Leaving Space to Roost: An Examination of Human Disturbances to Shorebirds in the Minas Basin, Bay of Fundy, Nova Scotia.

By

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Table of Contents

List of Tables

List of Figures

Abbreviations

SRB – Shorebird Resting Beach

STR – Space to Roost

WHSRN – Western Hemisphere Shorebird Reserve Network

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Abstract

Every year, up to 1.4 million shorebirds, such as the Semipalmated Sandpiper (*Calidris pusilla)*, use the Bay of Fundy and the Minas Basin as a stopover site before continuing their transoceanic migration to their southern wintering grounds. According to the 2019 State of Canada's Birds report, shorebird populations have declined an average of 40% since the 1970s due to various threats. One such risk is anthropogenic disturbances to roosting shorebirds on migratory stopover sites. If disturbed while roosting, shorebirds will attempt to avoid the threat, often taking flight and leaving the area in search of a safer roosting site. This unnecessary energy expenditure is detrimental as it depletes the fat stores used to supply them with enough energy to complete their migration. This research aimed to identify the frequency and nature of anthropogenic disturbances to roosting shorebirds caused by recreational beach users in the Minas Basin, Nova Scotia, Canada. It also examines the level of awareness and the attitudes the users have toward migratory shorebird conservation issues in the area. Through observation of disturbances at roosting sites, it was determined that the three recreational activities which cause the most disturbance to shorebirds in the Minas Basin are: walking, fishing, and wildlife photography. This finding in the 2020 season was consistent with disturbance data dating from 2016 onward. Surveys were conducted with recreational beach users, finding that many users were aware of migratory shorebirds in the Minas Basin but did not know about the detrimental effects of human disturbances.

Keywords: Shorebird Conservation; Migratory Shorebirds; Human Disturbance; Minas Basin; Bay of Fundy; Conservation; Roosting Shorebirds; High Tide Roosting.

Chapter 1 – Introduction

Along with countless other species of the world, various shorebird species are facing significant population decline. Since the 1970s, shorebird populations have decreased by an average of 40% (NABCI Canada, 2019). In particular, the Eastern Canadian Semipalmated Sandpiper (*Calidris pusilla)* population levels have seen a decline of 80% in the past two decades. These shorebirds have an extensive migratory range in which they nest in the arctic and subarctic regions of Canada and winter in the Caribbean and northern South America. Migratory shorebird populations often face numerous threats throughout their migratory range.

In many cases, these plights are unique to shorebirds. Shorebirds, including the Semipalmated Sandpiper, typically have long life spans with low recruitment levels, lengthy and energetically demanding migratory flights, and are restricted to a few critical habitats, including the Bay of Fundy (Fernández & Lank, 2008). The Minas Basin, and Bay of Fundy at large, function as a stopover site for migratory shorebirds, including large groups of Semipalmated Sandpipers. The mudflats and shorelines of the Bay of Fundy provide foraging and roosting spaces for the shorebirds, allowing them to accumulate sufficient energy to successfully migrate to their southern wintering grounds (Bay of Fundy, n.d.-b). Threats facing these shorebirds stemming from climate change include sea-level rise, coastal erosion, and increased temperatures. Shorebirds are also faced with several anthropogenic threats, including reduced viable habitat due to coastal development, the hunting and harvest of shorebirds, and human disturbances on critical habitat (NABCI Canada, 2019). Although migratory shorebird populations face many threats that can potentially cause population decline, this research will focus primarily on disturbances caused by human recreational activities on four beaches in the

Minas Basin of the Bay of Fundy, Nova Scotia, Canada. These sites include the Guzzle, Avonport, Evangeline, and Blue beaches (see Appendix C).

1.1 Threats to shorebirds – Loss of habitat

As coastal areas worldwide see an increase in development, wildlife is often left with less space for critical habitat. In coastal areas, the development of residential neighborhoods and cottages, agricultural intensification, and industrial expansion have led to an increase in the availability of coastline for anthropogenic users. These issues cause a reduction in the available habitat necessary for shorebirds to roost and feed during their migratory stopovers, such as in the Bay of Fundy ("Bay of Fundy," n.d.-a; Fernández & Lank, 2008). Shorebirds depend on coastal and interior wetland habitats, many of which have already experienced deterioration and loss (Fernández & Lank, 2008). These intertidal habitats are threatened by coastal development globally (Burger et al., 2018). Through theoretical modeling, it has been predicted that tidal mudflat habitat will continue to be lost in the future, which would cause a higher density of shorebirds to be confined to smaller available areas. In turn, this may result in higher mortality, and further population decline as competition for food and predation intensity would increase as more shorebirds are forced to occupy the same space (Murray et al., 2018). Many shorebirds, such as the Semipalmated Sandpiper, rely upon multiple staging, nesting, and wintering grounds in different countries due to their migratory nature. As such, the restoration and conservation of habitat, especially undisturbed habitat, throughout their migratory range are critical to halt the population decline of many shorebird species (Jehl, 2007; Burger et al., 2018).

1.2 Threats to shorebirds – Effects of Climate Change

Extreme weather events are becoming more frequent due to climate change, affecting many ecosystems and populations. An increase in the frequency of these events can cause habitat

to become degraded and impact the overall fitness of an individual. These events include changing weather patterns and more frequent coastal flooding due to sea-level rise (Barnard et al., 2019). Flooding events will impact shorebirds when selecting habitat to nest, roost, and forage (Bailey et al., 2019). In the future, the sea level is predicted to increase within the range of 0.18 to 1.80 meters, reducing the intertidal area (Mann et al., 2017). Mann and colleagues (2017) determined that adult Semipalmated Sandpipers arriving at the Bay of Fundy early in the migration period experienced more extreme tides, defined by tides greater than 15 meters. Those shorebirds experiencing more extreme tides remained in the Bay of Fundy for an additional 8.1 days on average. During extreme tides, the shorebirds were more likely to flock over the ocean for extended periods, leading to increased energy expenditure during the high tide. Therefore, the shorebirds must remain at their stopover sites for extended periods to make up for the energy deficit generated during high tide flights (Mann et al., 2017). As sea levels continue to rise, shorebirds will likely have to extend their stay in the Bay of Fundy and other stopover sites to accommodate for lost energy and roosting time.

Rising sea level also poses issues for other trophic web members, thereby influencing the potential fitness of the shorebirds. One such case is that of the Horseshoe Crab in Delaware Bay. The effects of rising sea levels, such as extreme tides and increased erosion, have led to a loss of critical habitat for the Horseshoe Crab (Smith et al., 2017). In turn, this has resulted in reduced food availability for Semipalmated Sandpipers, as they will often stopover in Delaware Bay during their arctic migration to feed on the eggs from spawning Horseshoe Crabs (Burger, 2018; Burger et al., 2018). In an effort to improve the spawning habitat for the Horseshoe Crab and, therefore, shorebird feeding habitat, Smith and colleagues (2020) replaced shoreline rubble with sand. Beaches with sand added that was coarse-grained and a similar or larger size to that of sand

native to the area had the most significant results with higher egg cluster abundances (Smith et al., 2020). Conservation efforts such as habitat and beach restoration are beneficial to many species, and in Delaware Bay are imperative for ensuring that the Horseshoe Crab can thrive, and therefore, produce a food-source that sustains migrating shorebirds.

At low tide in the Minas Basin, migratory shorebirds will typically forage intensively on small amphipods, biofilm, and insect larvae. *Corophium,* a type of mud shrimp, is one of the most abundant organisms distributed throughout the mudflats in the North Atlantic and makes up a large portion of the migratory shorebirds' diet (Hamilton et al., 2006; Tillin & Ashley, 2018). *Corophium volutator* populations in the Bay of Fundy reproduce from July to September. The males will move over the surface of the mudflat to find burrows containing reproductive females, making them an available food source for foraging shorebirds during this period (Tillin & Ashley, 2018).

Corophium is an important food source for many migratory shorebirds but is vulnerable to the effects of climate change. An increased water flow rate due to climate change-induced sea-level rise could cause the *Corophium* to be washed away from their burrows while swimming, increasing their mortality rate. Climate change may also lead to more instances of eutrophication, potentially leading to algal blooms and deoxygenation of the water (Nazari-Sharabian et al., 2018). If eutrophication were to occur in *Corophium* habitat, the local populations could be at risk of hypoxia, potentially leading to high rates of mortality (Tillin & Ashley, 2018). Significant disruptions to the *Corophium* population may limit the foraging success of shorebirds at stopover sites, thus impacting their ability to prepare for migration adequately.

With increasing temperatures associated with climate change, the phenology of organisms such as *Corophium* may be affected, leading them to breed at different times of the

year (Reneerkens et al., 2016). This alteration could lead to a phenological mismatch in which the shorebirds arrive when the Corophium is not breeding and are, therefore, not readily available. Reneerkens and colleagues (2016) described a case in northeast Greenland in which an invertebrate prey of Sanderlings, similar to that of *Corophium volutator* and the Semipalmated Sandpipers, emerged earlier each year for the course of the study. However, the hatching date of the Sanderlings did not adjust to reflect this shift. Due to this lack of change, Sanderling hatches were occurring increasingly after the maximal prey abundance (Reneerkens et al., 2016). Kwon and colleagues (2019) also investigated phenological mismatches between shorebirds and their invertebrate preys in the Arctic. The researchers found the most significant mismatches at easterly latitudes and determined this may be related to population declines found in only the eastern portion of two of the study species' range. Therefore, these shorebird populations, including that of the Semipalmated Sandpiper, may have demographic consequences due to phenological mismatches in the Arctic (Kwon et al., 2019). Suppose this were to occur in the Bay of Fundy, affecting available food sources for the migrating shorebirds. In that case, the shorebirds may not be able to forage enough to store sufficient energy to conduct their migration. However, due to the broad diet of Semipalmated Sandpipers, it is likely that if this were to happen, the shorebirds could potentially rely on other dietary options such as biofilm to meet their needs (Quinn et al., 2017).

1.3 Threats to shorebirds – Shorebird harvest

Hunting and harvest is another factor in the decline of shorebird populations. This includes subsistence, commercial, sport, recreational, nuisance, and control hunting. Shorebird hunting is legal in some jurisdictions and prohibited in other portions of their migratory range. Illegal hunting and the over-harvesting of shorebirds is detrimental to the recovery of declining

shorebird populations (Watts & Turrin, 2016). Shorebird hunting often occurs in the Caribbean and northern South America (Reed et al., 2018). Reed and colleagues (2018) used stable hydrogen isotopes to determine where harvested shorebirds originated. It was determined that most of the harvested birds, including Golden-Plovers, Stilt Sandpipers, and Short-billed Dowitchers, were primarily from breeding ranges in eastern Canada (Reed et al., 2018). It is imperative to understand the connectivity of the migratory pathway and which populations are most vulnerable to harvest, as it can occur throughout many jurisdictions, thus hindering conservation efforts. Population declines have been reported in 65% of Nearctic-breeding shorebirds, which utilize the Atlantic Flyway as their migration route (Reed et al., 2018). This decline is alarming, especially in the context of harvesting pressures, as Watts and colleagues (2015) have suggested that several species of shorebird have an extremely low tolerance to these pressures, indicating that the population will not be able to recover readily.

One challenge to mitigating hunting and harvesting pressures on shorebird populations is the sizeable migratory range of the birds, allowing them to pass through many different jurisdictions with varying laws and enforcement. Additionally, it is difficult to accurately determine the extent of harvest and its effect as a population driver due to a lack of information on annual harvest rates in each country (Watts & Turrin, 2016). Watts and Turrin (2016) evaluated the policies relating to the harvest of migratory shorebirds in jurisdictions across the Western Hemisphere. The vast majority have signed at least one international treaty to protect migratory birds. However, approximately one-half of jurisdictions completely prohibit shorebird hunting while many have limited to no protection policies in place. It is common for jurisdictions to have hunting seasons allowing for shorebird harvest within certain restrictions (Watts and Turrin, 2016). It is imperative to determine the capacity for sustainable harvest of shorebirds and

ensure these limits are enforced throughout the migratory range. Cooperation amongst all countries along the migratory path is necessary to ensure the conservation and stewardship of shorebirds, thereby allowing for population recovery.

1.4 Threats to shorebirds – Human disturbances

The shorebirds using the Bay of Fundy as a stopover site remain for approximately three weeks before continuing their southward migration. In this time, they must develop an energy store adequate for their three-day southern migration. However, the coastal areas shorebirds typically use for roosting often overlap with areas frequented for summer recreational activities (Fahey, 2020). This overlap can put intense pressure on the shorebirds, as they are more likely to be disturbed and expend energy via avoidance behaviours when sharing a space with recreational users. The Atlantic Flyway Shorebird Initiative, shorebird researchers, and land managers have identified human disturbances to shorebirds as one of the most significant threats they face (Mengak & Dayer, 2020).

Shorebirds must be able to find sufficient habitat that is relatively undisturbed to succeed in their southern migration. Weston and colleagues (2012) have proposed that high levels of disturbances along shorelines can decrease habitat quality. This could potentially reduce the carrying capacity of such habitat, in turn detrimentally affecting shorebird populations. If there is a high level of disturbance in a coastal area, such as a significant presence of recreational activity, shorebirds may avoid the area, thereby excluding themselves from roosting or feeding there. Further, the shorebirds could spend the majority of their time searching for undisturbed and unused areas, causing them to expend energy unnecessarily (Mengak & Dayer, 2020). Burger and colleagues (2004) examined the trends of human disturbance to shorebirds in Delaware Bay. Using data from 1982-2002, the authors examined human disturbances before

and after the implementation of conservation measures. These measures restricted human activities and access to the beaches in Delaware Bay, similar to those implemented by Birds Canada in the Minas Basin. In the 1980s, before conservation measures were implemented, shorebirds in Delaware Bay were often disturbed for over 40 minutes per hour, with an average disturbance duration of over 10 minutes (Burger et al., 2004). Through education of local people and eco-tourists, restricting access, building viewing platforms, patrolling beaches, and issuing summons for violators, the number of disturbances and the average time that birds were disrupted per hour in Delaware Bay declined. The results from this investigation by Burger and colleagues (2004) highlight the importance of implementing conservation measures to reduce the frequency and duration of human disturbances to shorebirds.

Both naturally occurring and anthropogenic disturbances can cause issues for shorebirds. Naturally occurring disturbances are those caused by other wildlife or nonhuman sources, such as avian predators or nonpredators including other shorebirds. Regardless of the origin, the disturbances can reduce energy stores, as the birds use precious energy to avoid a disturbance and occasionally travel to a new, safer location. A reduction of fat stores will lessen the likelihood that the shorebirds will successfully survive their transoceanic migration to wintering grounds in South America. The more frequent the disturbance to the shorebirds, and the more dramatic their evasion, the worse their chances of surviving the migration becomes (Lilleyman et al., 2016). Therefore, anthropogenic disturbances are of particular interest as they are one threat to shorebirds that can be mitigated and have almost immediate positive effects. Through education and outreach initiatives, recreational beach users are more likely to refrain from disturbing birds and understand the consequences of disturbance and how to avoid causing it (Fahey, 2020). This would allow for a reduction or elimination of disturbances, benefitting

shorebird populations and allowing them to roost uninterrupted. Unlike the aforementioned threats to shorebirds, efforts to mitigate and reduce disturbance can be more easily introduced.

1.5 Importance of Shorebirds

Some shorebird species have been used as ecological indicators, allowing for a better understanding of particular ecosystems. Shorebirds have been described as 'mud specialists' and are indicators of mudflat ecosystem functioning (Mathot et al., 2018). This could include the vast mudflats of the Bay of Fundy. Shorebird foraging behaviors and patterns are dependent upon food availability and community structures in intertidal zones. The presence of foraging shorebirds can influence both physical and chemical processes occurring in mudflats and can play an important role in local food webs (Mathot et al., 2018).

Shorebirds can also be a particular attraction for eco-tourists to an area as many photographers, naturalists, and birders are drawn to see the flocks of birds. Large flocks of shorebirds flying together are a beautiful sight and offer a unique experience for eco-tourists (Hevia & Bala, 2018). As the Bay of Fundy hosts thousands of shorebirds each summer, the promotion of such an activity would potentially encourage additional eco-tourists to visit the area in the summer months. However, it must be an appropriately managed attraction to ensure that the shorebirds are not being unnecessarily disturbed and are able to feed and roost as necessary. This is achieved at Johnson's Mills Shorebird Reserve and Interpretive Centre in the Shepody Bay of the Bay of Fundy, New Brunswick (Nature Conservancy Canada, n.d.). Allowing for eco-tourists to witness the shorebirds in their natural environment while also encouraging responsible behaviors to maintain conservation measures will foster a connection with nature and wildlife while functioning as an economic draw for the tourism industry.

1.6 Management Problem and Research Objectives

This research seeks to explore the question: to what extent do the recreational users in the Minas Basin disturb the shorebirds using the area to roost and conserve energy? Sub-questions would examine the differences in the frequency of disturbances between recreational activity groups, and the extent to which the conservation measures put into place by Birds Canada, including shorebird resting beaches (SRBs), are effective in reducing anthropogenic disturbances to shorebirds. To achieve this, disturbances to roosting shorebirds were observed on four predetermined beaches in the Minas Basin: the Guzzle, Avonport, Evangeline, and Blue beaches. Two of these sites, the Guzzle, and Avonport beach have conservation measures implemented by Birds Canada to reduce disturbance. Data collection included recording disturbances with natural origins (such as a predatory bird), anthropogenic origins (such as a recreational user of the beach), or unknown origins. Anthropogenic disturbances were categorized based on the recreational activity the disturber was performing. This data was then used to determine whether there was a difference in the frequency of disturbances between recreational activities. Additionally, surveys were given to recreational users of the space to ascertain their understanding of their impacts on the shorebirds and what they think of existing conservation efforts in the area.

Chapter 2 – Context

2.1 Shorebirds and the Minas Basin

The Bay of Fundy is a unique landscape feature situated between New Brunswick and Nova Scotia and is home to the world's highest tides. The Bay of Fundy has a massive tidal change, due to the natural shape and length of the Bay (Garrett, 1972). In part due to these tidal changes, it is a popular annual stopover site for thousands of shorebirds before they perform an almost 5000-kilometer migration to their southern wintering grounds, such as the countries of Suriname and French Guiana (Anderson et al., 2019). The flocks which utilize these stopover sites, including the Minas Basin, are primarily composed of Semipalmated Sandpipers. The migratory shorebirds undertake this migration as a non-stop flight, typically over the Atlantic Ocean. As such, these birds require a significant store of energy to ensure a successful migration.

The Bay of Fundy mudflats have an abundant availability of food. Many shorebirds, such as the Semipalmated Sandpiper, forage for a wide variety of prey items, such as C*orophium*, arachnids, crabs, bivalves, and cnidarians, and have thus been identified as generalist foragers (Gerwing et al., 2016). The extreme tides of the Bay uncover approximately 80,000 hectares of mudflats during low tide, making it an ideal location for the shorebirds to double their weight, allowing them to complete their migration ("Bay of Fundy," n.d.-b).

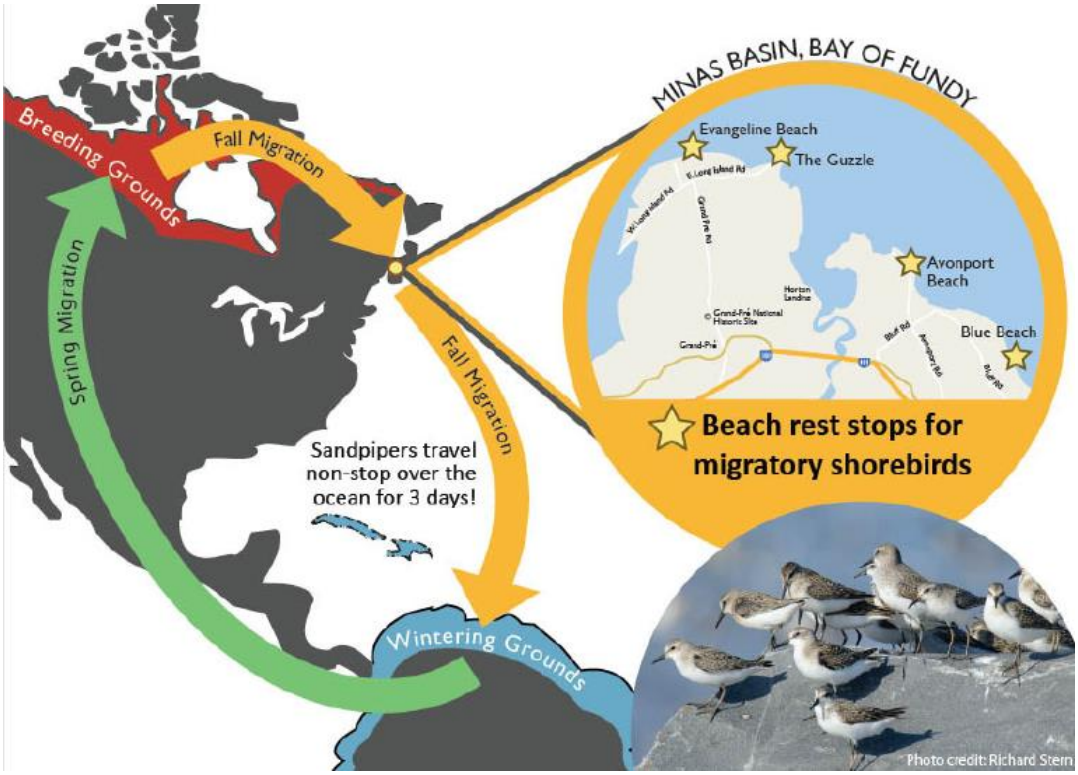

Figure 1: The infographic displayed on the Space to Roost project handouts detailing the migration route of the shorebirds. Also shown is the location of the project sites noted by stars on the inset map (Source: Birds Canada).

The Bay of Fundy acts as an essential last stopping place for shorebirds before undergoing their migration (Figure 1). Semipalmated Sandpipers cannot swim well and therefore require enough energy to fly non-stop over primarily open ocean. During their migration, Semipalmated Sandpipers will fly for three to four days at 50 kilometers per hour (Lilleyman et al., 2016). Utilizing radiotelemetry and field-readable markers, Neima and colleagues (2020) found that on average, the Semipalmated Sandpipers would use between one and four sites per day in the Bay of Fundy for roosting and feeding. It was also found that 97% of the shorebirds would return to the same areas each year. Therefore, Neima and colleagues (2020) concluded that due to high regional fidelity, conservation initiatives must be conducted at local and regional levels to provide productive areas for the birds to return to in future years.

2.2 Bay of Fundy Shorebird Conservation Efforts

The Bay of Fundy hosts large populations of shorebirds annually, with approximately 70% of the eastern population of Semipalmated Sandpipers using the region as a stopover site each summer ("Bay of Fundy," n.d.-b). The Minas Basin was inducted into the Western Hemisphere Shorebird Reserve Network (WHSRN) along with Shepody Bay in New Brunswick in 1987 – becoming the first Canadian WHSRN site and the second site of the network ("Bay of Fundy," n.d.-a) (Figure 2). In collaboration with partners throughout the Western Hemisphere, WHSRN aims to protect and conserve critical habitat for migratory shorebirds, such as the Semipalmated Sandpiper. Through the network, approximately 15 million hectares of shorebird habitat have been protected in 101 sites across 15 countries, including Canada, the United States, and Brazil. Together, the Minas Basin and Shepody Bay protect approximately 62,000 hectares of critical stopover habitat for migratory shorebirds ("Bay of Fundy," n.d.-a).

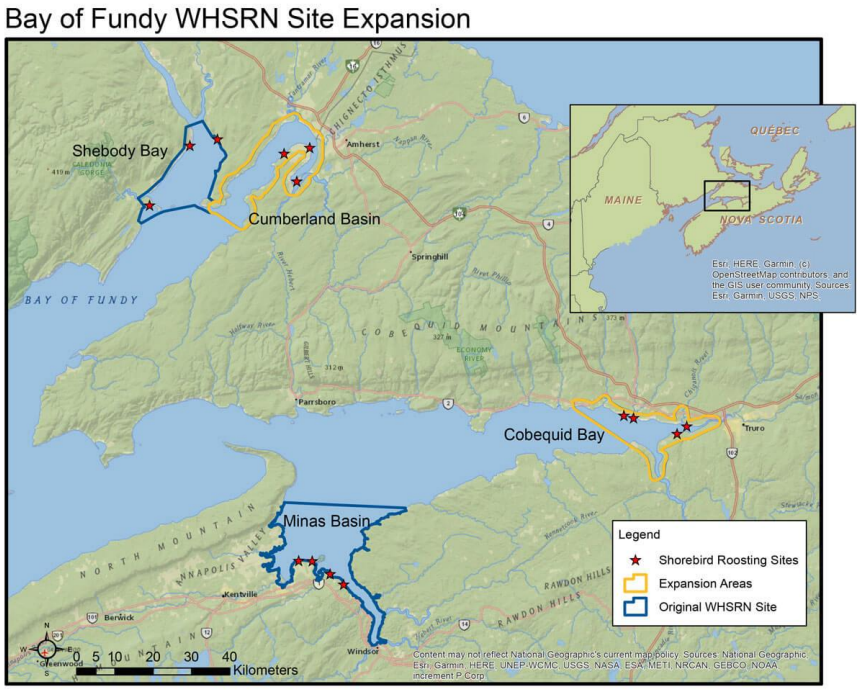

Figure 2: A map of the Bay of Fundy WHSRN sites. The Minas Basin is shown in blue in the lower half of the map. Red stars in this area indicate Space to Roost project sites (Source: "Bay of Fundy," n.d.-b).

An additional conservation effort occurring in the Bay of Fundy is the purchasing of vital habitat areas, including roosting beaches, by organizations such as the Nature Conservancy of Canada ("Bay of Fundy," n.d.-a). Preserving this habitat for shorebirds will reduce disturbance from recreation along the shore and prevent the development of the area, thereby providing a zone in which shorebirds can roost and feed without interruption. As previously mentioned, shorebirds have high site fidelity and return to the same area in the following years, so this habitat must be protected to ensure the shorebirds can successfully return in the future (Neima et al., 2020).

2.3 The Birds Canada Space to Roost Project

The Space to Roost (STR) project is implemented annually in the Minas Basin by Birds Canada (formerly Bird Studies Canada). The project began in 2017 after baseline disturbance data was collected and consultation with local beach users and stakeholders occurred in 2016. The STR project aims to provide an area of shoreline free from human disturbance for the shorebirds to use as roosting habitat during the high tides of the migratory season. To achieve this, signs are placed along beaches, indicating that a section of the beach is closed for two hours before and two hours after high tide throughout August (Figure 3). Each sign displays a map of the respective beach, with the designated shorebird resting beach (SRB) highlighted in red to ensure that beachgoers are aware of which beach to avoid (Birds Canada, n.d.). The signs also include a table showing the four-hour period around high tide each day in which the shorebirds are most likely to be roosting. This is displayed in the blank section of figure 3.

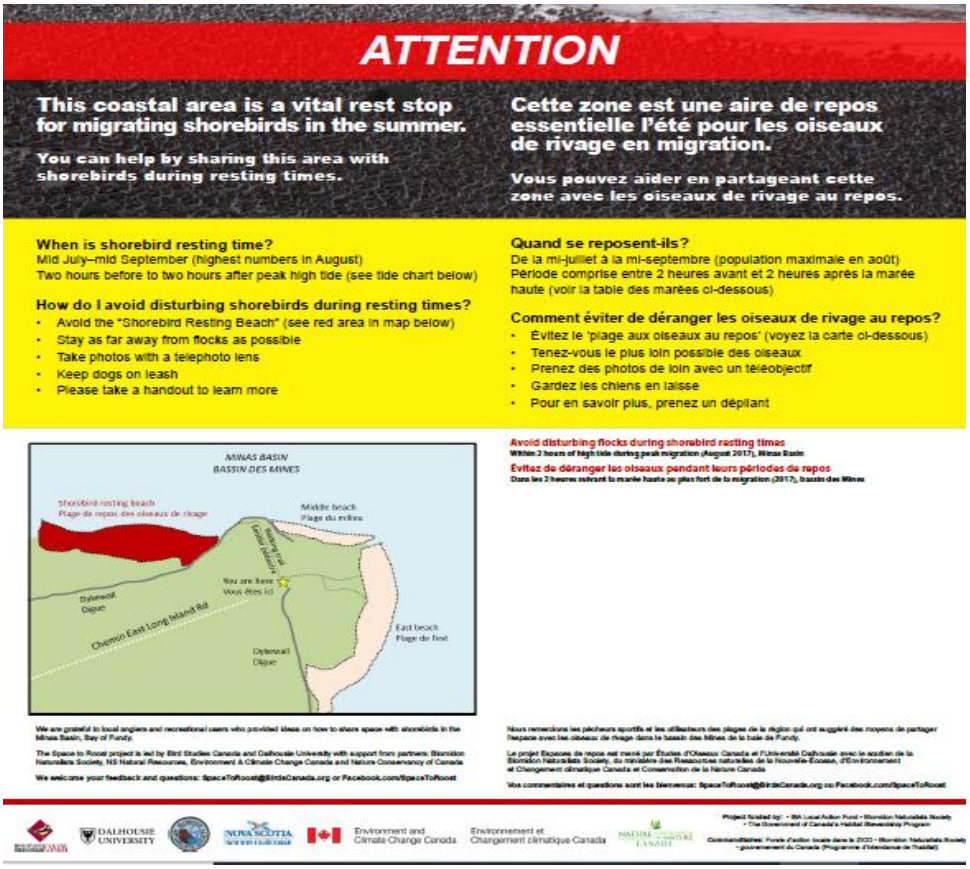

Figure 3: The text found on the STR project signs placed at each site, highlighting the SRB in red and giving key information. Pictured is the text for the signs placed at the Guzzle site (Source: Birds Canada).

The STR project implements conservation measures on two sites: the Guzzle and Avonport Beach. Throughout August, Birds Canada, in partnership with organizations such as the Blomidon Naturalist Society, Environment and Climate Change Canada, the Nova Scotia government, and the Nature Conservancy of Canada, asks all beachgoers to voluntarily avoid using the designated beaches for two hours before and after high tide (Birds Canada, n.d.). There is no active enforcement of the SRBs, and these measures are entirely voluntary. As such, no one is penalized for utilizing the space when advised otherwise.

While the signs put in place at the entrance to the beach and before accessing the SRB may deter individuals from using the beach during high tide, there can also be significant influence from other beach users who act in accordance with the STR project. According to the

social normative theory in social psychology, when potential violators are faced with others following the rules, they are more likely to adhere to them due to societal norms and pressures (Fahey, 2020). The STR project has excellent support from much of the local community who frequently visit the beaches. This allows for the enforcement of the SRB restrictions via social norms, as these individuals avoid the SRB, and encourage others in the area to support the project. Public support is beneficial to the project, as local supporters will help enforce the boundaries regardless of whether there is a representative of Birds Canada present on site. These acts of stewardship are valuable to the shorebirds using the area, as they are less likely to be disturbed and will have an available beach for roosting when they are in the area.

2.4 Introductory Conclusions

Global shorebird populations are in decline, including those that use the Minas Basin of the Bay of Fundy as a stopover site. Along their migration, shorebirds face many threats, such as habitat loss due to climate change and coastal development, harvesting and hunting, and anthropogenic disturbance. Before departing on the most considerable portion of their migration, the shorebirds use the Minas Basin of the Bay of Fundy as a stopover site to roost and build enough fat stores to last their migration. Therefore, the shorebirds must be allowed to roost undisturbed to metabolize their food and conserve their energy. Conservation measures such as the Space to Roost project are integral to the recovery of shorebird populations through the reduction of anthropogenic disturbances to roosting shorebirds. Countries in the Western Hemisphere must work together to improve conditions for the future of shorebirds, such as Semipalmated Sandpipers.

Chapter 3 – Methodology

3.1 Historical Data

In 2016, Birds Canada collected baseline data in preparation for the implementation of the STR project. At this time, data was collected at four sites in the Minas Basin: The Guzzle, Avonport, Blue, and Evangeline beaches. The following year, Birds Canada implemented the project at the Guzzle and Avonport Beach. Disturbance data were only collected at these two sites from 2017 to 2019. This past data was incorporated into the current research to allow for annual disturbance trends to be analyzed. In 2020, data was collected on all four original beaches. The researcher would visit each beach for the high tide period – two hours before and two hours after high tide throughout August – and perform disturbance surveys (see section 3.2). After 2016, each subsequent year utilized very similar data collection methods, up to and including data collected in 2020.

3.2 Collection of Disturbance Data

As in previous years, shorebird disturbance data was collected at four sites in the Minas Basin: the Guzzle, Avonport, Evangeline, and Blue beaches. Data collection occurred throughout August during the two hours before and after high tide and was dependent upon local weather conditions. One site was surveyed for the entire four-hour period, and each day a different site would be selected, with a preference for the Guzzle and Avonport beaches, as these two sites had SRBs in place as a conservation measure as well as open beaches, allowing for both situations to be observed. In contrast, Blue and Evangeline beach had no protective measures. The weather, tide times, date, location, and Beaufort wind scale were recorded before and after collecting data and conducting surveys. The number of recreational users present on the beach and their location was recorded every half hour. Each person on the beach was classified based upon their primary

recreational activity and was placed in one of the following categories: walker, unleashed dog walker, leashed dog walker, recreational fisher, birder, photographer, swimmer, sunbather, boater, and other vehicle users. The number of rods being used by anglers and the number of vehicles on-site such as kayaks, bikes, or stand-up paddleboards were also recorded. Throughout data collection, the number of shorebirds was recorded for each beach, and their behavior was categorized as either feeding, roosting, or flying. The shorebird behaviour was recorded based upon which activity the birds were conducting. If multiple behaviours were observed, the number of birds performing each behaviour would be recorded. This data was recorded every 30 minutes.

Throughout the four-hour survey period, all disturbances to shorebirds were recorded. A disturbance was identified based upon an unsettling of the shorebirds for any reason. For each disturbance, the time of disturbance, area of the beach, the origin of disturbance, number of birds disturbed, and their behavior was recorded. The origin of the disturbance was classified based upon the initial action that caused the disturbance. It could then be attributed to a recreational group, an unknown cause if there was no obvious source of disturbance, or natural origins, such as other predatory or non-predatory birds. The behavior of the birds was categorized as either being alert, moving away from the disturbance without flight, flushing and returning to the site, or flushing and leaving the site.

3.3 Analysis of Disturbance Data

The disturbance data collected between 2016 and 2020 was compiled according to the year and survey site. Total disturbances were determined for each site, year, and cause of the disturbance. The origin of the disturbance was categorized based on whether the roosting shorebirds were disturbed by a person, a natural source, or an unknown cause. Data analysis was

conducted on each disturbance category, including determining the frequency of disturbances and percent change over the course of the study. Statistical analyses included t-tests and analysis of variance to determine the significance of differences between categories.

3.4 Creation of Surveys

Two questionnaires were developed to survey recreational beach users. One was created for users of the Guzzle and Avonport beaches, which have protection measures for roosting shorebirds (see appendix A). The second questionnaire was created for users of Blue and Evangeline beach, which do not have any protective measures in place (see appendix A). Two versions of each survey were made – one for in-person interactions and an online version. The online survey was created on the Opinio platform through Dalhousie University. Each version had the same questions, but the different formats were implemented to reach a larger number of participants.

3.5 Collection of Survey Data

Surveys were conducted in person at each site throughout August 2020. According to Nova Scotia and Dalhousie recommended Covid-19 regulations, at least two meters of distance was kept between the researcher, participants, and all other recreational beach users. Each survey was conducted outdoors; however, the researcher had a mask with them at all times to ensure the safety of those in the area and to use if the two-meter physical distancing protocol could not be followed. The researcher approached individuals using the beach space and asked whether they would be willing to do a survey. If the participant agreed, the survey's purpose and consent form was explained before beginning the survey. The researcher verbally asked the participant each question and recorded their answers if they were comfortable doing so as an additional

precaution against Covid-19. Upon completing the survey, the participant was thanked, and the questionnaire was stored until it was analyzed.

Surveys conducted online using the Opinio platform were advertised at each site with a poster detailing the study (see appendix B). A sign was posted at the entrance to each site to allow for interactions with all beach users. These advertisements were only displayed at each research site and were not advertised online to ensure that each participant was an active recreational user at the specified site. A QR code was included on the poster to allow individuals to scan the poster with their cellphone and automatically access the survey. These online surveys catered to the respective site, with one survey being created for users of the Guzzle and Avonport beaches and one for those using Blue and Evangeline beaches. Recreational beach users were then able to access the survey from their homes or on-site when the researcher was not present. The signs advertising the online survey were removed from the sites at the end of the data collection period. The online surveys were also closed to prevent further surveys from being completed.

3.6 Participants

The requirements for individuals to participate in this research were that they consented to their responses being used and analyzed for research purposes and that they were active recreational users of one of the four study sites. Those who completed the surveys in-person were chosen via haphazard sampling while recreationally using one of the beach sites. The participants were able to withdraw from the survey at any time before completing and submitting their survey.

3.7 Analysis of Survey Data

The survey data collected in person was digitized, and paper copies were shredded. Data from the online surveys were downloaded and converted into an excel format to match the in-person survey data. The survey responses were compared via statistical analyses to determine the extent of the differences between the surveys' answers. The average and frequency of answers were also recorded. For qualitative questions, the responses were coded based on general themes common to all answers to compare the two surveys.

3.8 Limitations

While incorporating historical data into the current research allows for the analysis of yearly trends in the Minas Basin, this data also has limitations. As various researchers over multiple field seasons collected the data, it is impossible to ensure that data collection techniques were conducted in the same manner for each field observation. Additionally, it can be challenging to interpret years-old data collected by others, especially from the first year, when data collection methods were being adjusted to become more efficient.

An additional methodological limitation is how the number of recreational users was recorded. Users were recorded every half hour during beach surveys. Only individuals on the beach at the time of the survey were recorded. If individuals used the beach between survey times, they would not be included in the data. Further, if the individual is on-site but not on the beach, they were omitted. For example, if an individual were on the dyke during a Guzzle survey rather than on the beach proper, they would be excluded from the data, despite them being on-site. This was the case for many birders and photographers at the Guzzle, who stayed primarily on the dyke rather than going onto the beach. However, the data makes it seem as though there are fewer birders and photographers than were actually on-site due to the chosen method.

Therefore, the data regarding the number of individuals on-site is not representative of everyone present, just those on the beach at the moment of the survey.

Utilizing an online survey as an option for participants was beneficial. It allowed for data to be collected when the researcher was not on-site or while the participant was at home. Signs advertising the online survey were posted at the entrance to each site, allowing for greater visibility of the posters to each person using the site, regardless of recreational activity. However, due to strong winds, there were multiple occasions when the signs would blow away. Due to the temporary nature of the poster, a more permanent sign was not constructed to advertise the online survey. While the signs were replaced as often as possible and necessary, there may have been times when there was no advertisement present on-site. The researcher did not visit each site every day, so potential participants could have missed the opportunity to complete the survey due to an absent poster. Additionally, recreational users could potentially share links with other individuals to complete the survey. However, it seems unlikely that this was the case with any of the surveys.

A limitation of conducting surveys of this nature is the resulting self-selection bias. Consent is required to survey any participants; however, not everyone is willing to participate in such research. It is possible that because of this bias for self-selection that a representative view of the population was not obtained (Heckman, 1990; Bethlehem, 2010) and instead gave a distorted view of the recreational users of the beach sites. As such, those beach users who are more conservation-minded may have chosen to complete the study, while those who were not interested may not have had such concerns for the shorebirds. Therefore, the survey results could potentially be biased based upon the participants who chose to complete the surveys, unintentionally excluding those with potentially differing opinions.

Chapter 4 – Results

4.1 Disturbance Data

4.1.1 Shorebird Presence in the Minas Basin

Since 2016, over a million shorebirds have used at least one of the four study beaches as a stopover site to roost and feed before continuing their migration (Table 1). The highest recorded number of shorebirds on each beach was selected to represent the total count for the day. This was done to avoid artificially high numbers from counting the same shorebirds multiple times. Due to the methodological limitations of the study, site surveys were conducted assuming that the shorebirds did not use multiple sites throughout their stopover.

Table 1: The number of shorebirds recorded on each study site throughout August from 2016 to 2020.

	2016	**2017**	**2018**	**2019**	**2020**	**Total**
Guzzle	119,879	71,324	59,437	120,329	40,700	411,669
Avonport	197,446	733,460	190,488	24,400	20,050	1,165,844
Blue	13,344	-	-	-	1,444	14,788
Evangeline	90,478	-	-	-	3,850	94,328
Total	**421,147**	**804,784**	**249,925**	**144,729**	**66,044**	**1,686,629**

Over the past five years, Avonport has been the most popular roosting site (n=1,165,844), with the Guzzle having the second-highest shorebird numbers (n=411,669). Although there is only data available for both Blue and Evangeline beach in 2016 and 2020, these two beaches have lower numbers of shorebirds than both the Guzzle and Avonport. This can also be seen in the average number of shorebirds per year on the Guzzle (μ=82,333.80), Avonport (μ=233,168.80), Blue (μ=7,394), and Evangeline beach (μ=47,164). There was no significant difference between the average number of shorebirds observed per year ($F(4,9) = 1.86$, $p = .20$). Although shorebirds were prevalent in the Minas Basin, the lowest total numbers for each site were recorded in 2020 (n=66,044). The highest numbers were recorded in 2017 (n=804,785),

despite only two beaches being surveyed. The average number of shorebirds recorded each year was 337,325.80.

Table 2: The number of site visits conducted annually throughout August for each study site.

	2016	**2017**	**2018**	**2019**	**2020**
Guzzle	10	15	12	8	11
Avonport	11	16	12	4	7
Blue	11	-	-	-	3
Evangeline	8	-	-	-	3
Total	**40**	**31**	**24**	**12**	**24**

Each site in the Minas Basin was surveyed multiple times throughout August to observe shorebirds during their stopover period (Table 2). The Guzzle was surveyed the most frequently throughout August in 2020 (n=11), for a total of 41.50 audit hours of the site. Avonport beach had the second most visits (n=7) and was audited for a total of 23 hours. Both Blue and Evangeline beaches were surveyed three times for a total of 11 and 11.50 hours, respectively. Discrepancies in the length of site visits are due to site surveys being completed early due to inclement weather. The number of site visits varied over five years, with the most occurring in 2016 (n=40) and the least occurring in 2019 (n=12).

Table 3: The daily average number of shorebirds present on the Guzzle, Avonport, Blue, and Evangeline beaches between 2016 and 2020.

	2016	**2017**	**2018**	**2019**	**2020**
Guzzle	11,987.90	4,754.93	4,953.08	15,041.13	3,700.00
Avonport	17,979.64	45,841.25	15,874.00	6,160.00	2,864.29
Blue	1213.09	-	-	-	481.33
Evangeline	11,309.75	-	-	-	1,283.33
Total Average	**10,622.60**	**25,298.09**	**10,413.54**	**10,600.57**	**2,082.24**

While the total number of shorebirds observed on the four survey sites varies greatly across the five-year data collection period, the average number of birds seen on a site per day does not show the same differences for each year (Table 3). The daily average for 2016 (n=10,622.60), 2018 (n=10,413.54) and 2019 (n=10,600.57) were extremely similar despite having very different total numbers of shorebirds. There are no significant differences between

the average number of shorebirds observed each year ($F(4,9) = 1.48$, $p = .20$). Additionally, there were no significant differences between the average number of shorebirds per site ($F(3,10) = 1.31$, $p = .33$).

4.1.2 Human Presence in the Minas Basin in 2020

As thousands of shorebirds use the Minas Basin annually, hundreds of recreational beach users travel to the Guzzle, Avonport, Blue, and Evangeline beaches each summer. The most common activities occurring on these sites in August of 2020 were fishing (n=121), walking (n=125) with a leashed (n=7) or unleashed dog (n=12), birding (n=9), wildlife photography (n=20), swimming (n=134), sunbathing (n=138), boating (n=11), and using other vehicles such as bikes (n=9).

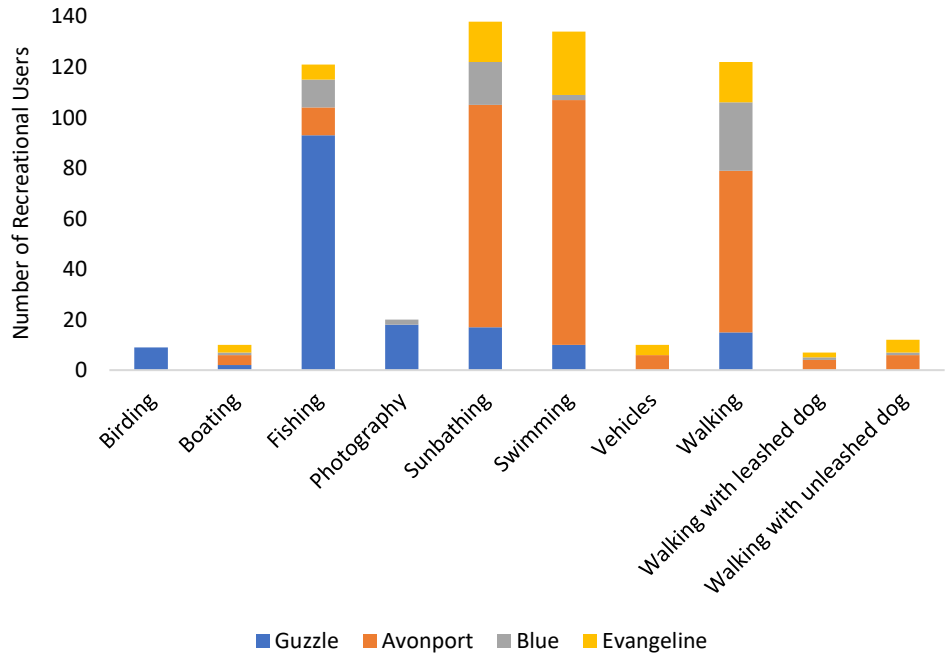

Figure 4: The total number of users for each recreational activity per site in the 2020 data collection season.

The most frequently used beach for recreational activity was Avonport beach (n=280), a popular spot for local families to go to in the summer. At Avonport, it is common to see

swimmers (n=97), sunbathers (n=88), walkers (n=64), walkers with leashed (n=4) or unleashed dogs (n=6), fishers (n=11), boaters (n=4), and other vehicle users (n=6) (Figure 4). For the Guzzle, the most prominent recreational activity is fishing (n=93), followed by photography (n=18), sunbathing (n=17), walking (n=15), swimming (n=10), birding (n=9), and boating (n=2). At Blue beach, the most common recreational activities were walking (n=27), sunbathing (n=17), fishing (n=11), swimming (n=2), photography (n=2), boating (n=1), and walking with a leashed (n=1) or unleashed dog (n=1). Similarly, Evangeline beach was popular with swimmers (n=25), walkers (n=16), sunbathers (n=16), fishers (n=6), walkers with unleashed dogs (n=5) or leashed dogs (n=2), unmotorized vehicle users (n=4), and boaters (n=3). Certain recreational user categories, such as birders and wildlife photographers, were not frequently recorded during the Guzzle and Avonport beach survey periods but were present on-site. They may not have been included in the site survey if they were not present for a long enough period, as the survey occurred every 30 minutes, or if they were not directly on the beach.

4.1.3 Disturbance in the 2020 Season

Due to the number of recreational users on the sites and the nature of their activities, overlap with shorebird roosting spaces is inevitable on the unprotected beaches. In total, 352 disturbances of natural, anthropogenic, and unknown origins were recorded in the 2020 field season at the Guzzle (n=220), Avonport beach (n=92), Blue beach (n=23), and Evangeline beach (n=17). The Guzzle had the highest average number of disturbances per site survey (μ=20.00), followed by Avonport (μ=13.14), Blue (μ=7.67), and Evangeline beaches (μ=5.67). There was no significant difference between the average number of disturbances recorded at each beach ($F(3,20) = 1.28$, $p = .31$).

Disturbances to roosting shorebirds will often elicit a behavioral response (Table 4). The extent to which the shorebirds will react can be unpredictable and includes being alert with their neck extended (n=1), moving away from the cause of the disturbance without flying (n=14), flushing and flying away from the disturbance, and shortly after returning to the beach (n=292), or flushing and flying away, leaving the area (n=64). When disturbed, there would often be multiple behavioural responses from a group of shorebirds. In this case, the most common reaction was recorded. For instance, if some individuals in a group moved away from the disturbance but the majority took flight then returned, the reaction would be classified as 'flush and return'. However, there were some instances of half of a flying group returning and the other half leaving the site, in which each behaviour was recorded as a response to the disturbance.

Table 4: The frequency of shorebird behavioral responses following a disturbance on each study site.

	Alert	Move	Flush and Return	Flush and Leave
Guzzle	1	10	182	37
Avonport	0	0	82	17
Blue	0	4	15	6
Evangeline	0	0	13	4

A natural disturbance can cause any of the behavioral reactions from a roosting flock (n=110). This includes predators such as Bald Eagles (n=10), Merlins (n=5), or Peregrine Falcons (n=13), or a non-predator, including other shorebirds (n=32) or Gulls (n=50). The majority of these natural disturbances occurred at the Guzzle (n=85), followed by Avonport beach (n=21), and Blue beach (n=4). There were no recorded instances of natural disturbances at Evangeline beach in the 2020 season. This corresponds to a rate of 2.05 natural disturbances per survey hour at the Guzzle, 0.91 per hour at Avonport, and 0.36 natural disturbances per hour at Blue beach. There is no significant difference between the number of natural disturbances at each site ($F(3,20) = 1.73$, $p = .19$).

Roosting shorebirds will also exhibit these behaviors when the source of a disturbance could not be identified. When this occurred, the origin of the disturbance was recorded as unknown (n=79). Unknown disturbances occurred at the Guzzle (n=40), Avonport (n=32), Blue (n=3), and Evangeline beach (n=4).

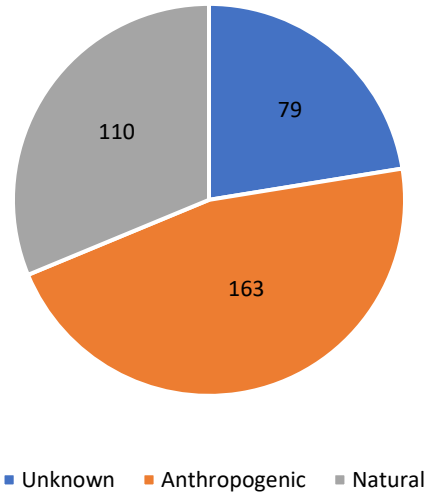

Figure 5: The proportion of disturbances occurring on all four Minas Basin sites in 2020 with anthropogenic, unknown, or natural origins.

The majority of disturbances across all sites in the 2020 season had anthropogenic origins (Figure 5). Human activities were responsible for 46.31% of all disturbances in 2020. The second-largest origins of disturbance stemmed from natural causes, accounting for 31.25% of all disturbances recorded in 2020. Unknown causes of disturbance were the least common in the 2020 season, with approximately 22.44% of disturbances being unknown.

4.1.4 Disturbance Over Time

Disturbances to roosting shorebirds in the Minas Basin were not isolated to the 2020 season. Disturbances were recorded on each beach in 2016 (n=219), 2017 (n=552), 2018 (n=379), 2019 (n=86), and 2020 (n=352). The disturbances were classified as either anthropogenic, natural, or unknown in origins (Table 5). In total, the majority of disturbances

across all years had unknown causes (n=706), followed by anthropogenic (n=462) and natural origins (n=420). Over five years, there was a total of 1,588 disturbances recorded across all sites.

Table 5: The number of disturbances of anthropogenic, natural, and unknown origins across all surveyed sites for 2016 through 2020.

	2016	2017	2018	2019	2020	Total
Anthropogenic	106	52	132	9	163	462
Natural	42	146	81	41	110	420
Unknown	71	354	166	36	79	706
Total	219	552	379	86	352	1,588

Table 6: The rate of disturbances per study hour according to their anthropogenic, natural, or unknown origins across all surveyed sites between 2016 and 2020.

	2016	2017	2018	2019	2020
Anthropogenic	1.91	0.46	1.55	0.24	1.87
Natural	0.47	1.30	0.95	1.11	1.26
Unknown	0.80	3.16	1.95	0.97	0.91

In 2016 and 2020, the majority of disturbances were attributed to anthropogenic origins. There were similar rates of anthropogenic disturbances per survey hour in 2020 and 2016, with a slight decrease in 2018 rates and much lower rates in both 2017 and 2019 (Table 6). The rate of natural disturbances occurring per survey hour increased in each year following 2016. Similarly, 2016 had the lowest rate of unknown disturbances per survey hour, with 2020 being slightly higher and 2017 having the highest rate of unknown disturbances occurring per audit hour.

4.1.5 Anthropogenic Disturbance in the 2020 Season

Anthropogenic disturbance was classified as any disruption to roosting shorebirds whose origins were from people using the beach space for recreational activity. Anthropogenic disturbances can be responsible for initiating the behavioral responses of the shorebirds (n=163). Many times, the anthropogenic disturbances are accidental and a result of sharing a space with the shorebirds. The majority of recreational activities caused disturbances to the shorebirds, including fishing (n=58), walking (n=50), walking with a leashed dog (n=5), or an unleashed dog

(n=4), photography (n=15), swimming (n=15), boating (n=10), and the use other vehicles such as bikes (n=6). Neither birders nor sunbathers were responsible for any recorded disturbances in 2020.

The vast majority of anthropogenic disturbances occurred at the Guzzle (n=95), followed by Avonport (n=39), Blue (n=16), and Evangeline beach (n=13). The origins of the disturbances at the Guzzle were fishers (n=57), walkers (n=18), photographers (n=14), vehicles (n=3), boats (n=2), and walkers with a leashed dog (n=1). There were no disturbances on the Guzzle caused by swimmers, sunbathers, birders, or walkers with unleashed dogs. The majority of the disturbances attributed to fishers at the Guzzle were caused by two fishers who chose to use the SRB at the Guzzle, despite birds present on the beach and the researcher's recommendation to use another beach (n=40). For Avonport, anthropogenic disturbances were caused by swimmers (n=15), walkers (n=11), boaters (n=8), other vehicles (n=3), and unleashed dog walkers (n=2). At Evangeline beach, the only recorded anthropogenic disturbances originated from three recreational activity categories: walking (n=8), with a leashed dog (n=3), and with an unleashed dog (n=2). Disturbances at Blue beach originated from walkers (n=13), walking with a leashed dog (n=), wildlife photographers (n=1), and fishers (n=1).

Both the Guzzle and Avonport beaches had conservation measures in place in the form of SRBs. These beach closures were meant to keep recreational users away from the area, to allow for a safe space for shorebirds to roost if they choose. However, anthropogenic disturbances occurred on the SRB at both the Guzzle (n=47) and Avonport beach (n=33) in the 2020 season. There were multiple occasions of anthropogenic disturbance on the SRB at the Guzzle, originating from walkers with a leashed dog (n=1), vehicles such as planes (n=2), walkers (n=1), photographers (n=1), boats (n=2), and fishers (n=40). The disturbances caused by the fishers on

the Guzzle SRB occurred in one afternoon within three hours. Without including this incident, the Guzzle would have fewer SRB disturbances (n=7) and no disturbances from fishers. At the SRB on Avonport beach, walkers (n=9), boaters (n=8), swimmers (n=13), and other vehicles, including farm vehicles (n=3), caused disturbances to roosting shorebirds.

4.1.6 Anthropogenic Disturbance Over Time

Implementing an SRB on the beaches at both the Guzzle and Avonport intended to mitigate or eliminate anthropogenic disturbances to roosting shorebirds. However, despite the conservation measures on these beaches, there were anthropogenic disturbances on the Guzzle SRB in 2017 (n=7), 2018 (n=6), 2019 (n=4), and 2020 (n=47). On the Avonport beach SRB, there were anthropogenic disturbances in 2017 (n=1), 2018 (n=10), 2019 (n=1), and 2020 (n=33). As the SRBs were not instated until 2017, no disturbances occurred on an SRB in 2016.

Table 7: The total number of anthropogenic disturbances occurring on SRBs at the Guzzle or Avonport beach throughout the study according to the recreational category.

	Guzzle					**Avonport**				
	2017	2018	2019	2020	Total	2017	2018	2019	2020	Total
Walking	1	0	0	1	2	0	0	0	9	9
Dog Walking	0	0	0	1	1	0	0	0	0	0
Fishing	0	3	1	40	44	0	0	0	0	0
Birding	0	0	0	0	0	0	0	0	0	0
Photography	6	0	2	1	9	0	0	0	0	0
Swimming	0	0	0	0	0	0	10	0	13	23
Sunbathing	0	0	0	0	0	1	0	0	0	1
Boating	0	0	1	2	3	0	0	1	8	9
Vehicle	0	3	0	2	5	0	0	0	3	3
Total	7	6	4	47	64	1	10	1	33	45

Each study year documented anthropogenic disturbances from most categories of recreational user. Three categories of recreational user caused disturbance in each of the survey years: walkers, fishers, and photographers (Table 7). Disturbances caused by recreational fishers were recorded in 2016 (n=17), 2017 (n=30), 2018 (n=36), 2019 (n=2), and 2020 (n=58). Similarly, walkers were the cause for disturbances recorded in 2016 (n=68), 2017 (n=3), 2018

(n=33), 2019 (n=1), and 2020 (n=50). Wildlife photographers also caused disturbances in 2016 (n=9), 2017 (n=12), 2018 (n=36), 2019 (n=3), and 2020 (n=15). Birders were only responsible for disturbances caused in 2016 (n=5), and in 2018 (n=1). Recreational users walking with a dog, whether leashed or unleashed, caused disturbances in 2016 (n=10), 2017 (n=1), 2018 (n=4), and 2020 (n=9). Swimmers were responsible for disturbances in 2017 (n=5), 2018 (n=12), and 2020 (n=15). Sunbathers were only responsible for disturbances in 2016 (n=1), 2017 (n=1), and 2018 (n=4). Boaters caused disturbances in two years: 2018 (n=3), and 2020 (n=10). Other vehicles, such as bikes, caused disturbances in 2018 (n=3), 2019 (n=2), and 2020 (n=6).

Table 8: The total number of anthropogenic disturbances caused by each recreational category on all surveyed sites for each study year.

	2016	2017	2018	2019	2020	Total
Walking	68	3	33	1	50	155
Walking with a dog	10	1	4	0	9	24
Fishing	17	30	36	2	58	143
Birding	5	0	1	0	0	6
Photography	9	12	36	3	15	75
Swimming	0	5	12	0	15	32
Sunbathing	1	1	4	0	0	6
Boating	0	0	3	0	10	13
Other vehicles	0	0	3	2	6	11
Total	110	52	132	8	163	465

The total number of anthropogenic disturbances were highest in 2020 (n=163), followed by 2018 (n=132), 2016 (n=110), 2017 (n=52), and 2019 (n=8) (Table 8). In total, walkers caused the highest number of disturbances (n=155), followed by fishers (n=143), photographers (n=75), swimmers (n=32), dog walkers (n=24), boaters (n=13), and other vehicles (n=11). The lowest number of disturbances caused by a recreational activity was tied for sunbathing (n=6) and birding (n=6). The rate of anthropogenic disturbances by survey hour was highest in 2020, with a rate of 1.87 anthropogenic disturbances per hour, followed by 2018 with a rate of 1.55

disturbances per hour, 2016 with a rate of 1.24 per hour, 2017 with 0.46 per hour, and the smallest rate in 2019 with 0.22 disturbances per hour.

Table 9: The number of anthropogenic disturbances recorded per survey hour on the Guzzle and Avonport beach SRBs each year.

	2016	2017	2018	2019	2020
Guzzle	0.67	0.13	0.14	0.15	1.13
Avonport	0.09	0.02	0.24	0.09	1.43

Despite the presence of active SRBs, anthropogenic disturbances occurred at both the Guzzle and Avonport beach in each year of the project (Table 9). Although there was no SRB in place in 2016, the number of disturbances occurring on the beach where the SRB would be implemented in the future were included to indicate the area's use prior to the implementation of conservation measures. The rate of anthropogenic disturbances occurring per survey hour was calculated to account for differences in the survey effort per site. The SRB at the Guzzle had a decline in the rate of disturbances occurring per audit hour, with a slight increase each year until 2020, when a large increase is recorded. The highest recorded number of anthropogenic disturbances on the Guzzle SRB were recorded in 2020, up 1075% from 2019, and 176% from 2016 values. This trend is similar to the Avonport SRB, with the highest number of disturbances recorded in 2020, up 1550% since 2016 (Figure 6).

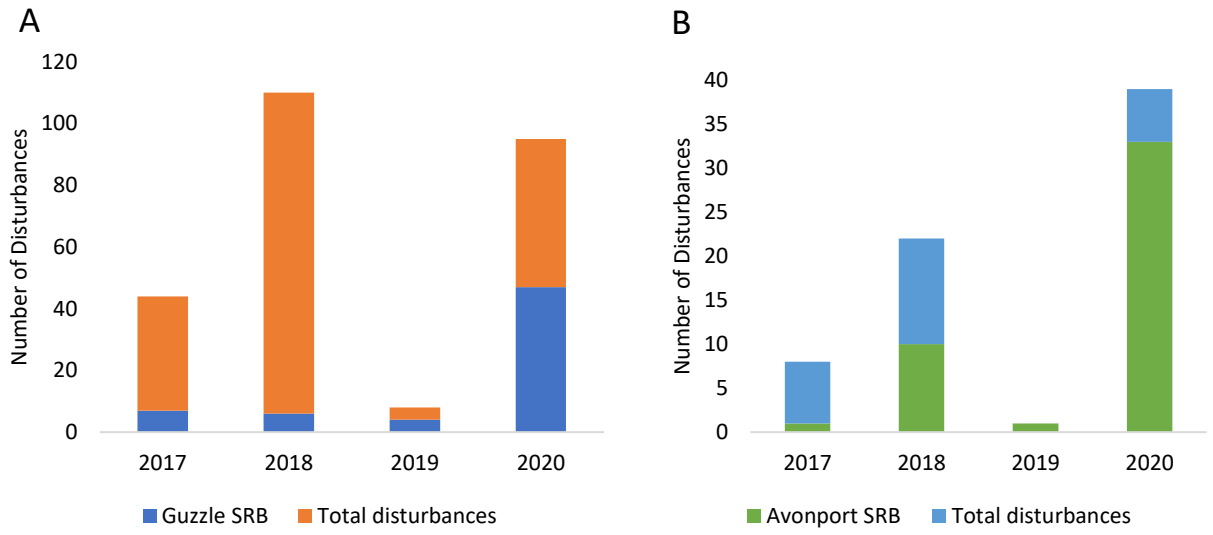

Figure 6: The number of anthropogenic disturbances occurring on SRBs for the Guzzle (A) and Avonport beach (B) in relation to the total number of anthropogenic disturbances throughout the site.

4.2 Survey Data

4.2.1 Participants

In total, 46 people completed surveys. Of this, 39 surveys were conducted in person, while seven were performed online. Each participant was an active recreational beach user at either the Guzzle, Evangeline, Avonport, or Blue beach. For Blue and Evangeline beaches, two participants completed the survey online, and 15 surveys were completed in person. At the Guzzle and Avonport beaches, five surveys were conducted online, and 24 were completed on-site. Those surveyed included recreational fishers (n=7), wildlife photographers (n=7), walkers (n=7), sunbathers (n=6), birders (n=9), and swimmers (n=10).

When asked how often they visit their respective beach, approximately 35% of participants (n=16) stated it was their first time visiting. The majority of participants had visited the site they were surveyed on before, with 26% visiting the site multiple times a month (n=12), 15% visiting multiple times per week (n=7), approximately 20% visiting a couple of times each

summer (n=9), and only 4% reporting they visit the site once per summer (n=2). None of the respondents indicated they visited a site daily during the data collection period.

Almost half of all participants (n=20) indicated that they traveled less than 50 kilometers to conduct their chosen recreational activity on the surveyed site. Almost three-quarters of respondents (n=34) traveled less than 100 kilometers to the site. Eleven percent of participants (n=5) traveled over 150 kilometers to participate in recreational activities at the study site.

Despite a relatively large proportion of participants who had never visited the beaches before, approximately 24% (n=11) indicated that they were not aware that the site is an important resting area for migratory shorebirds. Of those aware of the importance of the site for migratory shorebirds, the majority stated that this understanding was due to their prior knowledge of the area (n=13). Other participants indicated that they knew this due to prior visits to the beach (n=10) or previous knowledge of the shorebirds (n=7). Only 14% of respondents (n=5) stated that they knew the beaches are an important resting area because of the project signs.

4.2.2 Open-Ended Questions

The participants were asked how to best communicate the importance of these sites for migratory shorebirds to recreational beach users. The answers were coded into five categories: increase the number of signs on each site (n=14), design the signs to be more eye-catching and informative (n=11), develop community outreach and education initiatives (n=10), have an interpreter on-site (n=10), and increase awareness through the media, including social media (n=7) (Figure 7). Some participants gave multiple recommendations in their responses that fell into various categories, resulting in more recommendations than participants.

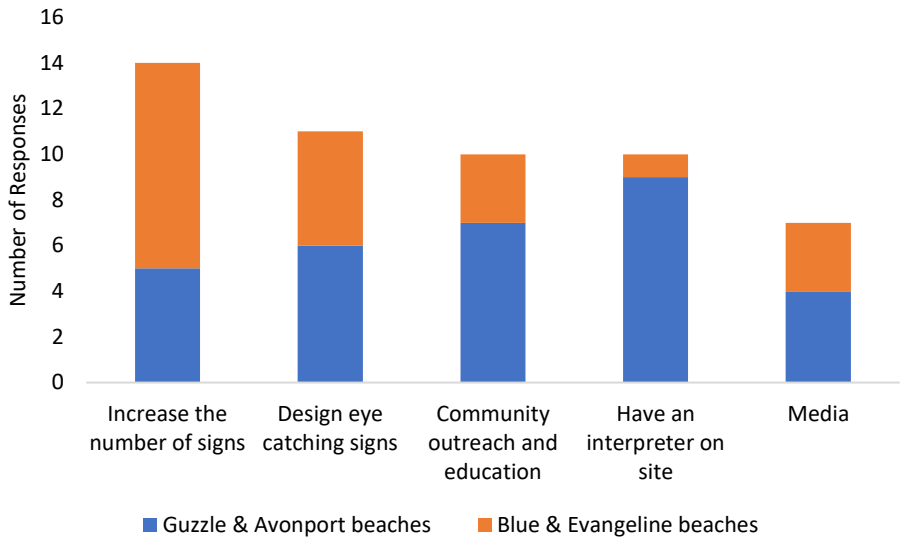

Figure 7: Participant recommendations for best communicating to recreational users the site's importance for migratory shorebirds.

Participants were asked to rank, in their opinion, a list of threats to shorebirds on a scale of least (one) to most (five) important on which to focus conservation efforts. The list of threats included loss of habitat, climate change effects, pollution, shorebird harvest and hunting, and human disturbances. These threats were included as they were identified by the State of Canada's Birds 2019 report as considerable threats to migratory shorebird populations (NABCI Canada, 2019). The average ranking for each threat was obtained using the averages from both survey sites to determine each threat's overall rank. The highest-ranked threat was loss of habitat, with an overall average rank of 4.76. The effects of climate change were ranked with an average score of 3.74. Pollution and human disturbances were given similar average rankings, with pollution being ranked slightly higher at 2.83 and human disturbances at 2.57. The lowest-ranked, and therefore the threat with the least perceived importance to conservation was shorebird hunting, with an average score of 1.13 (Figure 8). The analysis of variance revealed significant differences in these results, $F(4, 225) = 158.24$, $p = .000$. A post-hoc Tukey HSD test found that there was a significant difference between the rankings of all threats. When the results

from the survey conducted on the Guzzle and Avonport beach was compared to the results of the Blue and Evangeline survey, there was no differences in the ranking for loss of habitat, $F(1, 44) = 1.46$, $p = .233$, effects of climate change $F(1, 44) = 1.93$, $p = 1.72$, pollution $F(1, 44) = 1.10$, $p = .30$, hunting $F(1, 44) = 2.99$, $p = .09$, and human disturbance $F(1, 44) = .214$, $p = .65$.

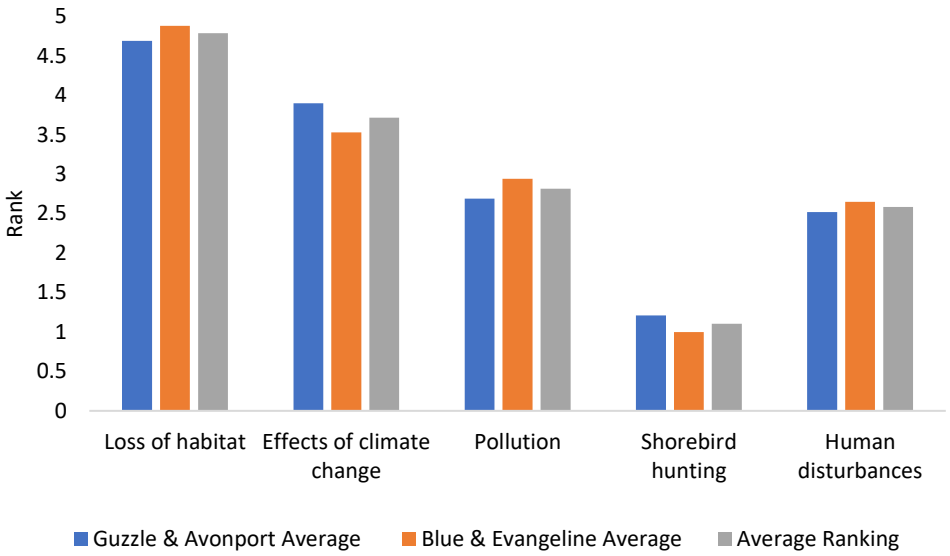

Figure 8: Participant rankings of the perceived conservational importance of each threat facing migratory shorebird populations from least (1) to most (5) important.

The surveys asked each participant to rank the recreational activities that occur on each beach from least (1) to most (7) disruptive based upon how significantly they perceive each activity to disturb roosting migratory shorebirds. The recreational activities included in the survey were: recreational fishing, wildlife photography, birding, walking, walking with an off-leash dog, sunbathing, and swimming (Figure 9). Respondents at the Guzzle and Avonport ranked birding as the least disruptive recreational activity (μ=1.59), followed by sunbathing (μ=2.41), wildlife photography (μ=2.79), angling (μ=4.07), swimming (μ=4.34), walking (5.79), and walking with an off-leash dog (μ=7). Participants surveyed at Blue and Evangeline beaches ranked the least disruptive activity to be birding (μ=1.59), followed by wildlife photography

(μ=2.29), sunbathing (μ=2.35), angling (μ=4.47), swimming (μ=5.06), walking (μ=5.18), and walking with an unleashed dog (μ=6.94) as the most disruptive activity. The average rankings concluded that participants perceived the least to most disruptive activities to be: birding (μ=1.59), sunbathing (μ=2.37), wildlife photography (μ=2.54), angling (μ=4.27), swimming (μ=4.70), walking (μ=5.49), and walking with an unleashed dog (μ=6.97).

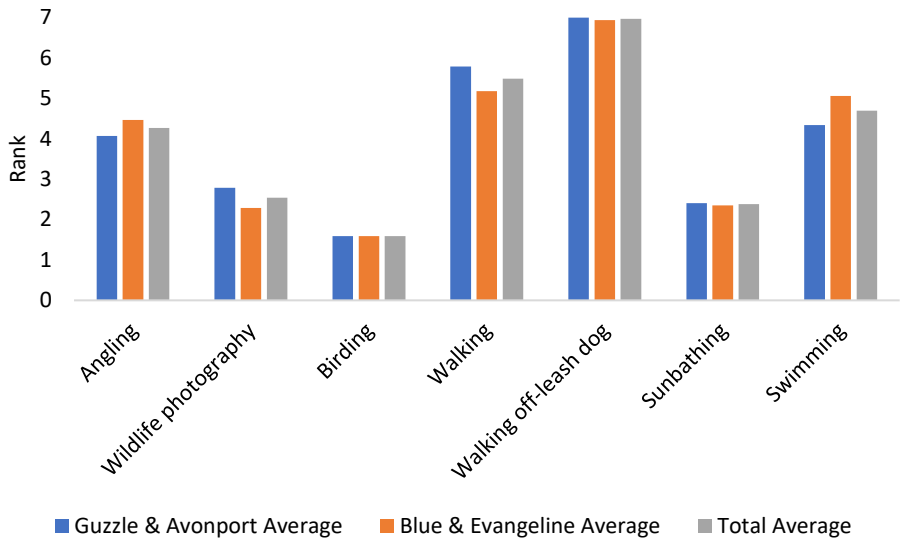

Figure 9: Participant perceptions of which recreational activities are least (1) to most (7) disruptive to roosting migratory shorebirds.

The final question on each survey asked the participant to rank five statements on a scale of strongly disagree (1) to strongly agree (5). The first statement, “this site is valuable to me for conducting recreational activities,” had an average response of 4.45 on the Guzzle and Avonport survey, an average of 4.41 on the Blue and Evangeline survey, and a total average of 4.43, corresponding to “agree.” There was no significant difference found between the two surveys' responses, $t(44) = 0.14$, $p = 0.89$. The second statement, “I would be willing to avoid using the beach two hours before and after high tide to reduce shorebird disturbance,” earned an average score of 3.93 on the Guzzle and Avonport survey and an average of 3.12 on Blue and

Evangeline. A total average score of 3.53 was obtained, indicating an average rank of "neutral." A significant difference was found between the averages of the two surveys, $t(44) = 2.46$, $p = 0.02$. The third statement, "I would be willing to avoid participating in certain activities on the beach when shorebirds are present," was ranked as an average score of 4.39 at the Guzzle and Avonport beaches, 4.29 at Blue and Evangeline, and an average total score of 4.34 corresponding to "agree." There was no significant difference between the two surveys, $t(44) = .49$, $p = .06$. The fourth statement, "I would be willing to use a different area of the beach to reduce shorebird disturbances," was scored an average of 4.62 on the Guzzle and Avonport survey and 3.88 on the Blue and Evangeline survey. It had a total average score of 4.25, indicating most participants "agree" with the statement. There was no significant difference between the two surveys, $t(44) = 4.20$, $p = .58$. The final statement, "prior to taking this survey, I was aware of the impacts human disturbances may have on migratory shorebirds," had an average score of 3.45 on the Guzzle and Avonport survey, 3.41 on the Blue and Evangeline beach survey, and a total average of 3.43, indicating that "neutral" was the most common response to the statement. There was no significant difference between these results, $t(44) = 0.121$, $p = .91$.

4.2.3 The Guzzle and Avonport Specific Questions

The majority of questions were used on both surveys; however, each survey had a question specific to its respective site. For the Guzzle and Avonport survey, the unique questions were based upon the conservation measures in place, as there are no such measures at Blue or Evangeline beach. The respondents were asked whether they think the current conservation measures are sufficient in preventing anthropogenic disturbances to roosting shorebirds. Of the 29 participants, the majority responded "yes" (n=27), and a few stated "no" (n=2). As a follow-up question, those who responded "no" were asked what they think could improve the current

interventions. One respondent indicated that because there are no deterrents such as fines to keep people off the SRB, people are not motivated to follow the rules. Therefore, some form of deterrent should be used to enforce conservation measures. The second respondent indicated that awareness of the project is too low, and advertising through the media should be used to increase awareness around the project, which would help people understand and encourage them to follow the guidelines of the conservation measures.

4.2.4 Blue and Evangeline Specific Questions

Unlike the Guzzle and Avonport beach, Blue and Evangeline beaches do not have any conservation measures to protect roosting migratory shorebirds. As such, we asked respondents whether they thought it would be practical to implement conservation measures on their respective beach. Examples of conservation measures given to the participants were signs with information on shorebirds and SRBs. When asked if signs would be an effective intervention in the area, the majority of participants stated yes (n=13), while one participant said no. When asked about implementing an SRB, few respondents said yes (n=3), while the majority said no (n=13). Three respondents only commented on the implementation of an SRB and therefore did not have a response regarding signs, leading to only 14 responses in that category. Additionally, one participant only responded regarding using signs as a conservation measure, resulting in only 16 responses in that category.

As a follow-up to the previous question regarding the potential implementation of conservation measures at Blue and Evangeline beaches, participants were asked to explain why they believed the measure would or would not be effective. Of those participants who believed that signs would be useful as conservation measures, the primary reason for this was that informative signs in the area would increase awareness and educate beach users on how to avoid

disturbing shorebirds in the area. The participant who indicated signs would not help stated that there are many recreational users in the space, but they rarely had seen birds in the area, so there was no point in adding signs. The three participants who responded “yes” to the implementation of an SRB stated that having conservation measures in place would increase awareness and having a beach closure at high tide would help reduce disturbances while still allowing access to the beaches at low tide. The primary reason participants disagreed with implementing an SRB in the area was due to the sizeable recreational user presence on the beaches. As both Blue and Evangeline are popular sites, many respondents indicated that recreational users would be unhappy with implementing an SRB as they would not want to be limited in their recreation.

Chapter 5 – Discussion

5.1 Shorebirds in the Minas Basin

Two sites in the Minas Basin were surveyed throughout August consecutively from 2016 to 2020, with two additional sites being surveyed in 2016 and 2020. The migratory shorebirds choosing to roost at these sites showed a preference for both Avonport and the Guzzle rather than Blue and Evangeline beach. The landscape features at each respective site may be responsible for the differences in choices of roosting habitat. Shorebirds will typically choose an open site away from potential cover for predators such as stands of trees (Sprague et al., 2008). At the Guzzle, the SRB is adjacent to open agricultural fields, with no stands of trees in the immediate area. Similarly, at Avonport beach, the SRB is at the base of a cliffside, atop of which is open agricultural land and a farm.

For each of these sites, the shorebirds roosting on the beaches can see incoming predators with relative ease as there is no prominent cover with which the predators could hide. This also may be why many shorebirds have been sighted using the agricultural land as a roosting site at the Guzzle. While there are many predators, such as Peregrine Falcons, Merlins, and Bald Eagles at the Guzzle, the open visibility may make the shorebirds feel safer while roosting at this site (Long & Ralph, 2001). There were fewer natural predators recorded at Avonport beach, potentially allowing for the shorebirds to roost at ease. This absence of predators may be due to the edge effects of the site's landscape features, including a lack of trees and appropriate habitat for avian predators (Batáry et al., 2014). However, similar features can be found at the Guzzle, where there were frequent recordings of disturbances with natural origins. This difference may be due to survey effort, in which more disturbances were recorded at the Guzzle as there were more visits to this site. Blue beach, where the lowest number of roosting shorebirds were

recorded, is the least open to surrounding areas. Cliffs and trees surround much of the beach. As with the Guzzle, many avian predators were present at Blue beach, with many surrounding trees that could be used as potential cover. Evangeline beach had two small stands of trees, allowing for some cover for predators, but for the most part was an open cliffside featuring a campground, motel, and cottages.

In the 2020 data collection period, fewer shorebirds were observed than in any previous years. This decline in shorebird observations in 2020 occurred at each of the sites. During this time, large flocks of birds were not recorded on a daily basis at any site. Despite anecdotal reports of larger shorebird flocks from local birders and photographers, the largest number of shorebirds observed in 2020 at any site in one day was 12,700 at the Guzzle. It is unlikely that the number of site surveys is responsible for the difference between years, as there were more surveys conducted in 2020 than in 2019 and a similar number of surveys for individual sites in 2016 and 2018. This could be due to the researcher merely being in the wrong place at the wrong time, resulting in lower counts than what may have been present at other times. In future research, it may be beneficial to compare numbers being observed in the Minas Basin with that of Johnson's Mills in New Brunswick (Nature Conservancy Canada, n.d.) and what is being reported on the eBird database by birders throughout the Bay of Fundy (eBird Canada, n.d.). It could also be beneficial to incorporate volunteers into the research program in the future to have a more extensive compilation of data for the season. To successfully compare data obtained by various volunteers, it would be necessary to implement a training course for estimating the size of shorebird flocks to ensure that counts conducted throughout the region follow the same method.

This research assumes the shorebirds show no site fidelity and will be present on one site for one day. However, this is not the case, as the shorebirds using the Minas Basin have high site fidelity. Shorebirds will likely utilize multiple sites or the same site multiple times throughout their stopover in the Minas Basin (Neima et al., 2020). However, each data collection session assumed that the shorebirds present on-site had not been observed before, as it would be impossible to discern whether a shorebird had previously been recorded. This may have led to inflated total numbers of shorebirds, as some shorebirds may have been counted multiple times throughout the data collection period.

5.2 Shorebird Resting Beach Implementation

The STR project implements two SRBs throughout August, one at the Guzzle and another at Avonport beach. Despite a few instances of recreational beach users violating the SRB conservation measures, overall, the project was successful in deterring some anthropogenic disturbances to roosting shorebirds. However, the SRBs must be strategically placed to be successful for both human and shorebird use. Before implementing the SRB at the Guzzle and Avonport beaches, stakeholders were consulted, including recreational user groups such as local anglers and birders. This was done to choose a site that would maximize the potential protection of roosting shorebirds while minimizing impacts on recreational beach users. Of the four beaches considered for SRBs – the Guzzle, Avonport, Blue, and Evangeline – only two were chosen to implement conservation measures (Fahey, 2020). The SRB at the Guzzle was implemented on one of three beaches at the site (see appendix 3). This site was specifically chosen as it was a well-used beach by the shorebirds and was the least used by recreational users. Therefore, the SRB would not interfere with users as extensively since it was not as popular as the other two beaches. Similarly, the site for the SRB at Avonport beach was also chosen for its lack of

popularity with recreational beach users compared to the main beach and for its ability to provide adequate roosting habitat for the shorebirds (see appendix 3).

A shorebird resting beach was not implemented at either Blue or Evangeline beach in 2017. These beaches were too popular with recreational users and did not have as large a presence for roosting shorebirds as the chosen sites. When asked in the site survey, most Evangeline and Blue beach users expressed that they would not want an SRB implemented on either beach. Due to a lack of support from stakeholders, particularly recreational users, the implementation of an SRB would be unsuccessful at either of these locations. If the conservation measures were put into place regardless of these objections, it is unlikely that many beach users would be willing to support the SRB and abide by the voluntary conservation measures. However, although this project may not be expanded to either Blue or Evangeline beach in the Minas Basin, there is potential for similar conservation measures to be implemented elsewhere in the Bay of Fundy. Further, lessons from this conservation project can be applied to stopover sites for migratory shorebirds worldwide, allowing for more opportunities for shorebirds to have uninterrupted space to roost.

5.3 Awareness of Recreational Beach Users

The majority of survey respondents, approximately 75%, reported that they knew their interview site was an important stopover area for migratory shorebirds. Signs were in place at each site, indicating that the location is an important bird area for migratory shorebirds and asking recreational users to share the space with roosting birds. On the sites featuring SRBs, additional signs are put into place on the beaches to explain the STR project, the purpose of the SRB, and how to help protect shorebirds and avoid disturbance. Despite this, only 14% of the

respondents indicating that they knew the site was an important bird area stated they had known because of the signs present on site.

When survey participants were asked to recommend potential methods to better communicate the site's importance to roosting shorebirds, many indicated that increasing the number of signs on the sites would be beneficial. Further recommendations encouraged updating the signs to be more eye-catching and informative regarding why disturbance is detrimental to roosting shorebirds. Changing the signs to incorporate additional explanations as to how the beach users' behavior impacts the shorebirds may help encourage the use of a different beach space (Fahey, 2020). The recommendations differed depending upon the site at which a participant was surveyed. Those surveyed at the Guzzle or Avonport beach were more likely to recommend having an interpreter on-site. In contrast, those at Blue and Evangeline beach recommended increasing the number of signs and updating the current signs. This difference could be due to additional signs already on-site at the Guzzle and Avonport. Utilizing an interpreter at the Guzzle and Avonport could be beneficial to deter recreational users from using the SRBs. It would increase interaction with beach users, expanding education and public awareness regarding the shorebirds and conservation efforts in the area.

5.4 Anthropogenic Disturbances to Shorebirds

Since 2016, disturbance data has been collected from the Guzzle and Avonport beach. Data was collected in 2016 and 2020 for both Blue and Evangeline beaches. During this time, numerous disturbances occurred to roosting shorebirds, causing them to expend unnecessary energy on avoidance behaviors (Lilleyman et al., 2016). While we can not easily mitigate disturbances with an unknown or natural cause, such as predatorial or non-predatorial birds, we are able to reduce the number of disturbances originating from human recreational beach use.

The majority of disturbances across all years stemmed from a few recreational groups, including anglers, walkers, and photographers.

Unlike many recreational activities, such as birding, which can be done from afar, recreational anglers share much of the same space as roosting shorebirds. The Guzzle is a popular spot for recreational fishing, with most fishers using the first beach (see appendix C). Small groups of roosting shorebirds would often utilize the same space despite the presence of the fishers. Many of the anglers were aware of the shorebirds and attempted to avoid disturbing them, but disturbances were inevitably caused when the fishers moved (Fahey, 2020). For the most part, recreational fishers of the area were happy to avoid the SRBs. However, in one incident during the 2020 data collection period, two fishers chose to use the SRB at the Guzzle despite the signs, encouragement from the researcher to use a different area, and other recreational users asking them to leave the SRB. The fishers were determined to use the SRB, even though thousands of shorebirds were roosting there at the time. The anglers told the researchers and other beach users, “it’s a free country,” indicating that they were not interested in following the voluntary conservation measures put in place and did not feel as though they needed to abide by the rules. These two fishers caused 40 disturbances to the roosting shorebirds over a three-hour period. This was the only incident of anglers causing disturbances on an SRB for the 2020 data collection season. While these actions may not be representative of all recreational users of this area, it is not an isolated incident. In previous years of the study, similar issues have occurred (Fahey, 2020).

Those using the beach for walking caused a large number of disturbances to the roosting shorebirds. While walkers did not cause disturbances on the SRB at the Guzzle, they did occur at Avonport beach. Walkers also frequently caused disturbances on beaches without conservation

measures in place. For the most part, these disturbances were caused inadvertently, with many beach walkers unaware of the presence of shorebirds in the area until they took flight. As with anglers, people walking along the beach utilize much of the same space as the roosting shorebirds. Additionally, if the shorebirds were roosting along the rocks of the dykes, such as at the Guzzle or near the top of the cliffside at Evangeline beach, walkers along the clifftop and not on the beach could also cause disturbances based on the sheer proximity to the shorebirds.

Although not necessarily sharing the same beach space, wildlife photographers frequently caused disturbances to roosting shorebirds. Due to a photographer's ability to zoom in on their subject, one would think that they would be most likely to keep their distance from roosting shorebirds. This was the case with many photographers visiting the survey sites; however, some photographers approached roosting shorebirds directly on the beach. Photographers without appropriate equipment to photograph shorebirds from afar would frequently go onto the beach near roosting shorebirds to get better photos of them, often disturbing the shorebirds while doing so. However, to obtain an aesthetically pleasing photo of the shorebirds in flight, photographers have been observed purposefully trying to cause a disturbance to initiate their avoidance flight reaction (Fahey, 2020). When flying together as one group after being disturbed, the shorebirds exhibit graceful and beautiful in-flight movements, which photographers often want to capture. Due to the need to get closer to the shorebirds or cause them to take flight, photographers were the reason for many disturbances to roosting shorebirds in the Minas Basin, despite signs, interpreters, and education initiatives asking them to behave otherwise.

A high level of disturbance was observed in the 2020 season compared to the disturbance levels of some past years. One potential reason for this increase in disturbance is the effects of the provincial regulations due to Covid-19, such as the required social distancing protocols

(Government of Nova Scotia, 2020). These Covid-19 regulations could have led to more people traveling within short distances of their homes, or within the Atlantic provinces, and conducting outdoor recreational activities that allow for physical distancing (CBC News, 2020). This could have contributed to the elevated number of people visiting the study sites for the first time this season. Each site allows for physical distance between users and is generally not overcrowded, potentially drawing in recreational users. An increase in beach users could also be a factor when considering the increased number of disturbances recorded in the 2020 season. These new users may be unaware of the consequences of disturbances to roosting shorebirds or may want to use different areas of the beach to keep distance between all users.

5.5 Perceptions of Recreational Beach Users

It is well known that shorebirds face many threats throughout their migratory range, including loss of habitat, effects of climate change, harvest and hunting, pollution, and human disturbances. When asked to rank these threats to shorebirds in terms of which would be the most vital for targeting conservation efforts, participants ranked the most important as the loss of habitat, followed by effects of climate change, pollution, human disturbance, and least important as shorebird harvest. Pollution and human disturbances received a similar average rank.

Participants likely ranked each of these threats based on the preconceived notions they had for each threat. Since climate change and habitat loss are well-known threats to all manners of wildlife, the respondents potentially chose to rank these threats higher due to their availability heuristic. This heuristic allows them to recall instances of these threats affecting wildlife more easily, causing them to assume they were the most important threat (Folkes, 1988). As such, hunting shorebirds is not common in the Minas Basin, and so it is likely that many people had not heard of nor considered it a potential threat, leading it to be ranked as the least important.

However, while it may not be an important conservation issue in the Bay of Fundy, shorebird harvest represents a threat in other areas of the shorebirds' migratory path. It would be interesting to see how the ranking of these threats would differ depending on where on the migratory path the participant resided.

The study participants were asked to rank recreational beach activities according to the amount of disruption they thought the activity would cause to roosting shorebirds. The average ranking across groups indicated that the general population believes that birding is the least disruptive activity, followed by sunbathing, wildlife photography, fishing, swimming, walking, and the most disruptive to be walking with an unleashed dog. Participants on the Guzzle unanimously ranked unleashed dog walking as the most disruptive activity, with the vast majority of Blue and Evangeline beach participants agreeing. Contrarily, the results of this study show that walking a dog, whether leashed or unleashed, did not cause many disturbances on the study sites when compared to other activity groups. Perhaps if there were more dog walkers on the sites, the frequency of disturbances would change in favor of the activity. However, few dog walkers were present on any of the sites, making it difficult to validate this almost unanimous conclusion. Participants may have preconceived negative connotations, especially regarding off-leash dogs, as they typically represent a more significant threat to wildlife in general.

The survey participants underestimated the potential impacts of both photographers and anglers, ranking them at third and fourth, respectively, when they are among the top three regarding total and per person disturbances. The participants may have believed photographers would not have a significant number of disturbances as the activity could, in theory, be performed from a distance using the zoom functions on a camera. Additionally, respondents may have assumed that photographers would be aware of and sensitive to issues facing vulnerable

populations, such as disturbances to shorebirds. Regarding the anglers, the activity requires them to be relatively stationary, which could be why many participants thought it would not be a high disturbance activity. Due to the overlap in space used by fishers and roosting shorebirds, disturbances are relatively common for the activity (Fahey, 2020). However, the rankings determined by those involved in the study were accurate for both birders and sunbathers, as both recreational activities have very few recorded disturbances over time.

To assess how the participants feel about the site, shorebirds, and conservation measures, they were asked to rank their agreement to multiple statements on a scale of 'strongly disagree,' 'disagree,' 'neutral,' 'agree,' and 'strongly agree.' The first statement assessed how much the participants value their respective site. The average rank from both the Guzzle and Avonport and Blue and Evangeline beaches was to 'agree.' This indicates that participants using all the survey sites value being able to use the site for their respective recreational activity. However, this may cause them to be against implementing further conservation measures, especially if it were going to limit their access to the site, as in the case of respondents being against potentially establishing SRBs on Blue and Evangeline beaches.

The second statement assessed the willingness of participants to avoid the beach, which resulted in average answers of 'neutral' from both surveys. The Guzzle and Avonport beach average was closer to 'agree' than the average achieved from Blue and Evangeline beach. This could be due to the fact that many of the participants at the Guzzle and Avonport are already avoiding a beach for conservation measures and accept this. However, this result shows the participants would not necessarily be interested in any further closures at the site, as the average response was 'neutral'. Since there are currently no volunteer measures to avoid either Blue or

Evangeline beach areas, the users were more hesitant and less likely to be open to losing access to their valued recreational site.

The third statement assessed whether individuals would be willing to avoid certain activities that are more likely to disturb the shorebirds. Both surveys had an average answer of 'agree' with this statement. However, if the statement had been worded differently to state that their activity would be the one being excluded, there would potentially be different answers. Regardless, this answer shows that most participants for both surveys would be willing to adapt their behavior to a certain extent to benefit roosting shorebirds.

The fourth statement investigated whether recreational beach users would be willing to use a different beach area to conduct their activity. Those at the Guzzle and Avonport agreed to this statement. However, those at Blue and Evangeline beaches had an average response of 'neutral.' There was no statistically significant difference between these two groups, potentially due to the small sample size and high variability. However, this can also be compared to the current state of conservation measures on these beaches. Those at the Guzzle and Avonport were more willing to conduct their activity on a different beach area as they already do so by avoiding the use of the SRB. Those at Blue and Evangeline beach have not been asked to avoid using any sections of their beach voluntarily and are less likely to be open to change. Such opposition aligns with the 'Not in My Back Yard' concept in which those who value a place are less likely to support new development in the vicinity (Devine-Wright, 2009), especially when limiting access in said space. In the past, fishers at the Guzzle would continue using the SRB despite being asked not to, stating that they have fished there for many years, thus implying that they were entitled to continue fishing in the area (Fahey, 2020). The answers recorded from Blue and

Evangeline respondents aligns with the results indicating that they would not support the implementation of an SRB on those beaches.

The final statement assessed whether the participants were aware of the impacts human disturbances have on roosting shorebirds. On average, participants from both surveys responded as ‘neutral’ to this statement. This indicates that the majority of respondents do not really understand the impacts of human disturbances on migratory shorebirds, and therefore do not understand the importance of the conservation measures currently in place. Further, a ‘neutral’ response may indicate that the education and outreach currently in place is not effective in teaching recreational users the importance of the site and the effects of disrupting roosting shorebirds. This should be investigated further in future years to determine whether education and outreach efforts are effective or if new strategies will be required to increase awareness.

Chapter 6 – Recommendations

6.1 International Cooperation

Shorebird populations are faced with a myriad of threats, including loss of habitat, climate change, shorebird harvest, and human disturbances. Due to the migratory nature of shorebirds, there are many opportunities throughout their range for such threats to impact the populations. Unfortunately, as these birds cross international boundaries in their migration, it is challenging to ensure conservation across their entire range. Therefore, international cooperation will be imperative if these migratory shorebird populations, such as the Semipalmated Sandpiper, are to be conserved. This includes supporting and conserving nesting sites, stopover sites such as those in the Minas Basin, and wintering grounds. Simply providing conservation measures in one area, such as the Bay of Fundy, will not be sufficient in conserving shorebird populations if the birds continue to face significant threats in different areas of their range. Protections must be implemented and enforced in all areas of the migratory range (Bliss et al., 2019). Bliss and colleagues (2019) determined that of the Semipalmated Sandpipers using the Bay of Fundy as a stopover site, population declines have been distributed broadly across the breeding range. It had previously been thought the decline was due to disproportionate losses to a population of eastern breeding shorebirds.

Organizations such as WHSRN are beneficial for achieving such goals across international borders (“Bay of Fundy,” n.d.-a). However, all aspects of a shorebird’s life and migration must be considered when implementing protection. For instance, shorebird food sources will need to be protected as well, as in the case of the horseshoe crab. Shorebirds migrating northward along the Atlantic coast stop at Delaware Bay to feed on horseshoe crab eggs. Without this nutrition, the shorebirds would not successfully complete the migration to

their arctic breeding grounds, nullifying any other conservation attempts. Protection measures for the horseshoe crab, such as beach restoration, harvesting restrictions, and bait replacement in the Delaware Bay, has allowed for the recovery of horseshoe crab populations and, therefore, the number of available eggs (Smith et al., 2020). Shorebirds such as the Semipalmated Sandpiper are intricately connected to the habitat at each stopover site, nesting, and wintering ground. This must be considered when exploring conservation measures to mitigate the current declining trend in shorebird populations.

6.2 Protection Under the Law

When asked for recommendations to improve the current conservation measures on the Guzzle and Avonport beaches, one participant stated that it would be beneficial to penalize violators to deter recreational beach users from using the SRB. This would then aid in mitigating anthropogenic disturbance. As the current measures in place for both SRBs in the Minas Basin are voluntary, there are no consequences to individuals acting against the SRB and STR project. When the project is active, the primary deterrent is the presence of signs asking recreational users to avoid the SRB and the presence of other individuals who follow the rules. While the societal pressures of others abiding by the rules will often cause people to follow suit, it does not deter everyone, as shown by the individuals who continued to use the SRB for recreational activities each year of the STR project. Therefore, incorporating penalties and enforcement of the conservation measures would help ensure that the shorebirds can roost during high tides without human disturbance. To achieve this, provincial or federal legislation would be necessary. In the future, it is recommended that regulatory protection is implemented to act as a deterrent for human disturbances. Additionally, the SRBs should be monitored and enforced regularly to ensure that the recreational users act according to proposed rules.

Members of the Scolopacidae family, such as Semipalmated Sandpipers, are protected under the Migratory Birds Convention Act of Canada (Government of Canada, 2017-a) and the Nova Scotia Wildlife Protection Act (Duke, 1981). However, despite the current population decline, the Semipalmated Sandpiper is not currently protected under the Species at Risk Act nor under the Nova Scotia Endangered Species Act, unlike the Piping Plover, an endangered migratory shorebird. Human exclusion zones on Plover breeding beaches, similar to that of SRBs, have successfully deterred human disturbances on Nova Scotian beaches, thereby improving the survival rates of the birds and their chicks. The exclusionary zones are a buffer zone of at least 50-meters put into place around nests to prevent anthropogenic disturbances at nesting sites (Jorgensen et al., 2016). Increasing the buffer zone around the SRBs may help to reduce disturbances in the Minas Basin further while encouraging beach users to remain an appropriate distance from the shorebirds.

6.3 Citizen Science

Many resources would be required to monitor and enforce conservation measures across the entire 5000-kilometer migratory span of shorebirds, such as the Semipalmated Sandpiper. This includes a significant amount of human resources to promote conservation. One way to tackle a lack of funding and personnel is to develop a citizen science and volunteer program. Through the use of online databases such as eBird, citizen scientists and other volunteers would be able to approximate how many shorebirds are in a given area, the species distribution, and the location (eBird Canada, n.d.). For many birders in the Minas Basin, this is already a commonplace activity, in which they will report all birds seen in an area each day they are present. Since this is already occurring with many local birders, creating a program to utilize this data and giving basic training to volunteers would be a viable option to increase data collection

measures and the enforcement of conservation measures. Such training would include shorebird identification, how the conservation measures work, and how to use the online databases. Although many birders were not included in the 2020 data collection surveys, there were many on-site. These birders were present on either the Guzzle or Avonport beach but were on the dykes or paths rather than on the beaches themselves, resulting in fewer birders being counted in the survey. However, many of these were local birders who frequently visit the area. These individuals would be the target audience for creating a volunteer-based shorebird conservation project in the Minas Basin. Additionally, the STR volunteer project could be incorporated into the more extensive annual volunteer Atlantic Canada Shorebird Survey created by the Canadian Wildlife Service in the early 1970s (Government of Canada, 2017-b).

6.4 Education and Outreach

A recommendation received from survey respondents suggested using education and outreach initiatives in local communities to increase awareness of conservation efforts for roosting shorebirds in the Minas Basin. Many recreational users of the beach, especially if it was their first time at the site, were unaware of the conservation measures in place to protect the shorebirds and were unaware of the effects their disturbances may have. Increasing the awareness of local community members, especially those who are more likely to visit the beach sites frequently, would be beneficial as it would allow for informal enforcement of the conservation area. Informal enforcement could work in concert with a volunteer or citizen science program. Even if the individuals were not actively participating, their presence would deter unwanted actions such as recreationally using the SRB during high tide. The area surrounding some of the sites is a popular tourist area, including the Parks Canada Grand Pré National Historic Site (Parks Canada, 2020). As this is a high traffic area, it is an excellent

location to target recreational users who are new to the area. Education could come in the form of informative handouts, which the STR project currently supplies local businesses or sessions from set up booths.

6.5 Space to Roost Project Recommendations

The STR project is implemented annually for the month of August on the Guzzle and Avonport beaches. This conservation project targets the shorebirds using the Minas Basin as a stopover site during the bulk of their migration. As the voluntary beach closures are only in place for two hours before and two hours after high tide every day in August, many shorebirds will miss this temporary protection. Bliss and colleagues (2019) have indicated that the migration time for the shorebirds has been changing. Since the 1980s, the median passage date in the Bay of Fundy has advanced by five days. As the shorebirds arrive later in the season, it would be beneficial to adjust the project to encapsulate the bulk of arrivals in the conservation measures. Additionally, anecdotal evidence from Facebook pages such as the *Nova Scotia Bird Society* (Nova Scotia Bird Society, n.d.), and online databases such as *eBird* (eBird Canada, n.d.) could be used in concert with daily shorebird counts conducted in the Minas Basin to determine if more birds would be protected under the conservation measures if implemented later in the season or left in place for longer than one month. Additionally, these numbers could be compared to the daily population counts dating back to 2016 to give a general idea of how the arrival of large numbers of shorebirds has changed over the past few years in the Minas Basin, if at all.

Chapter 7 – Conclusions

Migratory shorebird populations, such as the Semipalmated Sandpiper, are facing threats such as the effects of climate change, habitat loss, hunting, and human disturbance. All of these threats have culminated in a decline of approximately 40% for all migratory shorebird populations. As many shorebirds have an extensive migratory range, spanning approximately 5000-kilometers from their southern wintering grounds to their northern breeding grounds, it will take international cooperation to ensure that threats are being mitigated throughout the migratory range. In the Minas Basin, the primary threat targeted by conservation efforts is the mitigation of human disturbances. The STR project, implemented by Birds Canada, puts an SRB into place at two beaches in the Minas Basin – the Guzzle and Avonport beach. The SRB acts as a conservation measure on a volunteer basis, as recreational users are asked to avoid the SRB for the two hours before and after high tide every day in August. However, there are no consequences to those who choose to use the SRB during this time.

Allowing beach space for migratory shorebirds to roost during high tide in the Minas Basin is imperative for a successful migration. The Minas Basin, and the Bay of Fundy, on a larger scale, is a critical stopover site for these shorebirds, who remain for approximately three weeks. During this time, the shorebirds will consume enough to double their weight in preparation for their transoceanic flight, so it is integral to their survival to conserve this energy and not wastefully expend it avoiding disturbances. When disturbed while roosting, shorebirds can have multiple reactions, such as being alert but remaining in the area, moving away from the source of the disturbance, flushing and taking flight but returning to the area, or flushing and taking flight and subsequently leaving the area. The most common recorded behavioral reaction was for the shorebirds to take flight but return to the beach shortly after being disturbed.

The STR project implements conservation measures annually to reduce anthropogenic disturbances occurring on the SRBs. However, the current method of employing educational signs and outreach and education alongside the SRBs did not eliminate all disturbances on these sites. Regardless of mitigation efforts, almost half of all disturbances recorded in 2020 had anthropogenic origins. Angling, walking, and photography were the top three recreational activities that caused anthropogenic disturbances in 2020, following the trends of previous years. Despite this result, surveyed participants perceived both photography and angling as moderately disruptive, as third and fourth-least disruptive, respectively.

The survey results indicate that to protect shorebirds in the Minas Basin better, awareness of the effects of human disturbances on roosting shorebirds must be increased in recreational users. The majority of recreational users were unaware of these impacts despite being aware of the presence of migratory shorebirds. Human disturbance was ranked as the second-lowest threat facing migratory shorebirds, indicating that the participants did not perceive it as significant a conservation issue as habitat loss, the effects of climate change, and pollution. Participants recommended implementing additional signs, education initiatives in local communities, having an interpreter on-site, and using the media to increase the awareness of recreational beach users.

While ventures such as the STR project help to mitigate some of the threats facing many migratory shorebird populations, there is still much more that must be done. Therefore, it is recommended that: international cooperation is prioritized to protect shorebirds throughout their migratory range; deterrents are implemented to further discourage human disturbances on roosting beaches; citizen science and volunteers are utilized to further our understanding of migratory shorebirds, and education and outreach programs are employed to increase awareness and reduce disturbance in these areas further.

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Appendix A – Survey Questionnaires

The Guzzle and Avonport Beach Shorebird Stewardship Survey

1. How often do you visit this beach?

   _____

   _____

2. How far have you travelled to use this beach?
   a. >50 km
   b. 50 – 75 km
   c. 75 – 100 km
   d. 100 – 125 km
   e. 125 – 150 km
   f. 150+ km
3. Did you know this beach is an important resting area for migratory shorebirds such as the Semipalmated Sandpiper?
   a. Yes
   b. No
4. If yes, how did you know?
   a. Signs
   b. Prior visits to the beach
   c. Prior knowledge of the area
   d. Prior knowledge of birds
   e. Other: _____
5. What primary recreational activity are you conducting while on the beach?
   a. Fishing
   b. Wildlife photography
   c. Birding
   d. Walking
   e. Swimming
   f. Other: _____

6. Do you think the current interventions (i.e. signs and shorebird resting beaches) are sufficient in reducing human disturbances on roosting shorebirds?
    a. Yes
    b. No
7. If you answered no to the previous question, what do you think could be improved?

_____

_____

_____

8. How can we best communicate with beach users the importance of this site to shorebirds?

_____

_____

_____

In your opinion, on a scale of 1 (least important) to 5 (most important), which of the following threats to shorebird populations is the most important factor to address to promote conservation.

Loss of habitat _____

Effects of climate change _____

Pollution _____

Shorebird harvest (i.e. hunting) _____

Human disturbances _____

Please rank the following recreational activities in order of least (1) to most (7) disruptive to shorebirds.

Angling _____

Wildlife photography _____

Birding _____

Walking _____

Walking with off leash dog _____

Sunbathing _____

Swimming _____

Please rank the following statements on a scale of strongly disagree to strongly agree.

1. This site is valuable to me for conducting recreational activities.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
O	O	O	O	O

2. I would be willing to avoid using the beach two hours before and after high tide to reduce shorebird disturbances.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
O	O	O	O	O

3. I would be willing to avoid participating in certain activities on the beach when shorebirds are present.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
O	O	O	O	O

4. I would be willing to use a different area of the beach to reduce shorebird disturbances.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
O	O	O	O	O

5. Prior to taking this survey, I was aware of the impacts human disturbances may have on migratory shorebirds.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
O	O	O	O	O

Blue and Evangeline Beach Survey

1. How often do you visit this beach?

   _____

   _____

2. How far have you travelled to use this beach?
   a. >50 km
   b. 50 – 75 km
   c. 75 – 100 km
   d. 100 – 125 km
   e. 125 – 150 km
   f. 150+ km
3. What primary recreational activity are you conducting while on the beach?
   a. Fishing
   b. Wildlife photography
   c. Birding
   d. Walking
   e. Swimming
   f. Other: _____
4. Did you know this beach is an important resting area for migratory shorebirds such as the Semipalmated Sandpiper?
   a. Yes
   b. No
5. If yes, how did you know?
   a. Prior visits to this beach
   b. Prior knowledge of the area
   c. Prior knowledge of the birds
   d. Other: _____
6. How can we best communicate with beach users the importance of this site to shorebirds?

_____

_____

_____

7. Would implementing interventions (such as a shorebird resting beach and signs) on this beach be effective in reducing human disturbances on shorebirds? Why or why not?

_____

_____

_____

In your opinion, on a scale of 1 (least important) to 5 (most important), which of the following threats to shorebird populations is the most important factor to address to promote conservation.

Loss of habitat _____

Effects of climate change _____

Pollution _____

Shorebird harvest (i.e. hunting) _____

Human disturbances _____

Please rank the following recreational activities in order of least (1) to most (7) disruptive to shorebirds.

Angling _____

Wildlife photography _____

Birding _____

Walking _____

Walking with off leash dog _____

Sunbathing _____

Swimming _____

Please rank the following statements on a scale of 1 (strongly disagree) to 5 (strongly agree).

1. This site is valuable to me for conducting recreational activities.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
O	O	O	O	O

2. I would be willing to avoid using the beach two hours before and after high tide to reduce shorebird disturbances.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
O	O	O	O	O

3. I would be willing to avoid participating in certain activities on the beach when shorebirds are present.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
O	O	O	O	O

4. I would be willing to use a different area of the beach to reduce shorebird disturbances.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
O	O	O	O	O

5. Prior to taking this survey, I was aware of the impacts human disturbances may have on migratory shorebirds.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
O	O	O	O	O

Appendix B – Survey Poster Advertisement

The poster was used to advertise for the online survey at Evangeline and Blue beach. A second poster, featuring a different QR code and location names, was used for the Guzzle and Avonport beach. Each poster followed the same format.

WE WANT YOUR OPINION!

What do you think about shorebird conservation efforts in the area?

Participate in a voluntary research survey through Dalhousie University and Birds Canada.

This survey will take 5-10 minutes to complete.

Who can participate?

Individuals using Evangeline Beach or Blue Beach for recreational activities.

How to participate:

Visit surveys.dal.ca/opinio/s?s=57867 to take the survey. Take a picture or use the QR code to access the survey from home!

Questions?

If you have questions about the research please contact Morganne: Morganne.Robben@dal.ca

If you have questions about Birds Canada or their projects, please contact spacetoroost@birdscanada.org

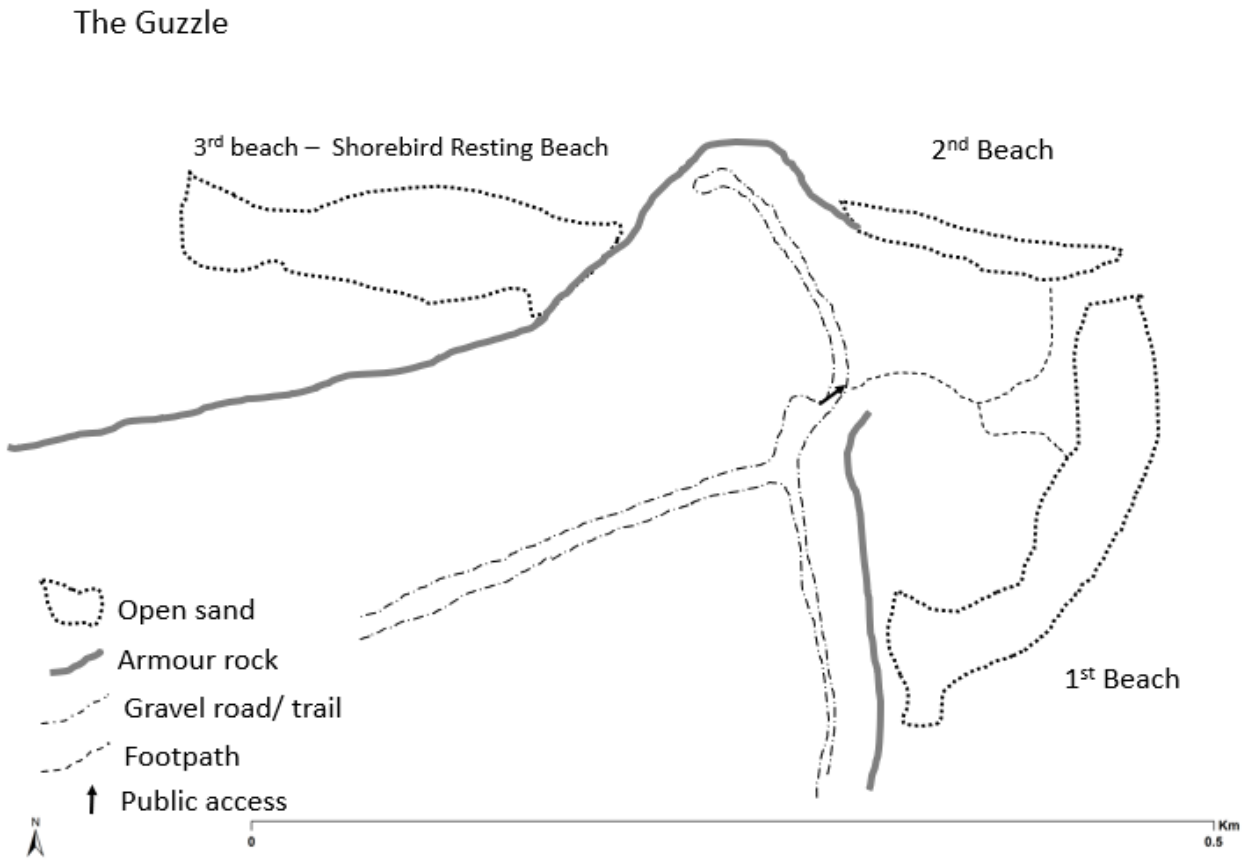
BIRDS CANADA OISEAUX CANADA

DALHOUSIE UNIVERSITY

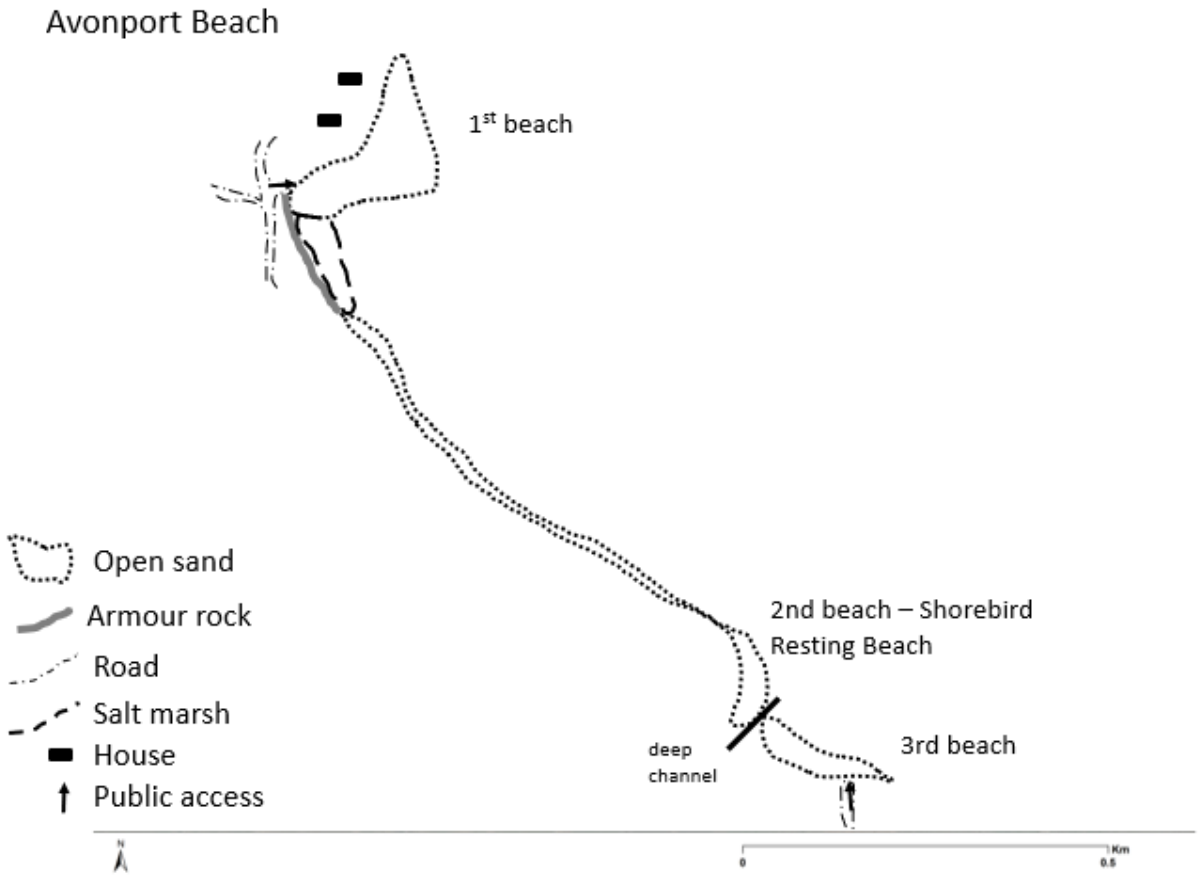
This research has been approved by the Marine Affairs Program Ethics Review Standing Committee. If you have questions regarding the ethics of the project, please contact marine.affairs@dal.ca (reference MAPERSC file # MAP2020-09).

Appendix C – Site Maps

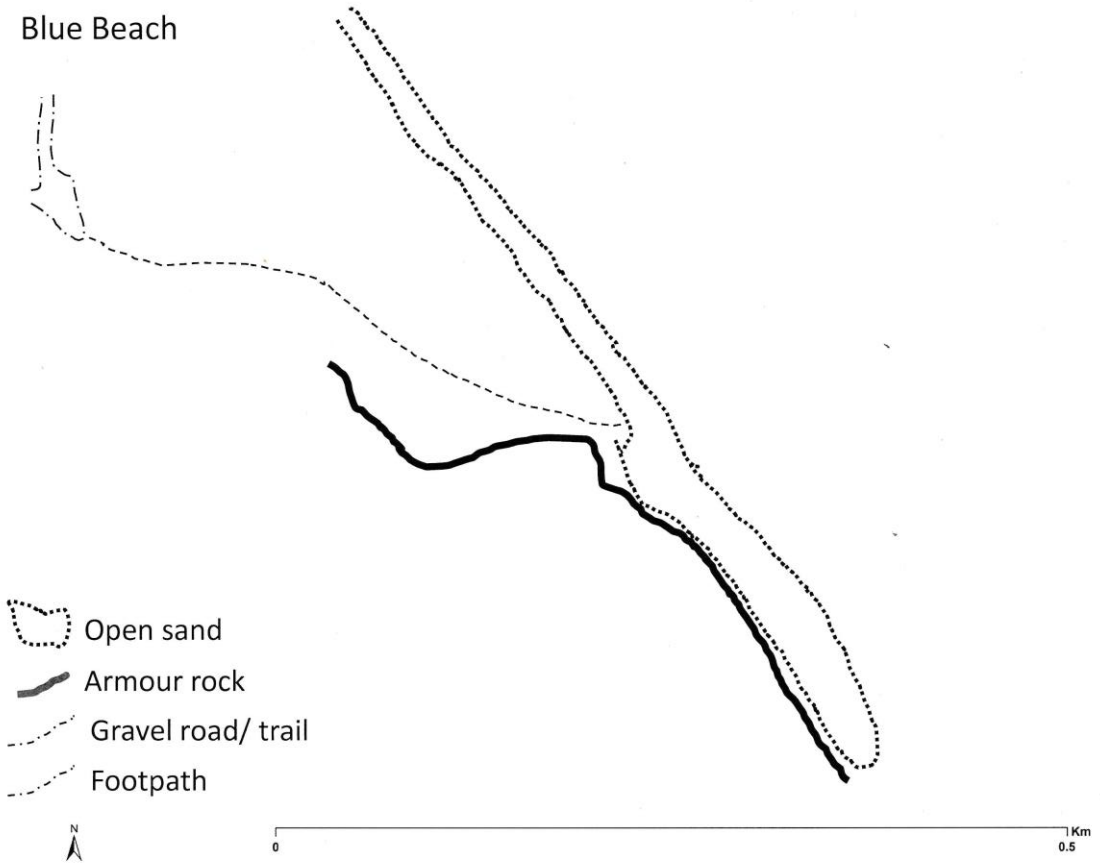
The Guzzle site map, including all three beaches, and the SRB featured on the third beach.



The site map of Avonport Beach, featuring all three beaches. The SRB was implemented on the second beach.



The site map of Blue Beach.



The site map of Evangeline Beach.