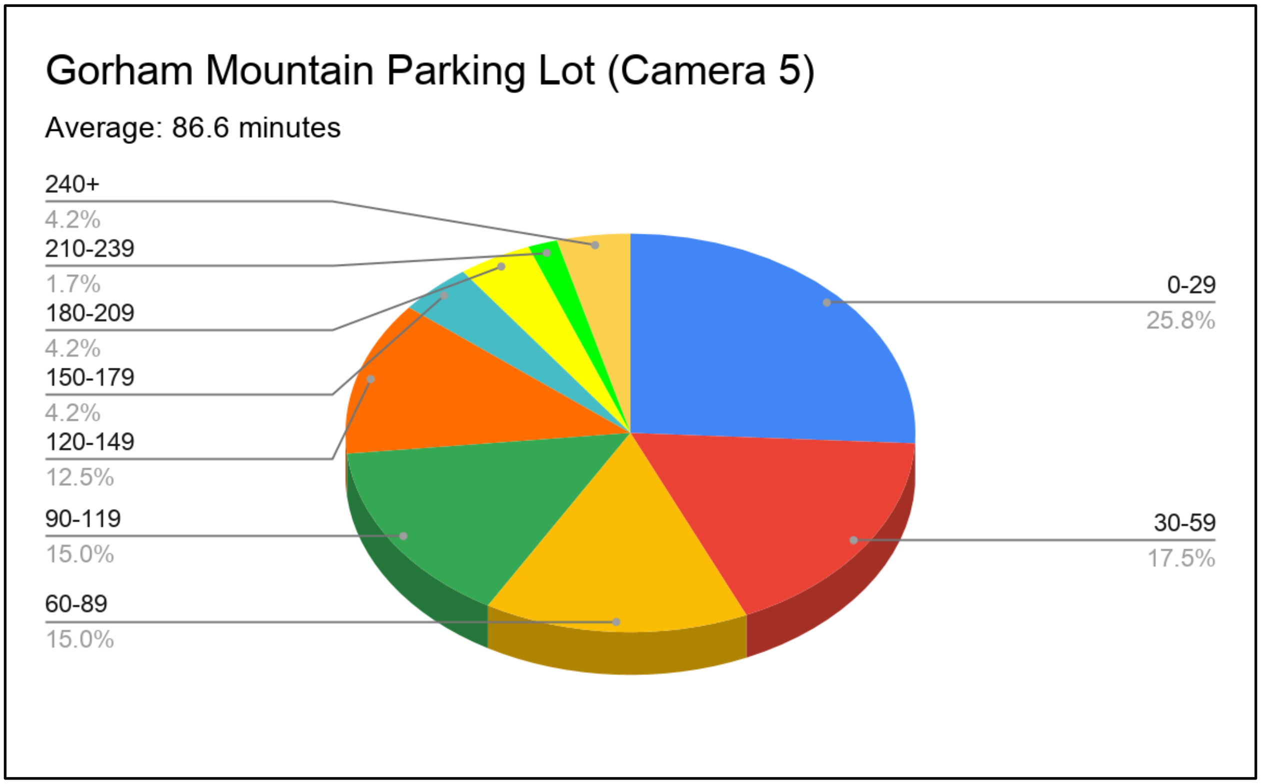


Figure 4.6 Pie Chart showing the Distribution of Length of Stay for Vehicles in the Gorham Mountain Parking Lot

Using the data shown in Figure 4.6, there were two main groups of visitors: those staying for a short amount of time, and those staying for a long amount of time. Those that stayed for less than half of an hour likely spent that time going to see Monument Cove, whereas other visitors stayed longer to hike on the Gorham Mountain Trail. This parking lot had the second longest average length of stay at 86.6 minutes.

4.1.1.5 Camera 6 Parking Lot

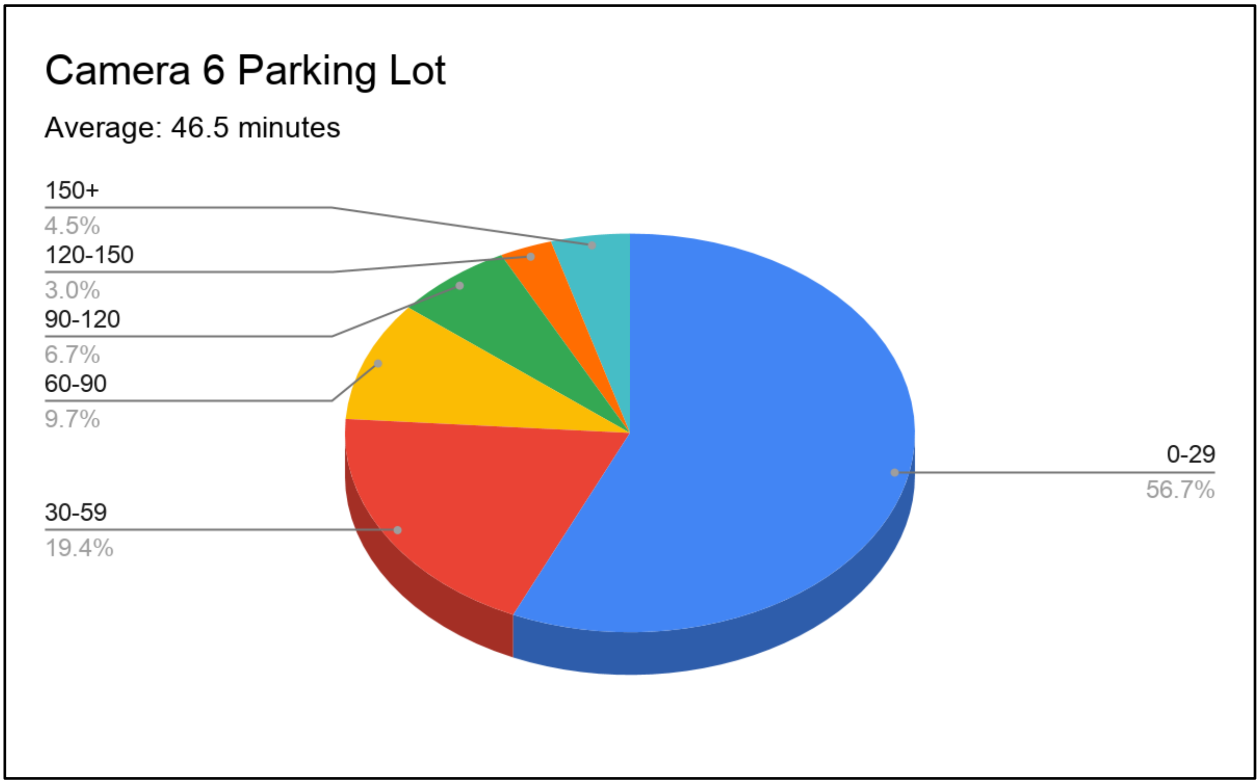


Figure 4.7 Pie Chart showing the Distribution of Length of Stay for Vehicles in the Camera 6 Parking Lot

Looking at the data represented in Figure 4.7, the parking lot covered by Camera 3 best resembles that of Thunder Hole. The average length of stay was higher at 46.5 minutes, but most vehicles still parked for less than half of an hour. We believe the low length of stay is due to the primary attraction near the lot being Boulder Beach, which is primarily for looking at and briefly walking on.

4.1.1.6 Otter Cliff Parking Lot

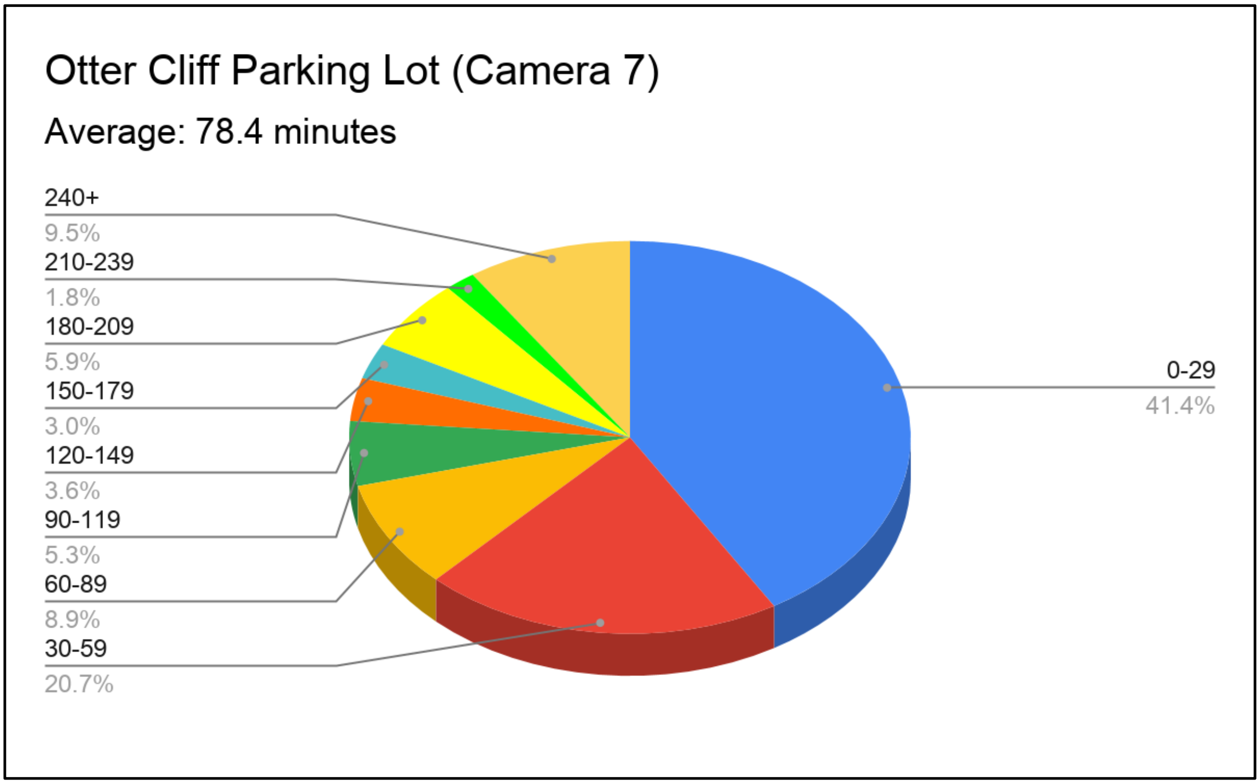


Figure 4.8 Pie Chart showing the Distribution of Length of Stay for Vehicles in the Otter Cliff Parking Lot

Looking at the data visualized in Figure 4.8, a significant portion of vehicles are parked for less than half of an hour, and more than half stay for under an hour. We infer this is due to the primary attraction nearby being the Otter Cliff Overlook, which does not take long to appreciate. However, there were still a noticeable percentage of vehicles parked for long periods of time, as the average length of stay came out to be 78.4 minutes, and of all the parking lots had the greatest percentage of vehicles staying for more than 4 hours.

4.2 Vehicle Length of Stay in Ocean Drive Corridor

4.2.1 Tracking Vehicles in Ocean Drive

The greatest issue that impeded our efforts to track vehicles was a lack of coverage with the cameras. As explained previously in this report, we did not have any photos from the Gorham, Camera 6, and Otter Cliff parking lots during this time so we could not locate any vehicles in them. Additionally, there were times when a vehicle was pictured entering Ocean Drive through Camera 9, but was never pictured exiting through Camera 8, implying some vehicles did not trigger the motion sensor. Furthermore, there were examples of vehicles whose total time in Ocean Drive could be calculated, but we could never find them in the parking lot photos. Some vehicles were in a parking lot, but their time in that specific lot did not account for their entire time in Ocean Drive, which meant we were missing them in another parking lot. Due to this lack of coverage, we were unsuccessful with tracking most vehicles between the various parking lots.

4.2.2 Length of Stay in Ocean Drive

During our tracking, we encountered two vehicles that were extreme outliers in terms of their length of stay. They resided in Ocean Drive for 464 and 518 minutes, and the next highest duration was only 306 minutes. Thus, we calculated different average lengths of stay, some of them including the outliers and others not.

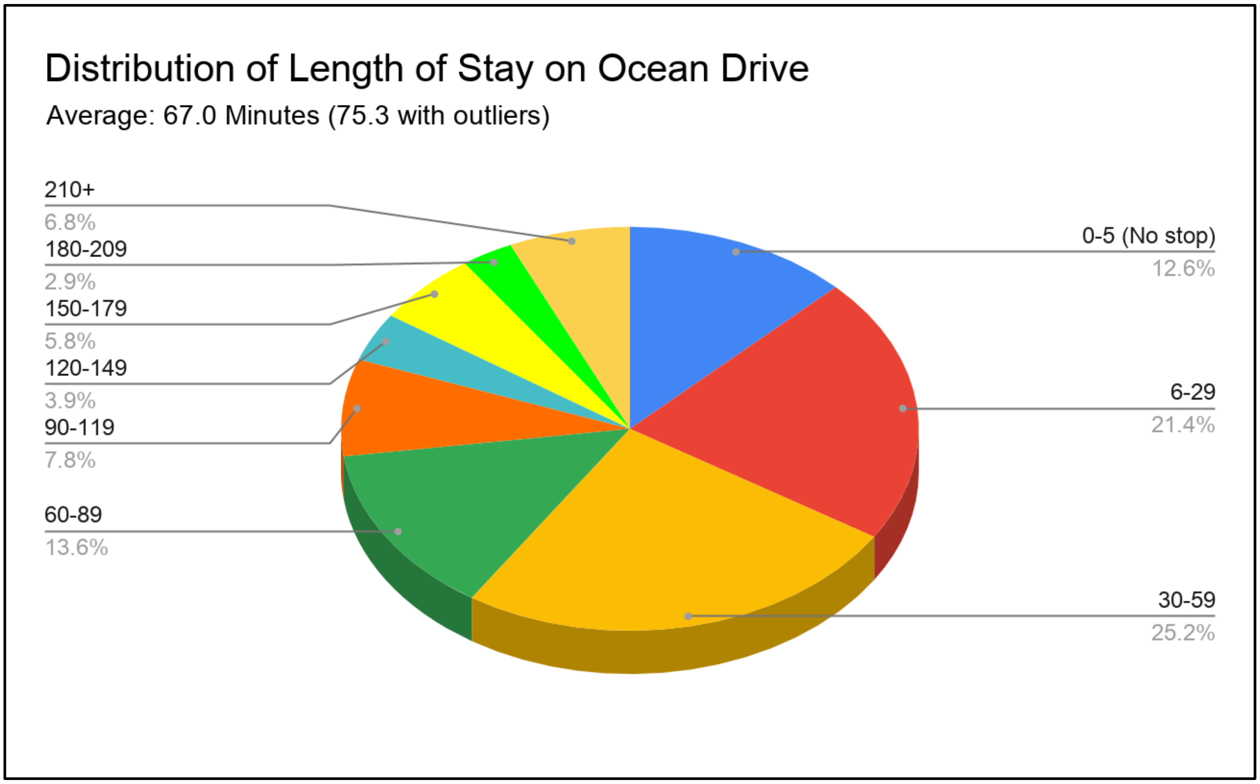


Figure 4.9 Pie Chart showing the Distribution of Length of Stay for Vehicles in Ocean Drive

Looking at Figure 4.9, the first important conclusion that can be made is that 12.6% of the vehicles that go through Ocean Drive do not stop at all in this section of road. Since all vehicles going through the area would need a reservation, the reservation system can take into account that more than a tenth of reservations would not contribute to parking lot congestion.

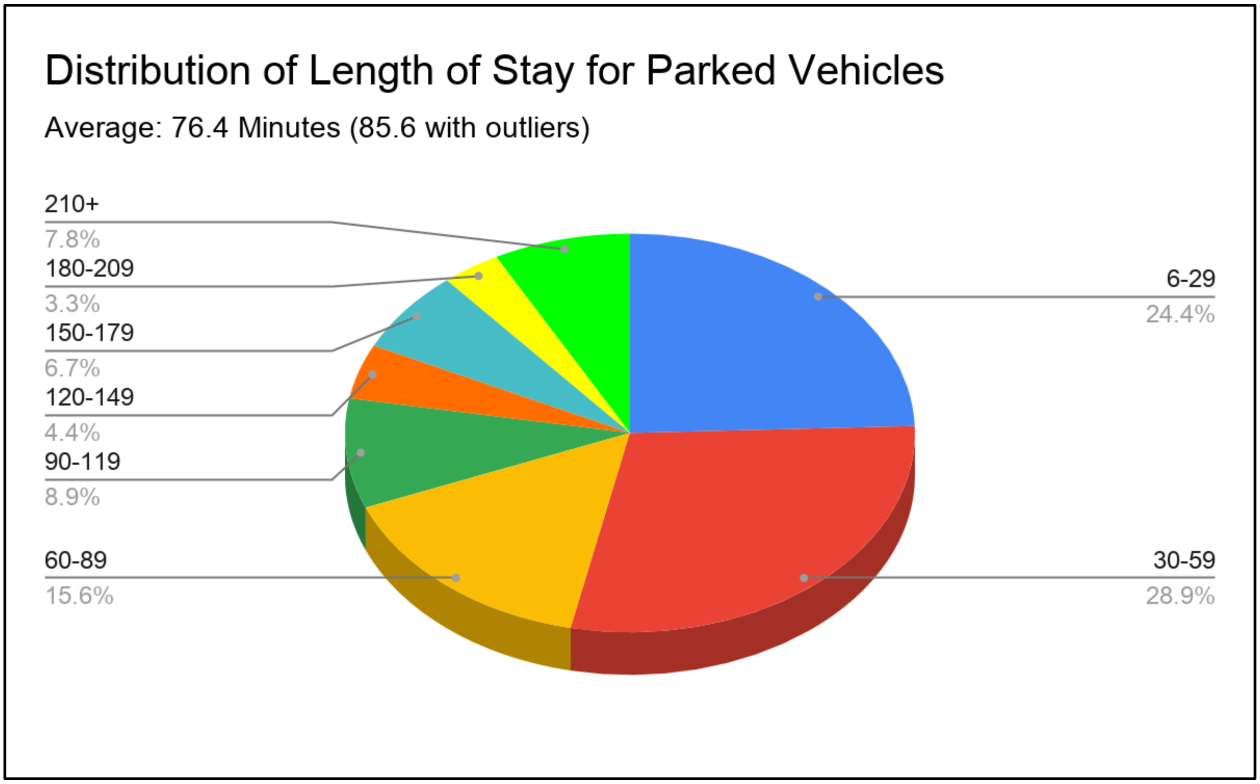


Figure 4.10 Pie Chart showing the Distribution of Length of Stay for Parked Vehicles in Ocean Drive

The next important conclusion is that a majority of visitors to Ocean Drive stay for less than an hour. For vehicles that stopped somewhere along Ocean Drive, more than half (53.3 %) of them parked for less than an hour (as seen in Figure 4.10) and stayed on average for 76.4 minutes (85.6 when including major outliers). When including vehicles that did not park, the percentage increases to 59.2% of all vehicles driving through the corridor, with an average duration of 67 minutes (75.3 when including major outliers).

After the data had been gathered, it was decided that organizing the distribution of the lengths of stay based on the time of day would also be important. Having this information available to Acadia National Park would allow them to adjust reservations depending on the time of day. We split up a day into 4 sections, based on our experience with how the parking lots looked at various times. The 4 sections were for the morning (up to 10:59 AM), lunchtime (11

AM to 12:59 PM), afternoon (1 PM to 4:29 PM), and evening (4:30 PM to 7 PM). We then made a pie chart for each section of the day, using the same data as in Figures 4.9 and 4.10.

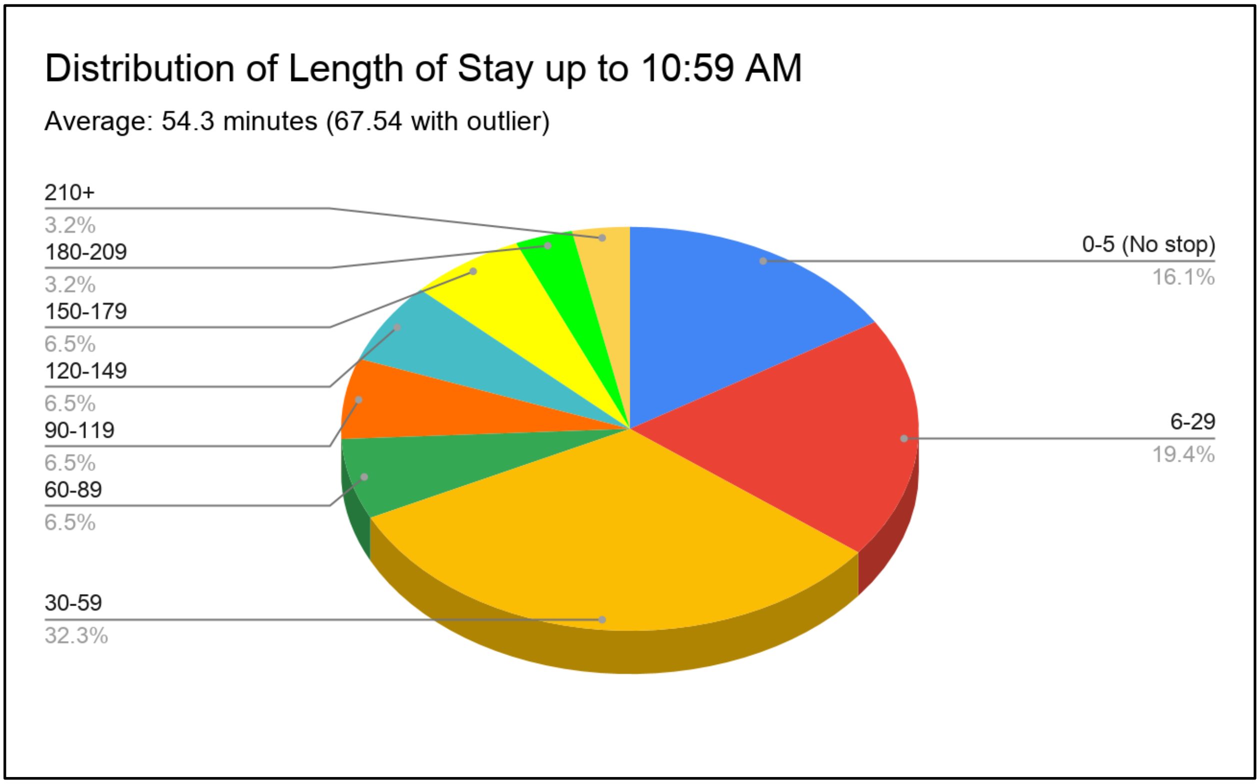


Figure 4.11 Pie Chart showing the Distribution of Length of Stay for Vehicles in Ocean Drive in the morning

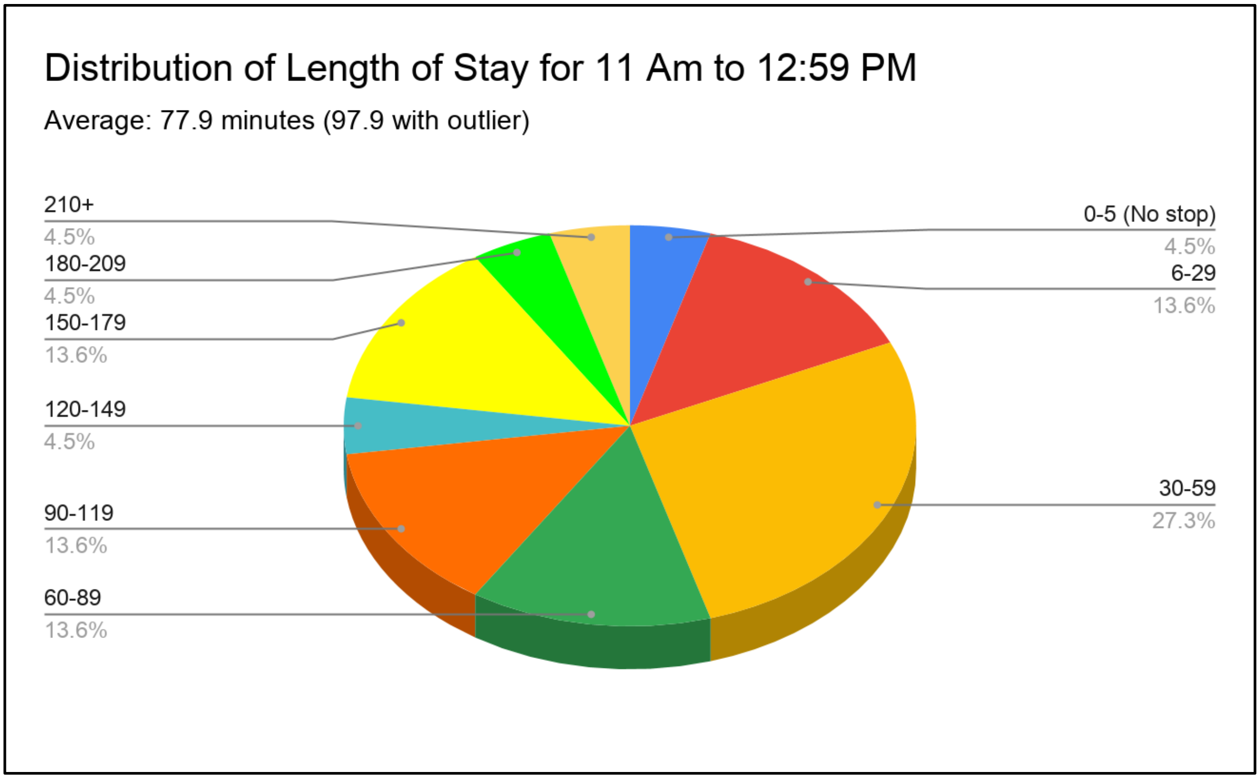


Figure 4.12 Pie Chart showing the Distribution of Length of Stay for Vehicles in Ocean Drive during lunchtime

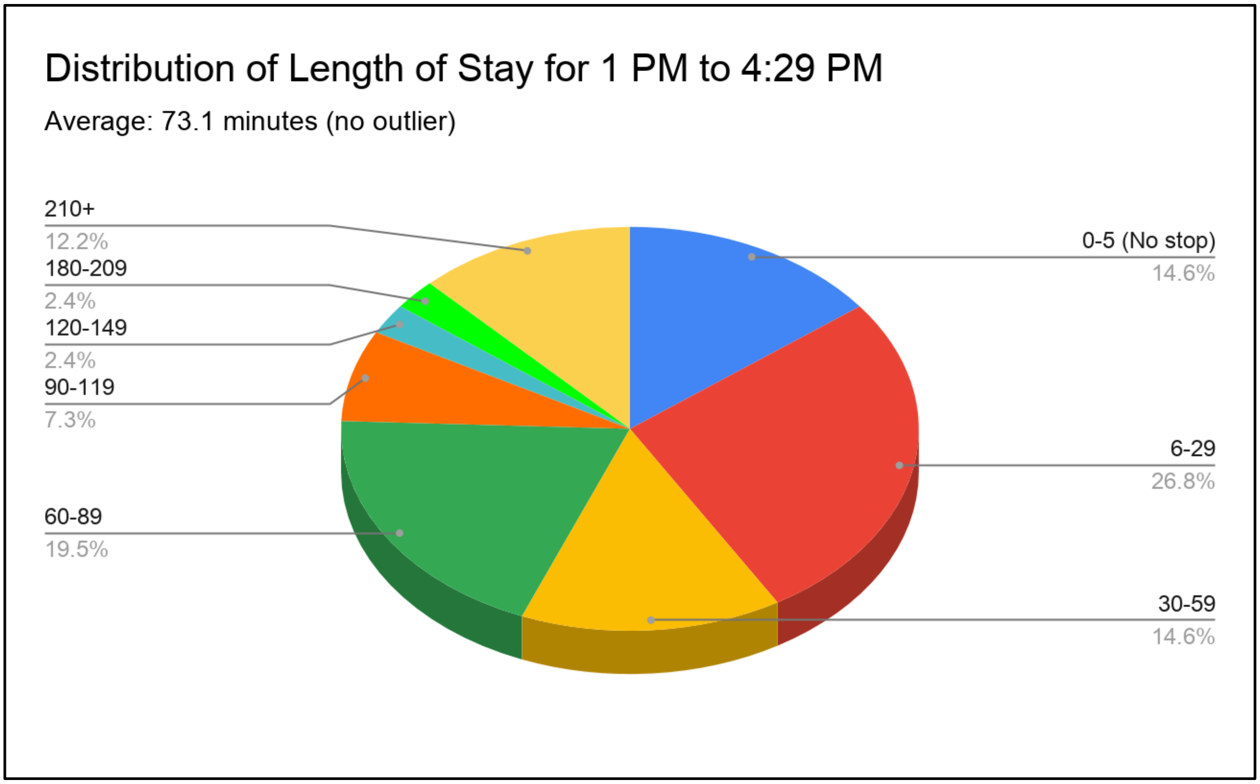


Figure 4.13 Pie Chart showing the Distribution of Length of Stay for Vehicles in Ocean Drive in the afternoon

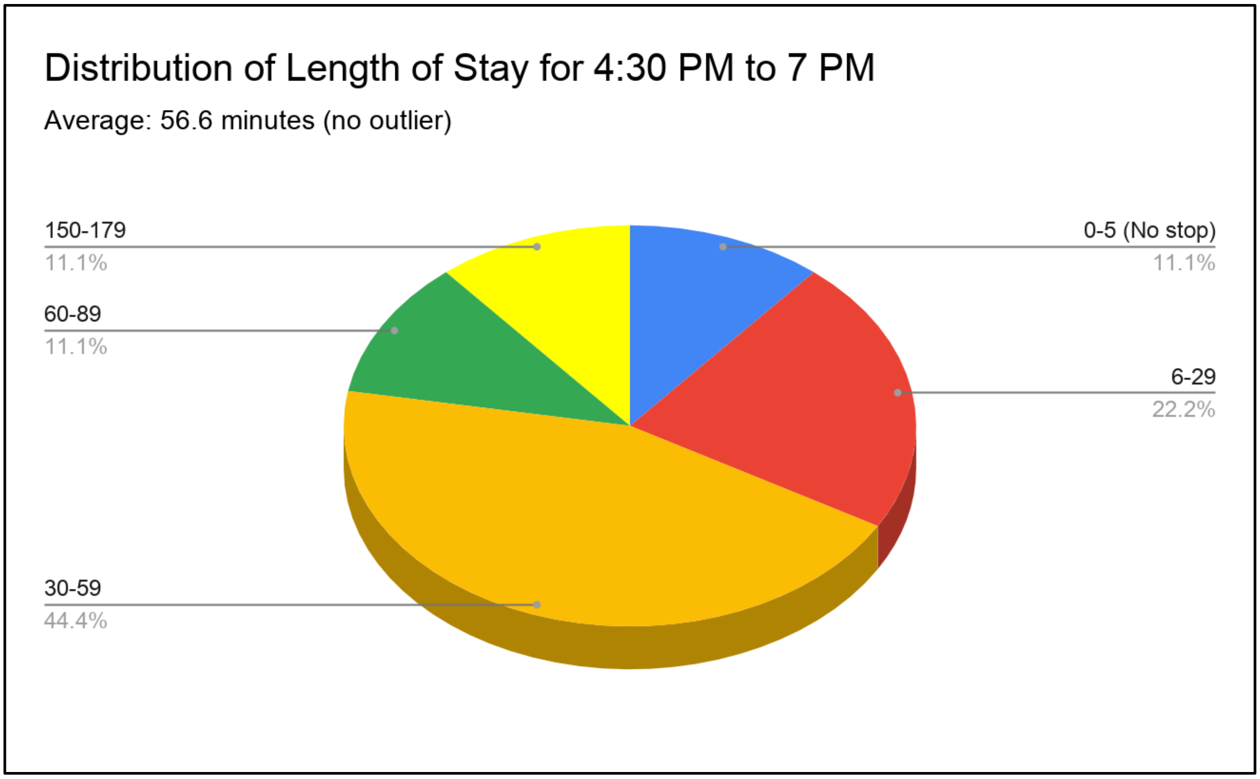


Figure 4.14 Pie Chart showing the Distribution of Length of Stay for Vehicles in Ocean Drive in the evening

Looking at Figures 4.11 to 4.14, it is evident that vehicles that came in the morning (before 11 AM) or the evening (4:30 PM and later) were less likely to stay in Ocean Drive for an hour or more. Vehicles that entered in the morning stayed on average 54.3 minutes, and those that entered in the evening stayed for 56.6 minutes on average. Vehicles that entered during lunchtime or the afternoon tended to stay longer, with average length of stays being 77.9 minutes and 73.1 minutes, respectively. In particular, the evening was the only time period where all vehicles that entered during this time stayed in Ocean Drive for less than 3 hours.

Of the four time periods, only the lunchtime period (Figure 4.12) had less than half (45.4 %) of the vehicles entering during that time stay for less than an hour. This section of the day also had the highest average duration for vehicles staying in Ocean Drive, at 77.9 minutes.

Interestingly, vehicles that entered during the afternoon period (Figure 4.13) were the most likely to reside in Ocean Drive for 210 minutes or more.

4.3 Analysis of the Acadia Reservation System

Park Name	When are Reservations Made	How are Reservations Made
Haleakala	2 months in advance 2 days - last minute	recreation.gov
Muir Woods National Monument	50% up to 90 days in advance 50% up to 3 days in advance	gomuirwoods.com or phone
Great Smoky Mountains - Firefly Event Lottery	During an 84 hour period approximately one month before the Firefly Event	recreation.gov phone
Yosemite National Park (Bus parking for Mariposa Grove)	N/A	recreation.gov
Yosemite National Park trial program	N/A	recration.gov or phone
Bruce Peninsula National Park	N/A	online or phone
Ha'ena State Park	1-30 days before reservation	online or phone
Baxter State Park	maine resident - any day after april 1st non resident - 2 weeks before both up untill 3pm the day before	oline or phone
Rocky Mountain National Park	At the start of the month, reservations for the next month, as well as any availabilites for the current month, become available; Ten percent of availabilities become available 48 hours in advance, and can be bought up to immediately beofre the reservation window if spots are still available.	recreation.gov
Acadia National Park	Some available 2 months in advance; rest available 48 hours in advance	recreation.gov

Figure 4.15 Reservation System Comparison Google Sheet: When Reservations are Made; How are Reservations Made

Acadia National Park's policy for how far in advance reservations can be made is modelled off of Haleakalā's system. We see no need for Acadia to alter this policy, as Haleakalā has not felt the need to change it either. Acadia also will be using recreation.gov for making reservations just like Haleakalā and the Yosemite National Park trial program. However, other systems such as those at Muir Woods and Bruce Peninsula also had a phone option for making reservations. This could be beneficial for potential visitors that might need assistance with making a reservation. We would suggest Acadia also attempt to implement reservations made through the phone.

Park Name	Reservation Period
Haleakala	3am to 7am
Muir Woods National Monument	Electric, ADA, short: until end of park hours on reserved day Medium, large: 1 hour 45 minutes
Great Smoky Mountains - Firefly Event Lottery	On the day assigned, must arrive between 6:30pm to 7:30pm Dates are between 3rd week of may to 3rd week of June
Yosemite National Park (Bus parking for Mariposa Grove)	3-hour time period (forfeit if 1 hour late from start)
Yosemite National Park trial program	Guarenteed parking if arrive before 11am. For weekends in august only.
Bruce Peninsula National Park	4 hours (6 different time slots)
Ha'ena State Park	Morning pass: 6:30am to 12:30 pm; Afternoon: 12:30pm to 5:30pm; Sunset: 4:30pm to after sunset; Overnight: depends on reservation
Baxter State Park	N/A
Rocky Mountain National Park	For entering the park between 6 am and 5 pm | Lasts all day | Have a 2-hour window to enter for the reservation
Acadia National Park	Cadillac Mountain: from before sunrise to after sunset | Ocean Drive: 7 am to 5 pm | all day for both

Figure 4.16 Reservation System Comparison Google Sheet: Reservation Period

Acadia allows visitors to make reservations around the times Cadillac Mountain and Ocean Drive are the busiest. For Ocean Drive, the policy assumes that distribution of the length of stay of vehicles would be consistent throughout the day. Our research determined otherwise, so we would suggest breaking down the day into different sections.

Park Name	Reservaion Cost
Haleakala	1 dollar reservation fee per vehicle. $30 entrance fee for automobiles, $25 for motorcycles
Muir Woods National Monument	$8.50 per vehicle and increases $0.50 every two years for short vehicle, 30 for medium, 45 for large. $15 entrance fee.
Great Smoky Mountains - Firefly Event Lottery	$1 application fee, + $24 parking reservation fee
Yosemite National Park (Bus parking for Mariposa Grove)	$6 reservation fee per advance reservation, $35 entrance
Yosemite National Park trial program	$1.50 service fee per reservation, $35 entrance
Bruce Peninsula National Park	11.70 per vehicle, plus 6 for online or 8.50 for phone reservation
Ha'ena State Park	5 per vehicle
Baxter State Park	5 per vehicle
Rocky Mountain National Park	$2 reservation fee, plus a separate pass | $25 for a vehicle |
Acadia National Park	$2 reservation fee | $30 entrance pass for automobiles, $25 for motorcycles

Figure 4.17 Reservation System Comparison Google Sheet: Reservation Cost

For the cost of a reservation, as well as entering the park, Acadia has a similar price plan to Haleakalā and Rocky Mountain. There are differences in the cost, but these are minor on the visitor’s end. We see no reason to alter these price points for the initial implementation of the reservation system.

Park Name	Verification
Haleakala	The person whose name is on the sunrise reservation will need to present a paper copy of the reservation and their photo ID at the entrance station, on the day specified on the reservation. Cars with sunrise reservations will need to display their reservation printouts on their dashboards.
Muir Woods National Monument	Visitors who make their reservations online will receive an email confirmation or confirmation number
Great Smoky Mountains - Firefly Event Lottery	N/A
Yosemite National Park (Bus parking for Mariposa Grove)	N/A
Yosemite National Park trial program	N/A
Bruce Peninsula National Park	Lottery winners must occupy the vehicle and must present photo identification, which matches the name of the lottery winner, before the vehicle is admitted to the parking area.
Ha'ena State Park	N/A
	N/A
Baxter State Park	N/A
Rocky Mountain National Park	Print out permit and have it on the dashboard
Acadia National Park	Physical or digital receipt must be shown at the Entrance Booth

Figure 4.18 Reservation System Comparison Google Sheet: Verification

For verifying a reservation, Acadia requires a physical or digital receipt. This does not specifically match what is done at other parks, however we feel this was an adequate method of verification.

Park Name	When/where is the reservation valid	Weather
Haleakala	3 days starting on the date of first entry, in both park districts. Four different viewpoints, first come first serve.	No refund for bad weather
Muir Woods National Monument	Reservation last until the end of regular park hours on the day of their reservation, regardless of their scheduled arrival time.	
Great Smoky Mountains - Firefly Event Lottery	N/A	No refunds
Yosemite National Park (Bus parking for Mariposa Grove)	Mariposa Grove	
Yosemite National Park trial program	N/A	No refunds
Bruce Peninsula National Park	photo ID and print-out of reservation confirmation	
Ha'ena State Park	N/A	No refunds for bad weather
Baxter State Park	untill 7 am that day	
Rocky Mountain National Park	Provides access to the park, not locations within; If the vehicle entered during their window, they may leave and reenter at their pleasure throughout the rest of the day.	Can cancel reservation at least 72 hours in advance
Acadia National Park	15 minute window to enter with reservation; access to either Ocean Drive or Cadillac Mountian for rest of day. Requires new reservation to reenter area	no refunds

Figure 4.19 Reservation System Comparison Google Sheet: When/Where is the Reservation Valid; Weather

Acadia’s choice of giving vehicles a 15-minute window to get to their reservation is different from how other parks run their systems. We feel that this could be too limiting if there is sufficient traffic in the areas around the entrance stations and increasing this window could be more flexible. The choice of requiring vehicles to make a new reservation to re-enter an area is also an unusual choice, but we do not have concerns with how it will affect visitors. Acadia’s policy of not refunding the reservation fee in case of inclement weather is like all of the other parks we could find data for, and we see no potential complications with the policy.

Park Name	Vehicle has no reservation	Cancelation Fee
Haleakala	Turned away untill 7am	N/A
Muir Woods National Monument	Turned away	Electric, ADA, short: Full refund at least 72 hours in advance, no parking res refund afterwards, changes to reservations can be made without penalty
Great Smoky Mountains - Firefly Event Lottery	N/A	No refunds
Yosemite National Park (Bus parking for Mariposa Grove)	Buses turned away; other vehicles do not require a reservation	No refunds
Yosemite National Park trial program	N/A	No refunds
Bruce Peninsula National Park	N/A	N/A
Ha'ena State Park	N/A	No refunds
Baxter State Park	allowed to take spaces after 7 an	N/A
Rocky Mountain National Park	N/A	Reefunds available if reservaiton is cancelled up at least 72 hours in advance
Acadia National Park	Turned away	No refunds for reservation fee

Figure 4.20 Reservation System Comparison Google Sheet: Vehicle has no Reservation; Cancellation Fee

Acadia's policy of turning away all vehicles without reservations is like Muir Woods, and we see no issue with the policy. Acadia's cancellation fee policy is similar to Yosemite and Ha'ena and given how the reservation fee is only $2 we see no issue with this policy either.

Park Name	Restriction on Vehicles	Parking options
Haleakala	None	N/A
Muir Woods National Monument	no oversized (over 35 ft long)	Electric Vehicle (for charging), ADA, short (under 17 ft), medium (17 to 22 ft), large (22 to 35ft)
Great Smoky Mountains - Firefly Event Lottery	None	N/A
Yosemite National Park (Bus parking for Mariposa Grove)	None	Commercial and Noncommerical Buses
Yosemite National Park trial program		
Bruce Peninsula National Park	None	N/A
Ha'ena State Park	None	6:30am -12:30pm,12:30 - 5:30,4:30-sunset,Overnight parking for campers Limited free parking for Hawaii State Residents (first-come, first-serve)
Baxter State Park	None	N/A
Rocky Mountain National Park	none	N/A
Acadia National Park	Vehicle must be no more than 9 by 18 ft; RVs are prohibited from Cadillac Mountain, and prohibited from using regular parking spots along Ocean Drive	For Ocean Drive, RV's must park either roadside or in special RV spaces. No difference in fees

Figure 4.21 Reservation System Comparison Google Sheet: Restrictions on Vehicles; Parking Options

Acadia's policy of not allowing oversized or Recreational vehicles to use normal parking spaces in Ocean Drive is understandable, as is the prohibition of RVs in the Cadillac Mountain area. Muir Woods also has restrictions on vehicles, so this is not a novel policy. RVs do have limited specific parking in Ocean Drive, however there are no other options for other oversized vehicles. Due to the lack of space to add new oversized parking spaces, we understand the reasoning behind the policy.

Park Name	Who is required to make a reservation	Roadside parking
Haleakala	Those who park atthe sunrise lots, or those who enter the summit district during sunrise hours 3 am to 7 am	N/A
Muir Woods National Monument	all vehicles and shuttle passengers	N/A
Great Smoky Mountains - Firefly Event Lottery	N/A	N/A
Yosemite National Park (Bus parking for Mariposa Grove)	N/A	N/A
Yosemite National Park trial program		
Bruce Peninsula National Park	N/A	N/A
Ha'ena State Park	N/A	No
Baxter State Park	N/A	N/A
Rocky Mountain National Park	All visitors to the park	N/A
Acadia National Park	All vehicles entering Cadillac Summit Road and the Ocean Drive Corridor	Yes, along Park Loop Road

Figure 4.22 Reservation System Comparison Google Sheet: Who is Required to Make a Reservation; Roadside Parking

Acadia's policy on who requires a reservation is like those at Haleakalā and Rocky Mountain, and we see no issue with the policy. Acadia's current plan is to potentially phase out roadside parking in Ocean Drive, depending on the success of the reservation system.

5. Recommendations

5.1 Potential Alterations to Acadia National Park Vehicle Reservation System

The following recommendations revolve around potential alterations to the Acadia National Park reservation system. First, we believe that the reservation system could be improved by adding the option to make a reservation by phone. Currently, the only way to make a reservation is online at reservation.gov. Adding a reservation by phone call method could make it easier for people that are less technologically savvy to make a reservation. Second, we worry that the policy of a fifteen-minute window to make it to a reservation might result in some potential problems for visitors. For example, if there is extensive traffic in or around the park, a visitor may miss their fifteen-minute window to use their reservation. We suggest testing out a longer entrance window for reservations.

Next, based on our observations, we feel that allowing vehicles to stay parked in Ocean Drive for an entire day would negatively affect the maximum amount of reservations that can be made available each day. An overwhelming majority of vehicles stay in Ocean Drive for less than three and a half hours (see Figure 4.9) and limiting the reservations to lasting only 4 hours at most would only affect a small minority. This would allow for more reservations to be made for each day, since no parking spaces would be occupied for more than 4 hours.

Additionally, we recommend a variety of reservation period lengths, 1 hour, 2 hours, 3 hours, and 4 hours, as this would increase turnover of parking spots. If needed a reservation can be added that allows a visitor to stay longer than four hours. Although the percentage of visitors is low, (see Figure 4.9), there may still be a small percentage of visitors that wish to stay for longer than four hours. Based on the reservation length, the reservation fee could be altered. Ideally there would be an increasing reservation fee for longer reservation lengths. Furthermore, we suggest that the park consider that the distribution of different lengths of stay changes throughout the day (as seen in Figures 4.11 to 4.14) when distributing reservations.

5.2 Improving the use of Cameras for Observations

We feel that the use of cameras for observations could be a powerful tool for booth future IQP groups and for Acadia National Park. The following are adjustments to address weaknesses we encountered in our methodology. Our first improvement would be to place the cameras higher up in order to get a better view of the parking lots. We ran into some issues with having cameras closer to the ground such as branches blocking vehicles, and larger/closer vehicles blocking the view of other vehicles. Placing cameras at least 30 feet above the ground would provide a wider view and allow more vehicles to be observed per photo. This would also provide more data for the park; however, this would also require the need to observe more vehicles. We struggled with manually tracking the number of vehicles we did, so an increase in vehicles to track may be tough to handle. Thus, we suggest using a third party to complete the analysis if more vehicles will be tracked. We spoke with a representative from a company named Parquery that specialized in real-time video and image analysis of parking lots, but we could not use their services due to the pandemic’s effects on our project. We would recommend anyone that expands on the use of camera observations to contact Parquery for analysis of parking lots. Having cameras upload photos in real time, while it is not necessary for their services, would be beneficial for both Parquery and manual analysis. We suggest looking into using cameras that have options for data plans, although we recommend looking into the connectivity available around the areas to be monitored. Having cameras that can connect to the internet can result in a drain on the battery, and we did run into issues with the batteries of some of our cameras running low and affecting their performance, such as how often they took photos. If cameras can be placed high enough to have unobstructed access to the sun, we suggest using solar panel add-ons to decrease the possibility of the battery running out. If possible, connecting the cameras to the power grid would also assist with maintaining power in the cameras, and batteries could be used for emergency power instead.

5.3 Evaluation of the Reservation System Dry-Run

In order to evaluate the efficacy of the reservation system's test in October, Acadia National Park will require a comparison of visitor parking behavior before and during the test. To gather this data, we suggest using the observation methods utilized by our project, taking into consideration the recommended improvements we discussed earlier. We suggest the control data be gathered in the week before the test run, in order to mitigate variables relating to the time of the year.

5.4 Improvements for Future Tracking of Vehicles in Ocean Drive

Our efforts to track vehicles throughout the various parking lots of Ocean Drive were unsuccessful, as we encountered substantial issues with parking lot coverage. For any future work involving the tracking of vehicles throughout the area, we recommend a modified method of tracking. Instead of having the cameras observing parking spaces in the lots themselves, we suggest placing the cameras at the entrances and exits of each of the parking lots. Like how we used Cameras 8 and 9, these cameras would use motion sensors to take photos whenever a vehicle enters or exits a parking lot. Because all vehicles in the lots would need to go through the entrance and exit, this would prevent the need for looking over an entire parking lot. This method still allows for determining how long vehicles are in each parking lot, and it should prevent the lapses in data we encountered during our tracking attempts.

6. Conclusion

By providing data on vehicle behavior in Ocean Drive, our group was able to provide vital data for Acadia National Park's reservation system. We were also able to make recommendations on how to fine tune the system's policies to ensure it operates as effectively as possible. We also developed a method of observing vehicles in the parking lots along Ocean Drive. While working out potential issues with it, we made recommendations on how future work on tracking vehicles can be conducted. The methods we used can also be expanded to gather data on additional areas of the park where the reservation system may be implemented in the future, such as the Jordan Pond House area. We also developed a proposal for how cameras can be used to evaluate the efficacy of the vehicle reservation system. With this evaluation method, Acadia National Park can better understand how to improve the system after its test run.

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8. Appendix

8.1 Appendix A: Parking Lot Distribution of Length of Stay

Minutes	Number of Vehicles
0-29	65
30-59	38
60-89	61
90-119	52
120-149	34
150-179	18
180-209	12
210-239	7
240+	15

Cameras 1 and 2 (Sand Beach Parking Lot)

Minutes	Number of Vehicles
0-29	22
30-59	17
60-89	9
90-119	7
120-149	3
150-179	4
180+	5

Camera 3

Minutes	Number of Vehicles
0-29	166
30-59	52
60-89	20
90-119	10
120-149	7
150+	3

Camera 4 (Thunder Hole Parking Lot)

Minutes	Number of Vehicles
0-29	31
30-59	21
60-89	18
90-119	18
120-149	15
150-179	5
180-209	5
210-239	2
240+	5

Camera 5 (Gorham Mountain Parking Lot)

Minutes	Number of Vehicles
0-29	76
30-59	26
60-89	13
90-119	9
120-149	4
150+	6

Camera 6

Minutes	Number of vehicles
0-29	70
30-59	35
60-89	15
90-119	9
120-149	6
150-179	5
180-209	10
210-239	3
240+	16

Camera 7 (Otter Cliff Parking Lot)

8.2 Appendix B: Ocean Drive Distribution of Length of Stay

Minutes	Number of Vehicles
0-5 (No stop)	13
6-29	22
30-59	26
60-89	14
90-119	8
120-149	4
150-179	6
180-209	3
210+	7

Total Loop Time

Minutes	Number of Vehicles
0-5 (No stop)	5
6-29	6
30-59	10
60-89	2
90-119	2
120-149	2
150-179	2
180-209	1
210+	1

Morning

Minutes	Number of Vehicles
0-5 (No stop)	1
6-29	3
30-59	6
60-89	3
90-119	3
120-149	1
150-179	3
180-209	1
210+	1

Lunchtime

Minutes	Number of Vehicles
0-5 (No stop)	6
6-29	11
30-59	6
60-89	8
90-119	3
120-149	1
150-179	0
180-209	1
210+	5

Afternoon

Minutes	Number of Vehicles
0-5 (No stop)	1
6-29	2
30-59	4
60-89	1
90-119	0
120-149	0
150-179	1
180-209	0
210+	0

Evening