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Coexistence of the Arctic tern (*Sterna paradisaea*) and the inhabitants of the municipality of Ísafjörður in Iceland

Conflicts and Solutions

Bachelor thesis

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Nature conversation and landuse planning

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Abstract

This thesis studies the conflict of an Arctic tern (*Sterna paradisaea*) colony breeding in a highly trafficked area in Ísafjörður, Iceland. Frequent tern attacks and following negative attitudes from humans occur. To analyze this conflict, field observations were conducted to document tern behavior over the breeding period, and a survey to explore public opinions and experiences of the residents and visitors. Results reveal that overall aggression rates are low; however, specific factors, such as the presence of pets and certain activities like running or walking, can increase aggression and attacks. Survey respondents generally support protecting the terns, although negative attitudes were more common among those who had experienced unpleasant encounters. The field observations also showed that the current breeding location is not only inconvenient for people but also unsafe for the terns themselves, with chicks at risk of being killed on nearby roads. Overall, the findings suggest that the best management approach would be to combine actions that reduce the attacks and to encourage the terns to nest in a more suitable area, reducing conflicts while improving chick survival.

Diese Arbeit untersucht den Konflikt einer Brutkolonie von Küstenseeschwalben (*Sterna paradisaea*) in einem stark besuchten Gebiet in Ísafjörður, Island. Es kommt häufig zu Angriffen der Vögel, gefolgt von negativen Reaktionen der Menschen. Das Verhalten der Seeschwalben wurde während der Brutzeit dokumentiert, sowie eine Umfrage durchgeführt, um die Ansichten der Anwohner und Besucher zu ermitteln. Die Ergebnisse zeigen, dass die Aggressionsrate insgesamt gering ist, jedoch bestimmte Faktoren, wie die Anwesenheit von Hunden und bestimmte Aktivitäten wie Laufen oder Gehen, die Aggression und Angriffe verstärken. Die Befragten sprachen sich im Allgemeinen für den Schutz der Seeschwalben aus, obwohl negative Einstellungen unter denjenigen, die unangenehme Begegnungen erlebt hatten, häufiger anzutreffen waren. Die Feldbeobachtungen zeigten auch, dass der derzeitige Brutplatz nicht nur für Menschen, sondern auch für die Seeschwalben selbst unsicher ist, da die Küken auf den nahe gelegenen Straßen Gefahr laufen, getötet zu werden. Insgesamt deuten die Ergebnisse darauf hin, dass der beste Managementansatz darin bestehen würde, mehrere Maßnahmen zu kombinieren, welche die Angriffe reduzieren könnten und die Vögel anzuspornen, in einem geeigneteren Gebiet zu nisten.

Foreword and Acknowledgements

I want to express my deepest gratitude to everyone who supported me throughout this project. My warmest thanks go to my supervisor, Ingrid, whose guidance and support carried me through every step. Thank you to everyone from Náttúrustofa Vestfjarða who made this project possible and helped me. I am grateful for my partner, Ágúst, and his family for translating my survey into Icelandic finding exactly the right words.

To everyone who took the time to answer my survey and showed genuine interest in this work, thank you. Your encouragement and belief in this project fill me with hope that we can find a way to coexist with these wonderful birds.

The essence of coexistence is quite simple: live and respect how others live

(Eraldo Banovac).

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Introduction

Animals are losing their space in this world—everywhere, every day. In a world characterized by urbanization and human expansion, conflicts between humans and wildlife are increasingly common, especially in shared spaces. “Human–wildlife conflict is one of the most complex and urgent issues facing wildlife management and conservation today” (Frank et al., 2019). While animals are forced to adapt to human-dominated environments, humans may often feel disturbed by certain wildlife presence, which is leading to growing tension.

Birds in urban areas face numerous challenges. For instance, constant disturbance from traffic, people, lights, and pets can significantly impair the breeding success, because birds and people live in proximity; conflicts tend to arise (Reynolds et al., 2019).

One example of such a conflict occurs in the town of Ísafjörður, in Iceland’s Westfjords region. Here, Arctic terns (*Sterna paradisaea*) nest in areas frequented by people. Human-tern encounters in these areas lead to disturbances for the nesting birds and trigger defensive behavior by adult terns, often culminating in aggressive behavior towards humans. In response to those unpleasant encounters, actions have been taken by residents and the municipality to try to address the issue, including measures to dissuade the terns from nesting in the area. With Arctic tern populations already declining in Iceland, protecting their nesting sites is critical. Improving the conditions for both humans and Arctic terns is important for sustainable urban wildlife management.

The aim of the study is to identify the points of conflict between Arctic terns and humans and propose potential solutions for coexistence. This is addressed through 1) field observations of interactions between Arctic terns and humans passing near the colony, carried out during the breeding period. 2) The opinions and experiences of Westfjords residents are collected through a survey. 3) Integrating the field data and the survey responses to identify where, when, and how conflicts arise, and which groups are most affected. This approach enables the development of evidence-based recommendations that address the needs of both the Arctic terns and the local community to foster sustainable coexistence. This study was conducted during an ERASMUS internship with Náttúrustofa Vestfjarða in summer 2025.

1. Background

1.1. Study species Arctic tern (*Sterna paradisaea*)

Sterna paradisaea is a medium-sized migratory coastal seabird in the family of *Laridae.* The Arctic tern has a white and dark gray slender body about 33-35 cm long and a wingspan of 75-80 centimeters. The Arctic tern (*Sterna paradisaea*) breeds in the Arctic, subarctic, and temperate regions of the northern hemisphere. The northern winter (southern summer) is spent by Arctic terns in the Antarctic (figure 1). On their migrations they cover up to 20000 km one way—the longest migration route of any bird species (Ulbricht, 1995). Iceland has an important role in the survival of the Arctic terns; 150,000-250,000 pairs are estimated to breed in Iceland (Skarphéðinsson & Pálsdóttir, 2025).

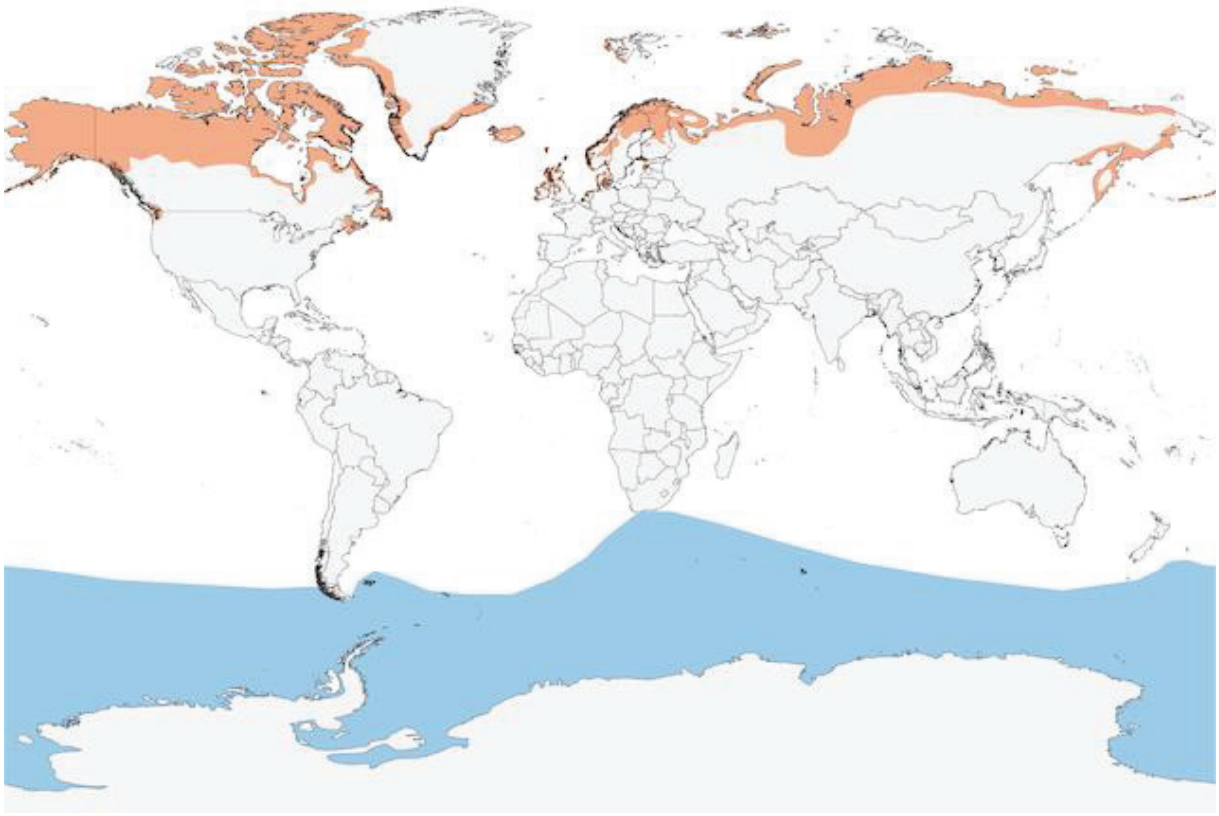

Figure 1: Abundance Sterna paradisaea, blue=non-breeding, red=breeding (CornellLab;Birds of the world, 2020)

The Arctic terns arrive in Iceland at the beginning of May and typically start breeding in June. The birds incubate for 20 to 24 days and lay between 1 and 3 eggs. The rearing of chicks to fledging takes about 3 weeks (Hilmarsson, 2011). Within a colony, pairs usually breed at the same time, though this synchrony can break down if the conditions are unfavorable (Syrová et al., 2020). Terns are biparental; both parents

care for their offspring, but in most cases the female spends more time caring for the clutch and brood (Cabot & Nisbet, 2013; as cited in Hromádková et al., 2023). As a semi-precocial species, the chicks are mobile soon after hatching but still stay near the nest (Vigfúsdóttir et al., 2013).

They are ground-nesting birds, usually breeding in sparsely vegetated areas; the largest colonies are found in coastal areas and on islands. Sometimes *Sterna paradisaea* can also be found at lakes and rivers or at small ponds, towns, and even in the Icelandic highlands (Hilmarsson, 2011).

Arctic terns feed on small fish and other marine life they catch from the sea, like sandlance (*Ammodytidae*) or Polychaeta, marine worms. They may also feed on insects, small crustaceans, and inland mostly fishes of the stickleback family (*Gasterosteidae*) (Hilmarsson, 2011).

1.1.1 Endangerment

Worldwide the Arctic tern is listed as least concern (LC) in the IUCN Red List of Threatened Species. However, the population trend is decreasing; in Europe the decrease is expected to be less than 25% in the next three generations (BirdLife International, 2018). In Iceland, *Sterna paradisaea* is listed as vulnerable (VU) in the Red List 2025 (Náttúrufræðistofnun, 2025). The breeding population of Arctic terns has declined in many parts of the country since 2005. Arctic terns on the Snæfellsnes Peninsula are showing a clear decline in the local population (Stefánsson et al., 2024). In the Westfjords, colonies are unstable and vulnerable (Gallo et al., 2023).

A reason for the decrease of Arctic tern population is the decline in sandlance (*Ammodytes spp.)* population, the main source of food for the Arctic tern in south and west Iceland. In north and east Iceland, the main food source is capelin (*Mallotus villosus*) and krill (*Euphausiacea*) (Lilliendahl, 2009; Thompson et al., 1999, as cited in Gallo et al. 2023). Iceland's capelin are heavily fished (MFRI, 2023). Arctic terns feed on the surface and have a limited foraging range. The absence of a fitting food source can cause starvation (Vigfúsdóttir et al., 2013).

Predation represents a significant threat to Arctic terns, particularly during the crucial breeding period. In Iceland, common predators for ground-breeding birds are the American mink (*Mustela vison*) (Stefansson et al., 2016), Arctic fox (*Vulpes lagopus*)

(Unnsteinsdóttir, 2016), and several avian species such as ravens (*Corvus corax*) (Chen, 2016). Eggs, chicks, and even adult terns can fall prey to mink and foxes. In some colonies predation is causing the majority of chick losses (Degot et al. 2024). When encountering a predator, adult birds leave the nest to defend their brood, while eggs and nestlings rely completely on the parental protection (Ibáñez-Álamo, 2015).

Human activity poses multiple threats to Arctic terns, including those associated with climate change, pollution, road infrastructure, and disturbance of breeding colonies (Umlah, 2019).

1.1.2 Behavior

Terns are considered aggressive and effective colony defenders, with strong defense behaviors against potential intruders (Mallory et al., 2010.) Defensive strategies of Arctic terns depend on the type of intruder and can range from temporarily leaving the nest to alarm calls, swooping, and even carrying out direct physical attacks, sometimes as group mobbing (Špička, 2022). Those active defense strategies enhance offspring survival, but they put the adults at risk of injuries and cost a lot of energy. To minimize these costs, adult terns must recognize when a threat is occurring and respond accordingly (Ellis-Felege et al., 2013). Depending on the danger the predator poses to the brood or the adults, the defense strategy changes. Arctic terns respond more aggressively to a potential egg predator than to a potential adult predator (Clode et al., 2000).

A study conducted by Špička (2022) demonstrated how Arctic terns exhibit different behavioral responses depending on the type of intruder. The study found that humans are perceived as threats comparable to natural predators such as falcons. The most common response was that the terns leave their nests, likely because they assessed themselves as unable to defend effectively against this kind of threat.

Foraging Arctic terns show little to no behavioral response to the presence of people along shorelines; therefore, disturbance of foraging or commuting individuals is considered unlikely. However, outside the breeding season, Arctic terns frequently roost on beaches and may be displaced from resting areas due to human disturbance (Goodship et al., 2022).

1.2 Human-avian relationship in Iceland

Human–bird relationships in Iceland can be traced back to the 9th century, when the first settlers relied on birds both as a food source and for material like their feathers, while also integrating them into early folklore (Sua, 2020). Although birds are no longer exploited to the same extent, they continue to hold significant (cultural) value today. Iceland has large eider colonies that are actively protected and managed by eider farmers; this stewardship can indirectly benefit Arctic terns, which often breed in the same habitats and are generally welcomed by the farmers (Morin, 2020). Birds also play an important role in tourism—so much so that Iceland is often described as a "birdwatcher's paradise" (Visit Iceland, n.d.). Most express appreciation for the country's birdlife and support bird conservation and further education (Martell, 2023). Seabirds and waders are generally the most valued groups, yet some species, such as the Arctic tern, are considered "pests" due to their aggressive breeding behavior (Martell, 2023). The Westfjords were named an especially important region for birds in people's perceptions (Martell, 2023). However, it is important to note that the respondents behind those survey findings included a large proportion of researchers and students, which may limit its representativeness. Arctic terns are more than just birds for many Icelanders; they are a sign of summer. Nevertheless, there are downsides to this relationship: Some bird species, such as geese and swans, can negatively affect agricultural harvests (Jones, 2018), and others, including certain gull species and the Arctic tern, can cause unpleasant experiences due to their aggressive defense behavior. The relationship between Icelanders and their birds is a complex one, holding the cultural identity and value on one hand while also encompassing the inconveniences and conflicts caused by certain species on the other.

1.3 Study area

1.3.1 Geographical and environmental conditions

The study site is located in Ísafjörður, Iceland (66°03′41.5″ N, 23°10′31.7″ W). It is the largest settlement in the Westfjords region (Northwestern Iceland) and the administration center of the municipality Ísafjarðarbær, with a population of approximately 3,900 residents *(Ísafjarðarbær, 2025).* The landscape of the Westfjords is characterized by mountains, fjords, and valleys. Flat plateaus are rising about 600 to 900 meters above sea level (Decaulne & Sæmundsson, 2006). The climate is subpolar oceanic, strongly influenced by the North Atlantic low-pressure system. The weather conditions are highly variable and often turbulent, with frequent and rapid temperature changes with heavy rain or snowfall (Decaulne & Sæmundsson, 2006). Because of Iceland's unique landscape, most life is concentrated along the coast, where both people and seabirds live.

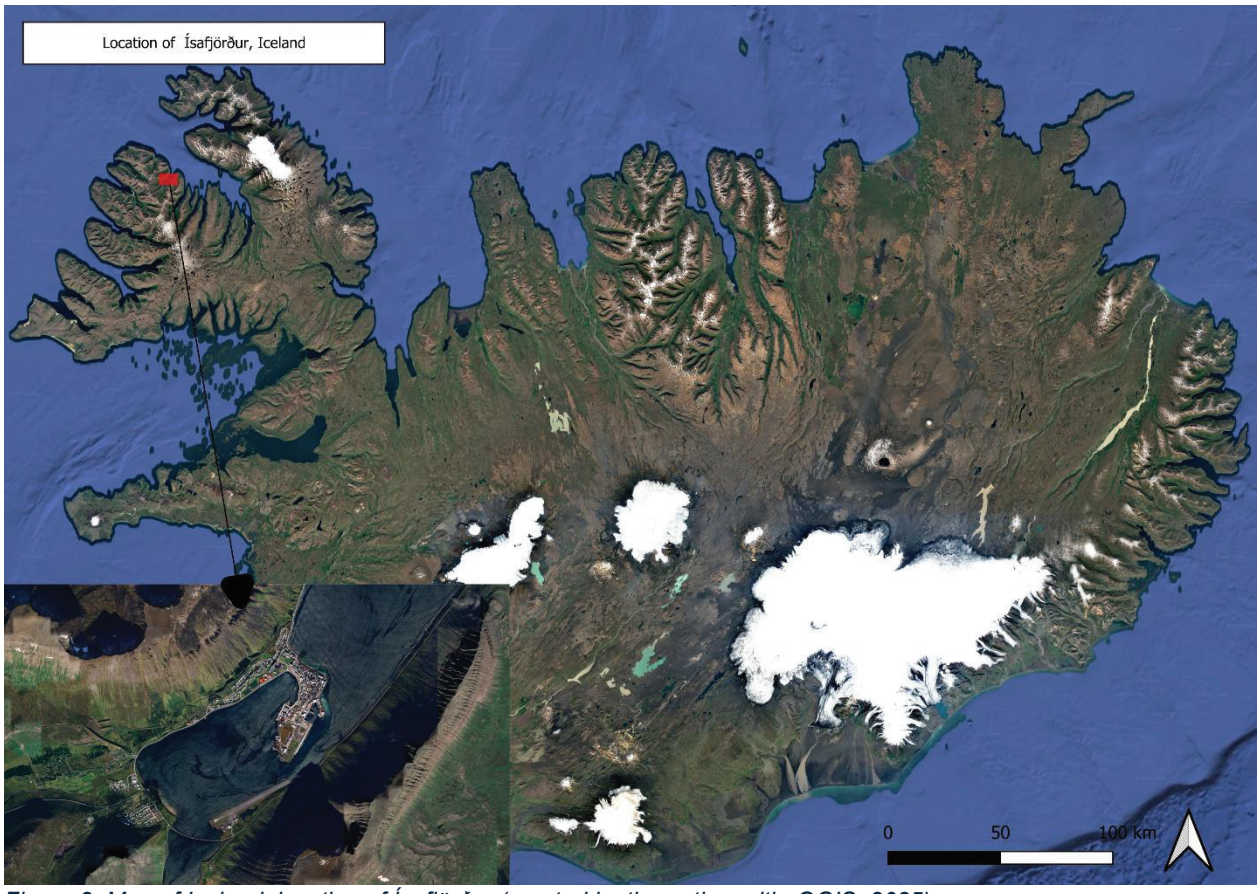

Figure 2: Map of Iceland, location of Ísafjörður (created by the author with QGIS, 2025)

1.3.3 Study site

The site lies at a short distance from the inner harbor *Pollurinn* within the fjord Ísafjarðardjúp (figure 3). The flat terrain is covered by short grass with patches of bare ground, lupins (*Lupinus nootkatensis*) are growing sporadically but mostly at the edges. A small river flows nearby, and the area borders a walking/cycling path, a road, and a supermarket with moderate human activity.

Figure 3: Breeding ground in Ísafjörður 2025 (created by the author with QGIS, 2025)

Figure 4: Breeding ground of Arctic tern in Ísafjörður (red outline) in, supermarket in background (own picture, june 2025)

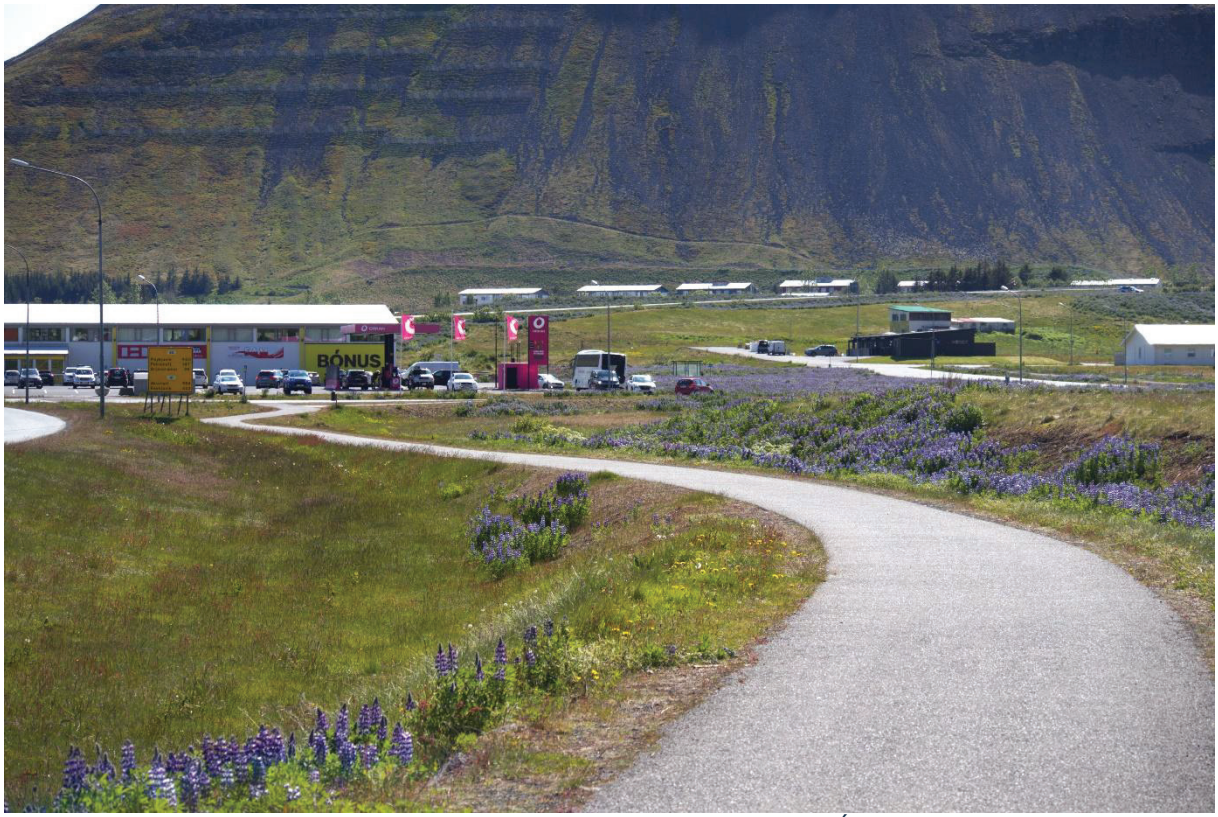

Figure 5: Walking/cycling path next to the breeding ground of the Arctic terns in Ísafjörður (own picture June 2025)

1.4 Current situation

Many residents have negative experiences with Arctic terns and are seeking a solution. The conflict with the terns has been acknowledged or reported by the municipality on multiple occasions. In 2020 it was noted that a reduction of the terns' breeding habitat forced the terns to relocate, with the colony settling adjacent to the supermarket parking lot (Ísafjarðarbær, 2020). Since then, several deterrence or relocation efforts have been performed, though none with a formal management plan for the terns or with cooperation with ecologists or conservation experts. A sound deterrent has been installed in Ísafjörður (Ísafjarðarbær, 2023) and the nearby village of Suðureyri, intended to prevent the settling down of birds to breed. Scientific data on how effective deterrents are in this particular case is lacking. However, they might avoid breeding directly next to the deterrent but still within the broader area. Other deterrence attempts, including planting vegetation around the playground to keep the terns away or spreading manure, were not successful (Ísafjarðarbær, 2023). Existing measures are the placement of educational warning signs and sticks for protection (figures 8 & 9). Since Arctic terns always attack the highest point of an intruder, the sticks can be held over the head of humans that are passing through the area to prevent being attacked themselves. The signs are in Icelandic and placed at both sides of the most used part of the path. However, the maintenance has been lacking. One of the signs was broken and had fallen into the field; the stick box is usually completely empty (figure 10). Another attempt to reduce the aggressiveness was made in 2025; Náttúrustofa Vestfjarða placed pallets in the breeding field to provide more hiding spaces for the chicks, which might reduce the aggressiveness of the adult birds. The effectiveness of this is not yet known.

Figure 7: Signs next to breeding ground (own picture, June 2025)

Figure 6: Sticks behind educational sign (own picture, June 2025)

Figure 8: fallen over sign (own picture, June 2025)

2. Materials and Methods

2.1 Field work

2.1.1 Study site delineation

The path around the terns breeding ground was divided into 5 sections to be able to identify spatial differences in tern and human behaviors and activities. An elevated vantage point providing clear visibility of the area was selected as the observation post.

2.1.2 Field data-collection

Field observations were carried out for twelve hours per week, typically divided into three sessions of four hours each. Data collection began on 17 June 2025, when the terns initiated nesting, and continued until 7 August 2025, when no more birds remained on the breeding grounds. Only during one week (July 14-20) were less than 12 hours of fieldwork conducted, because of volcanic activity in Iceland and resulting poor air quality in the area that made fieldwork not possible.

Following Information was collected in each session: date, weather, temperature, cruise ship in town, session time, and status of colony (breeding stage). Each human-tern encounter within the session got recorded, and that information was gathered: time, number of persons, number of adults/children, number of pets, type of activity, and reaction level of terns and humans in every section (appendix A). The definition of the reaction levels is seen in table 1. In further analysis the term *"strong reactions"* refers to the combined level 3 and 4 of term reactions.

The breeding cycle was categorized into stages. The first stage was “breeding.” The terns arrived on the breeding ground and began nesting; my observations of this stage lasted from the 17th of June to the 3rd of July. The second stage was “breeding/hatched chicks”; while some chicks had already hatched, some others were still breeding. This stage was noted from the 4th of July to the 14th of July. The third breeding stage was “chicks left the nests and are on the path/street.” No more breeding was observed; the chicks left their nest or close area around the nest, and some wandered onto the walking path, the street, or the supermarket parking lot. The first day the chicks were observed outside of the breeding ground was the 21st of July and the last was the 1st of August. From the 5th of August no terns were visible on the breeding ground

anymore. The colony was seen feeding on a close beach, where no/very limited human activity occurs.

Table 1:Definitions for level of reaction, used for data entries of field observations (created by author)

Tern	Human
1. None (no noticeable reaction)	1. None (no noticeable reaction)
2. Mild (alert posture, minimal movement)	2. Protective (Stick or other protective measurements)
3. Aggressive (vocalizing, wing spreading, defensive postures)	3. Stopping
4. Attack (physical lunges or pecking)	4. Aggressive (Screaming, defensive postures)

2.2 Survey on human-tern conflict

2.2.1 Survey aims

The survey seeks to examine how residents and visitors of Ísafjörður and the Westfjords perceive the presence of Arctic terns, focusing specifically on their experiences with the Arctic terns and their opinion on the conflict. It also investigated which management strategies or solutions residents consider most appropriate or effective in mitigating these conflicts.

2.2.2 Survey design

The survey was directed primarily toward residents of Ísafjörður and individuals who visit the town frequently, though responses from tourists will also be considered. The survey consisted of seventeen questions (appendix B). The first section is to collect demographic information, including age and place of residence. Further questions explored participants' perceptions and experiences with the Arctic terns. Identifying the situations in which the birds affect daily life, the frequency of encounters, and the perceived severity of the issue. Respondents were asked to indicate which management measures they support. At the end it was possible to leave a comment. The survey was shared using both digital and physical methods, while it could only be answered digitally. It was posted via Facebook, which is commonly used by locals. Furthermore,

flyers were placed in commonly used locations such as supermarkets and the local swimming pool with QR codes that could be scanned and directed to Google Forms where the survey could be answered anonymously. It was published in both English and Icelandic.

Figure 10: Survey flyer in English

Figure 9: Survey flyer in Icelandic

2.3 Data analysis

Field data collected during observations were entered into a standardized Excel spreadsheet for processing. Survey data were gathered through Google Forms, in both English and Icelandic. Responses from both language versions were exported into an Excel spreadsheet and combined; Icelandic answers were translated into English for analysis.

A series of plots were produced to investigate patterns in both the field observations and the survey responses.

For the field data, bar plots were created to show the terns' reactions to different activity types, the distribution of reactions across the path sections, and the breeding stage. A line plot was used to illustrate temporal dynamics showing the daily percentage of strong tern reactions. Additional data was summarized with Excel, which was not put into a plot: weather, temperatures, attacks per day, and number of observed activities. A matrix table of human and tern behavior was created in Excel and exported to R to visualize the relationship as a correlation plot. Summarized data about the percentage of strong reactions per section and the overall use per section was used to create maps with QGIS.

For the survey data, several bar plots show the distribution of responses, including opinions on the presence of Arctic terns, behavioral changes due to tern activity, impacts on daily activities, reactions during attacks, and the frequency of encounters. Additional bar plots represent public knowledge and perception of terns, perceived reasons for tern attacks, support for different management actions, and levels of agreement with management priorities. Some survey questions allowed multiple responses, and percentages were therefore calculated relative to the number of respondents per question. All comments that were made in the survey were reviewed, and opinions were included in the discussion.

3. Results

3.1 Results of fieldwork

3.1.1 Temporal Patterns

The number of daily observed strong reactions from *Sterna paradisaea* in the observation area stayed roughly the same, typically below 10–15%, from the beginning of the observations until the 21st of July, when the highest number of strong reactions occurred (figure 11). On this day 41% of the observations recorded a strong reaction from the terns. After this spike, values declined but showed secondary increases near the end of July, then a decrease to zero aggressive reactions at the end of August, the end of the observation period. A very similar pattern shows the number of attacks only. The peak was reached on the 21st of July with 9 attacks, which accounts for 24% of encounters that day. No attack was observed after the 5th of August.

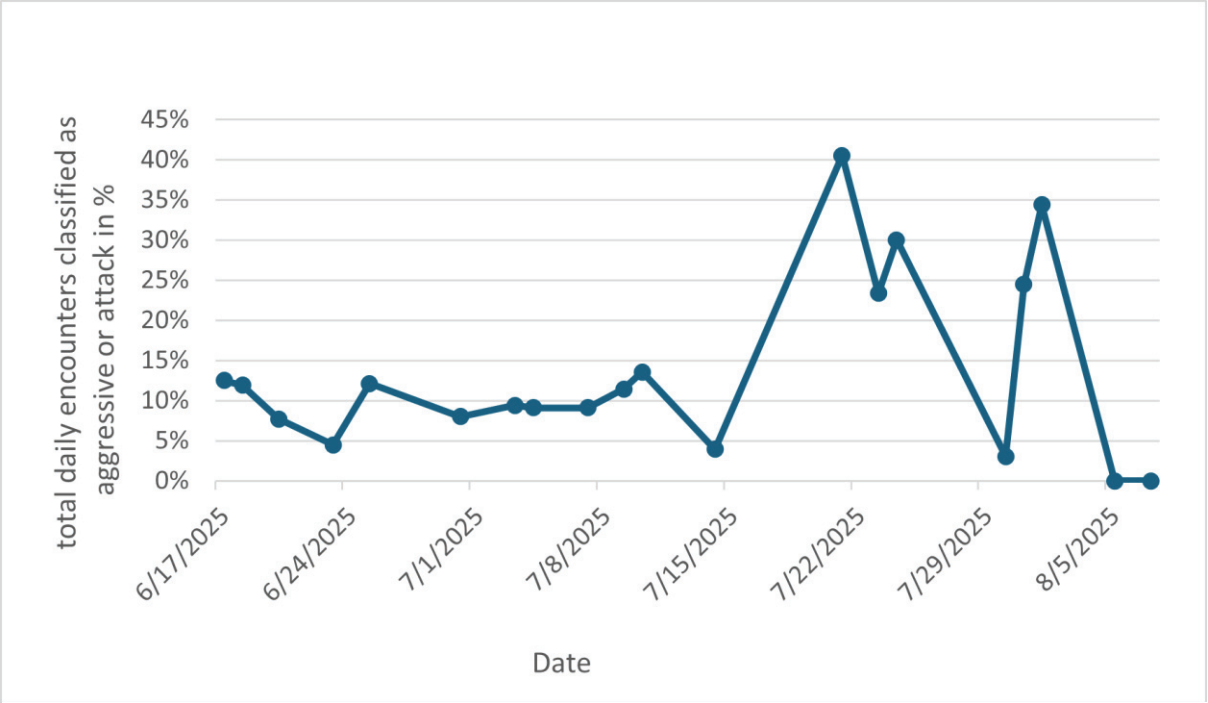

Figure 11: Daily percentage of strong reactions from Sterna paradisaea in at least one section over the observed breeding period (17th June-5th August 2025).

The stage of breeding influenced the way the terns are reacting. At the beginning of the breeding period when no chicks were hatched and adult birds were breeding, for 79% of encounters no reaction was observed, a mild reaction was recorded in 11%, 7% were aggressive reactions, and 3% were attacks. When chicks started to hatch, the mild reactions increased slightly to 12%, aggressive reactions accounted for 6%, and attacks for 4%. A shift in the proportion is visible during the third observed stage; chicks left the breeding ground and were walking and sitting on the road and walking path. The majority still showed no reaction, but a noticeable proportion exhibited mild reactions (14%), aggressive reactions (14%), and attacking reactions (12%). When the terns left the breeding ground and fed by the nearby water, no more reactions were observed.

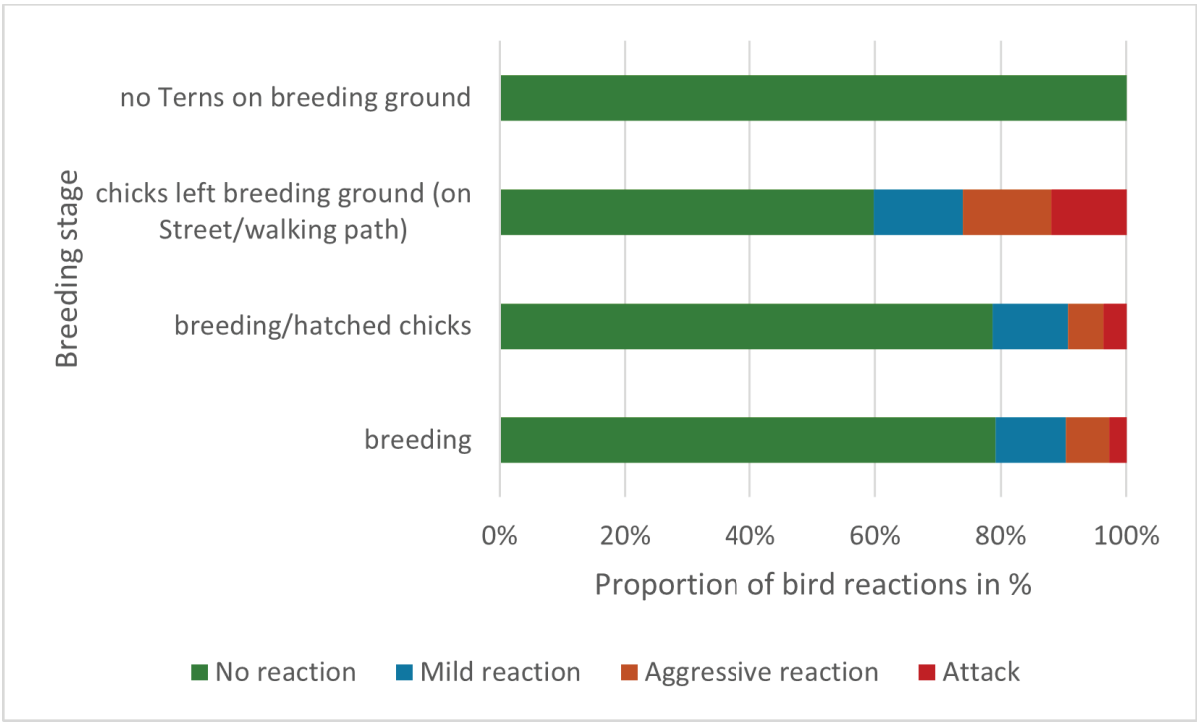

Figure 12: Proportion of Arctic tern reaction categories recorded during observed stages of the breeding period

3.1.2 Spatial patterns

The results reveal clear spatial differences in behavioral responses (figure 13). Section 1 is dominated by *no reaction,* exceeding 90% of the share, and 0% of strong reactions. Section 2 displays a slightly different distribution; *no reaction* holds the biggest share with 64%. Mild and aggressive reactions have a higher proportion than Section 1; attacks occurred in 7% of interactions in Section 2. For Section 3, no reaction was recorded in 17% of encounters—the lowest number of all sections for this category. In 3% of cases the terns had *mild reactions*. The biggest share has *aggressive reactions,* with 43%. Attacks also occurred often—in 37% of all encounters in section 3. That means that 80% of all encounters in section 3 turn showed a strong reaction. Section 4 shares the same percentage of *no* and *mild reactions*, each holding 23%. The biggest proportion is *aggressive reactions*, with 39%; attacks occurred in 16% of encounters. Over half of all encounters in section 5 showed no reaction from the birds, 20% were categorized as *mild*, 17% as aggressive, and the lowest part, with 8%, as attacks.

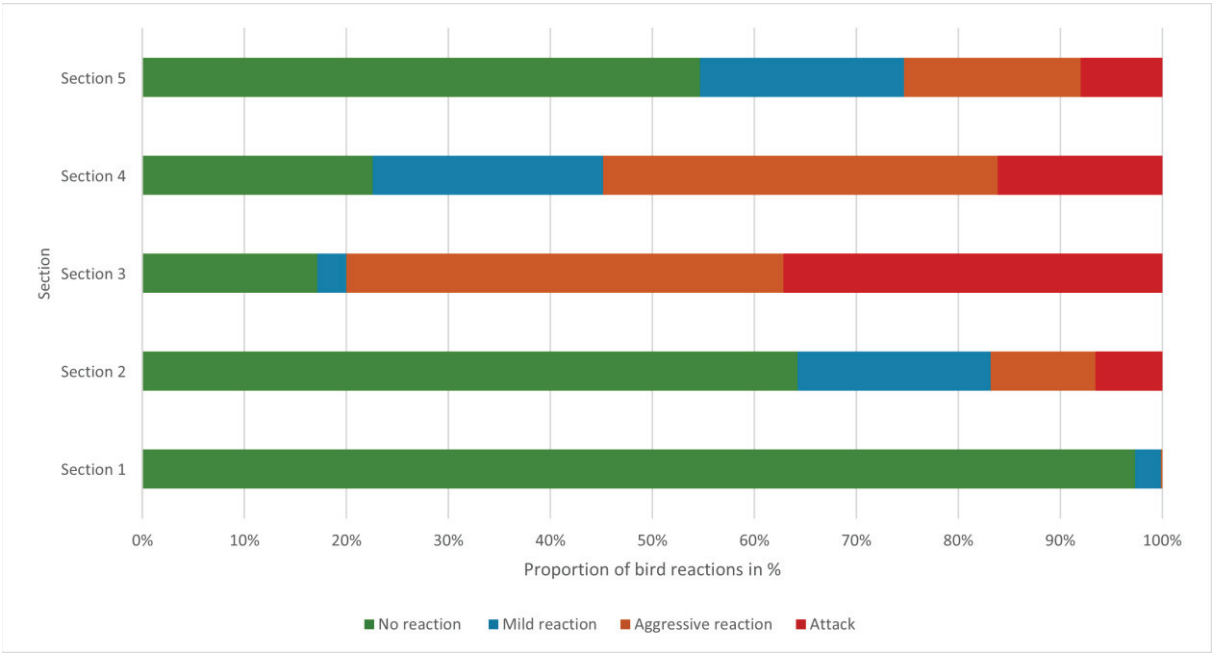

Figure 13: Proportional distribution of the four tern reaction categories, across the five sections of the study site. Each bar represents 100% of the reactions recorded in a section

Figure 14 visualizes the percentual difference in strong reactions in the 5 observed sections. It highlights the fact that section 3 has the highest percentage of strong reactions and section 1 the lowest. In section 3, 80% of all encounters were classified as strong reactions. Section 4 has the second highest with 55%. Sections 2 and 5 had a lower number of strong reactions, with about 30%. In section 1 only one strong reaction was observed, which accounts for less than 1% of all observed encounters in that section.

The number of observed human-tern encounters varied across the five observed sections due to different human activity. Figure 15 shows the total number of human-tern encounters observed over the breeding period per section. In total 1480 encounters have been recorded. Every human activity (walking, biking, running, skating, e-scooter) counts as an encounter even if no reaction from a human or tern occurred. By far the highest number of encounters were observed in sections 1 and 2, with over 600 encounters each, accounting for over 90% of observations. In section 5, 75 encounters were observed, and the lowest numbers were in section 3 (35) and section 4 (31).

Figure 14: Map proportion of strong reactions per Section

Figure 15: Number of observed human-tern encounters per Section

3.1.3 Influence of activities

No reaction has the largest share in all activity types, which means most interactions showed no visible reaction (figure 16). *Mild reactions* occurred more frequently during walking and running, while *aggressive reactions* and *attacks* were comparatively rare but slightly more prevalent in those same two categories. Activities involving faster or more movement, like biking, skating, and e-scooters, tended to show less strong reactions; over 80% of the encounters had no visible reaction from the Arctic terns, and only 1-2% of the encounters ended in an attack from the birds.

Those results show that slower, more exposed activities (such as walking and running) may be more likely to trigger noticeable reactions, whereas higher-speed or vehicle-assisted movement correlates with less strong reactions.

Biking is the most observed activity, observed 700 times. The second most common activity is walking, with almost 500 records. Less common were running, skating, and e-scooters (including mobility scooters).

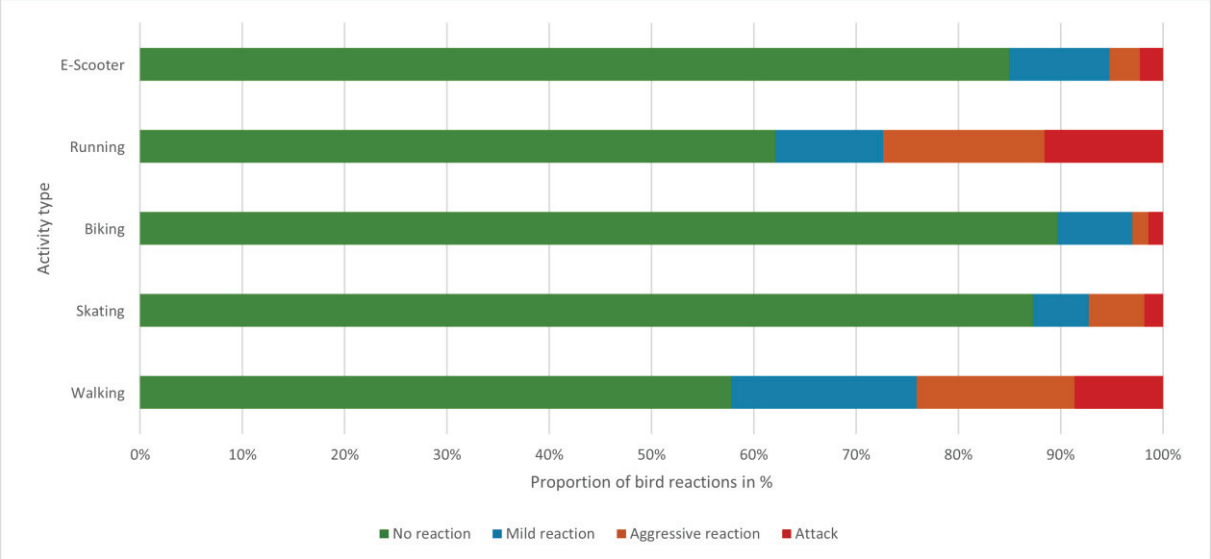

Figure 16: distribution of the four tern reaction categories across the five recorded activities: walking, skating, biking, running, and e-scooter use. Each bar represents 100% of the observations per activity

3.1.4 Effect of children presence

The presence of children has shown no influence on the percentage of strong reactions. With children and without, both situations have an average of 12% of aggressive reactions (table 2).

Table 2: Children presence effect on frequency of strong bird reactions

Children present	Strong Reactions (%)
No Children	12%
Children	12%

3.1.5 Effect of pet presence

The comparison shows that there is a clear difference between the two situations: when no pet was present, only around 10% of interactions had strong reactions, and when a pet was present, the proportion of strong reactions increased to more than 50%, indicating a more frequent occurrence of aggressive or attack-level responses in the presence of pets (figure 17). All observed pets were dogs, with one case of an unleashed dog. The reaction of the terns to the unleashed dog was not stronger than those who were on a leash, from personal observation (3=strong reaction).

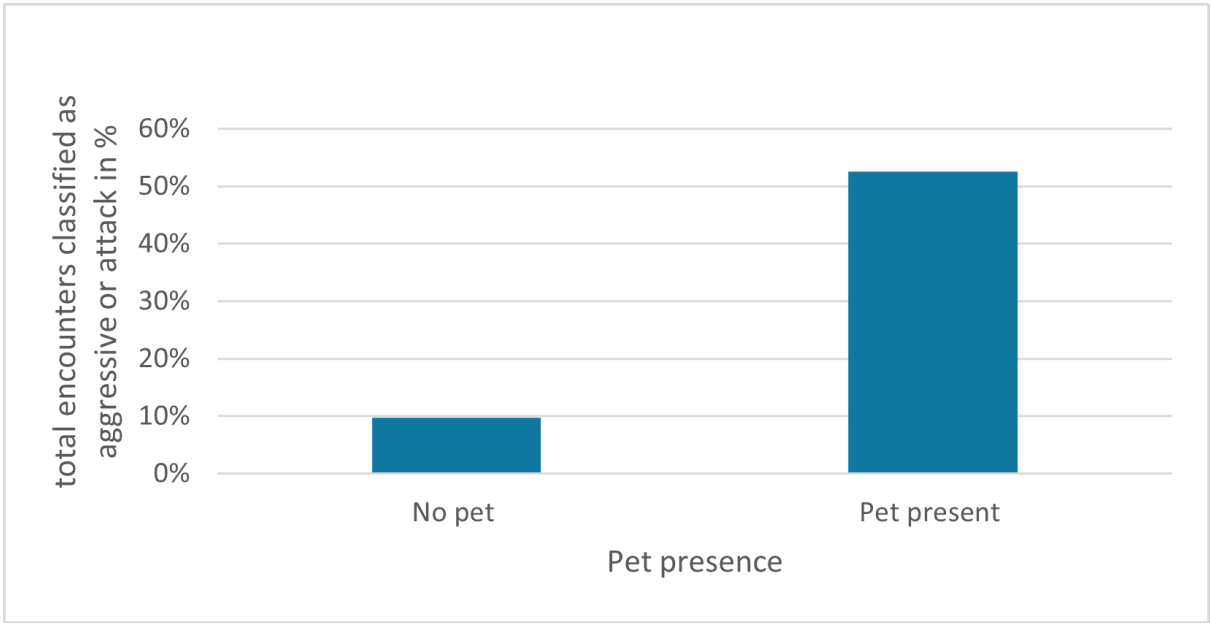

Figure 17: Effect of pet presence on tern aggression, measured in percentage of strong reactions for all encounters

3.1.6 Correlation of human-tern behavior

The big majority of encounters that were categorized showed no visible reaction from either humans or the terns. In 1127 cases *no reaction* was observed, which accounts for 76% of all encounters. In 10% (148 times) the terns showed a *mild reaction* while the humans showed *no reaction*. If the birds were reacting aggressively, most humans did not react or had a protective reaction; only once did they stop, and in 5 cases, they reacted aggressively. During attacks the most common reaction from humans was protective, and the second most common was a strong or aggressive reaction like screaming or defensive actions. The reactions of both observed groups are correlated; still, the terns have shown stronger reactions, while the humans were less visible reacting.

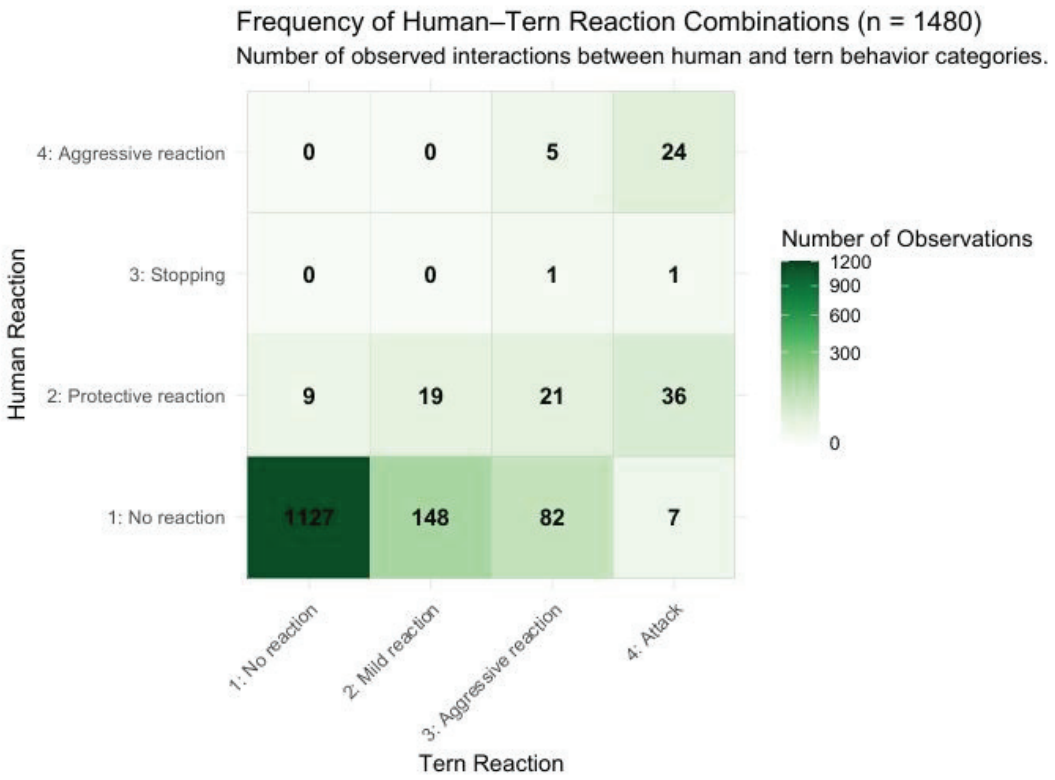

Figure 18: Frequency of Human-Tern reaction combinations; reactions, every recorded reaction from both humans and terns during the observation period

3.1.7 Additional observations

During the observations, several raven attacks occurred, which led to strong defensive reactions from the adult Arctic terns. When humans passed near the breeding grounds, they were also attacked or swooped at. Although I did not collect enough data on this specific scenario, the few incidents I observed showed a potential pattern.

3.2. Results of the Survey

3.2.1 Overall information

The survey received responses from 101 participants. Of these, 49 live in Ísafjörður year-round, 50 are visitors, and 2 reside there part-time. Only one respondent reported not living in Iceland, while the remaining participants are from other parts of the Westfjords or elsewhere in Iceland. Not all respondents answered all 17 questions. Also, some questions allowed multiple answers. So not every question has exactly 101 answers; the results show the percentual distribution of the answers available for each question.

3.2.2 Opinion on the presence of Arctic terns

The most common answer toward the presence of Arctic terns (*Sterna paradisaea*) in Ísafjörður was *positive*; 43% of respondents expressed that they are happy about the presence of Arctic terns (figure 19). A smaller proportion, 23%, reported a neutral stance, stating that the birds “don’t bother” them, while 34% of respondents expressed a negative opinion, reporting that they “don’t enjoy their presence.”

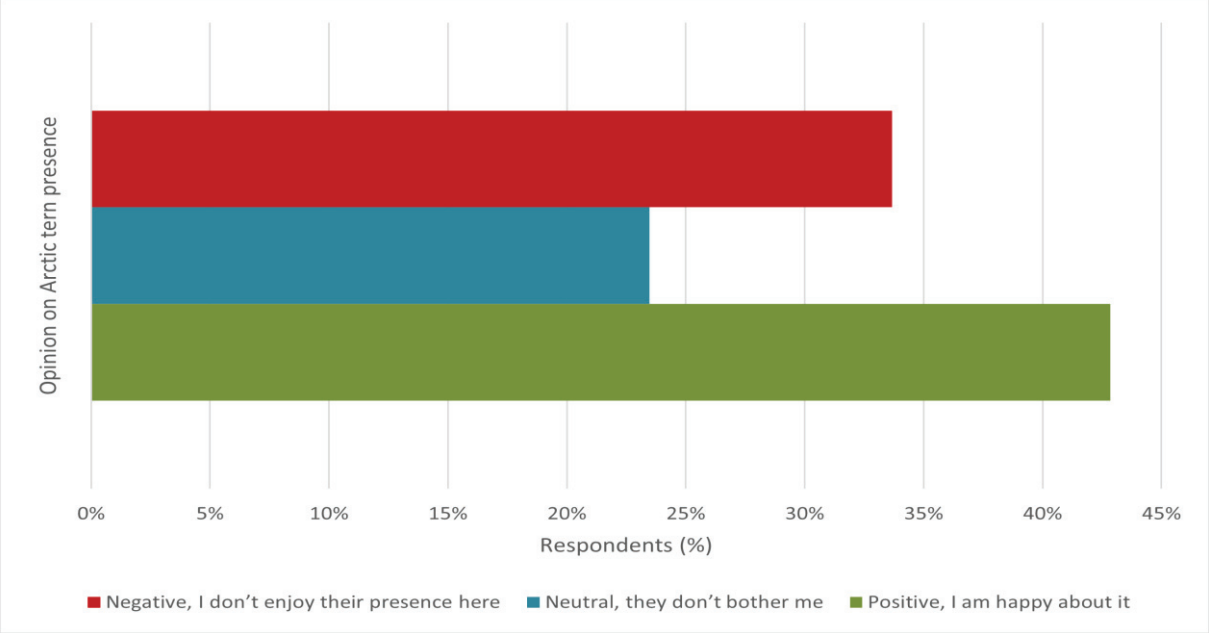

Figure 19: Responses to the question ” How do you feel about the presence of Arctic terns ?”, possible answers are Negative, I don´t enjoy their presence here, Neutral, they don´t bother me and positive, I’m happy about it

3.2.3 Behavioral changes due to Arctic terns

The presence of Arctic terns (*Sterna paradisaea*) influences human behavioral patterns, specifically in relation to avoidance of activity and areas. To explore this, two statements were given; the respondents could state their level of agreement with those statements.

For the statement "I avoid certain activities," the largest proportion (38%) *strongly disagreed,* and 21% of respondents *did not agree*. Smaller yet notable proportions of respondents *agreed* (17%) or strongly *agreed* (22%), so a part of the population does avoid certain activities due to the terms (figure 20).

A similar result is depicted for the statement "I avoid certain areas." Again, the largest proportion of participants, 32%, *strongly disagreed,* and 25% *disagreed*, indicating that most residents do not actively avoid specific locations due to terns. However, a combined 52% of respondents either *agreed* or *strongly agreed*, revealing that half of the respondents do avoid areas.

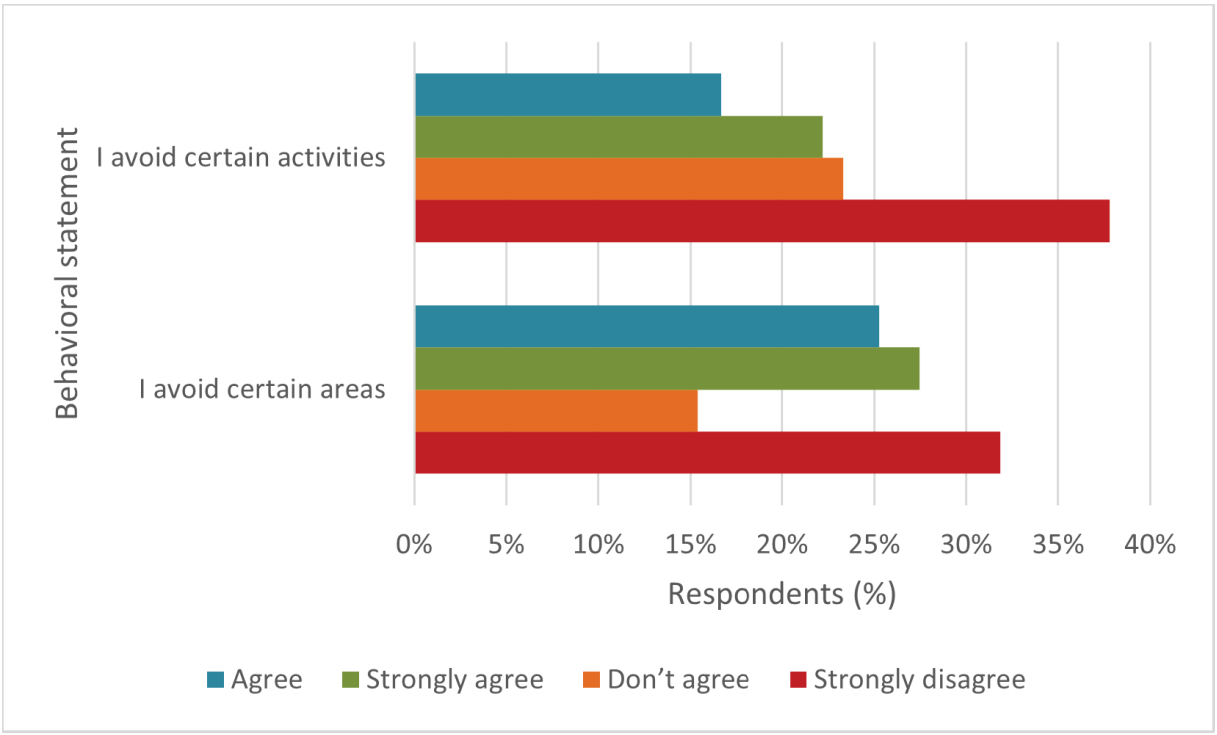

Figure 20: Responses to the question "Because of the Arctic terns I change my behavior..", respondents agreement to the two statements "I avoid certain activities" and " I avoid certain areas"

3.2.4 Impact on actitivies

The activity most frequently reported as negatively impacted is activities and sports, like running, cycling, and walking; 31% of respondents experience negative impacts. Shopping or filling petrol is the second most affected activity, reported by 15% of participants (figure 21).

Lower levels of disturbance were named for walking a pet (11%), commuting to school or work (11%), spending time around the home or garden (10%), being at playgrounds (8%), and during work (8%). The least affected activity is bird or wildlife watching, with 6% of respondents reporting negative effects.

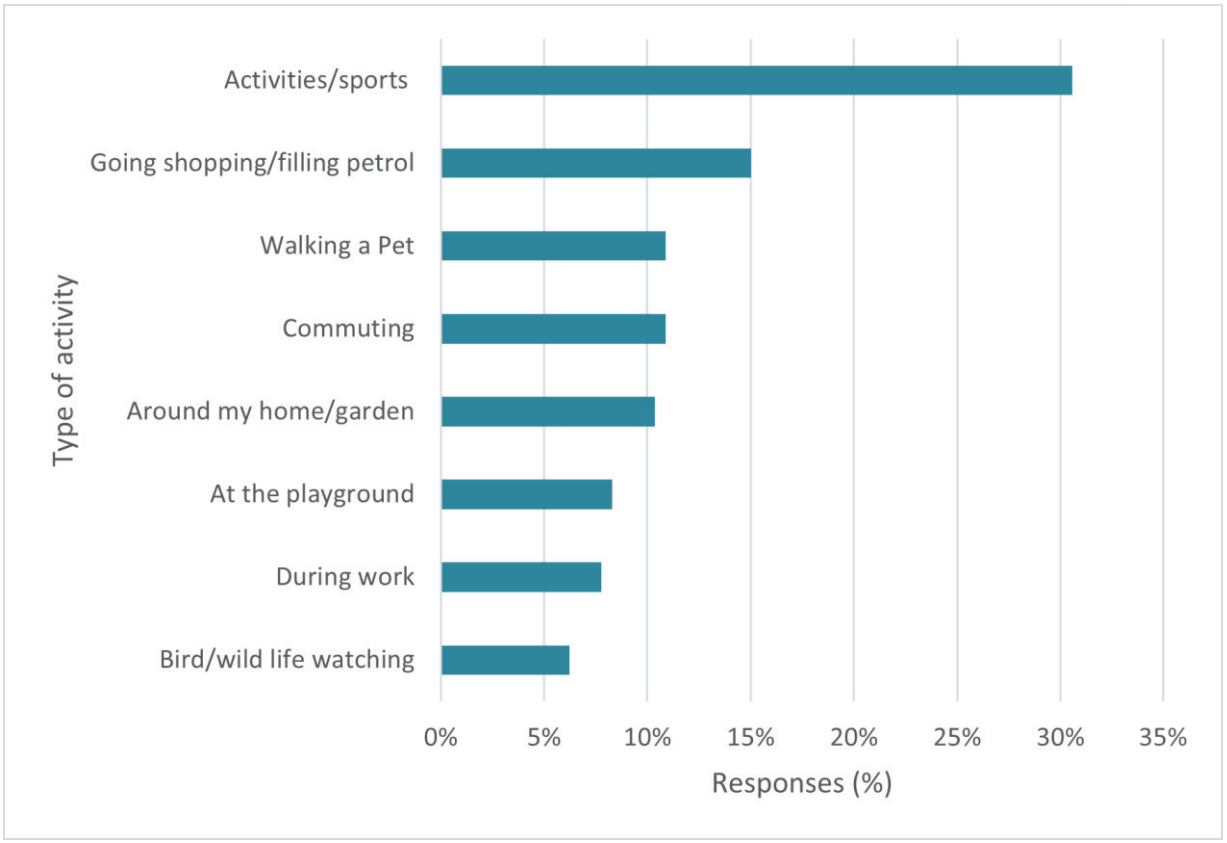

Figure 21: Responses to the question "During which activities do they [Arctic terns] negatively affect you?", multiple choices were possible

3.2.5 Reactions to Arctic tern attacks

The most common reactions when attacked by Arctic tern are *moving faster through the area*, *cover/protect head* and *ignore the Arctic terns* which most respondents reported doing very often (33%) (figure 22). To cover or protect the head is done *often* by 20% of respondents, *sometimes* by 34% and *never* by 17%. Similar distribution is also seen for *Ignore the terns*, the share of doing this *often* is slightly lower with 14% and sometimes was chosen 35% of times.

A less frequent response is *using distraction methods* such as carrying a stick or other object to deter the distract the birds. This reaction is most often marked as *sometimes* (39%). Only 16% answered to use this method very often and 22% often. 23% of responders stated to never use distraction methods.

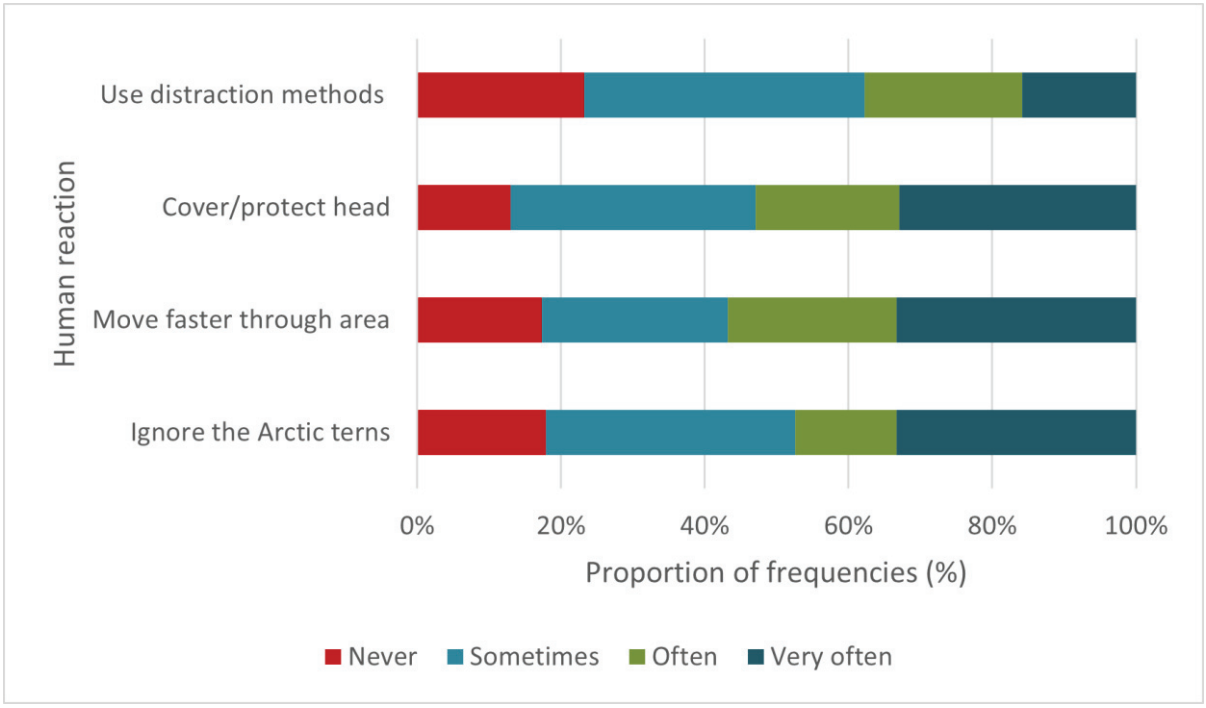

Figure 22: Responses to the question " What is your reaction if you get attacked?", Options provided were use distraction methods, cover/protect head, move faster through the area and ignore the Arctic terns.

3.2.6 Frequency of encounters

All those who stated they had direct encounters with Arctic terns were asked if those encounters had been a negative experience or negatively impacted them; 55% of respondents answered no and 45% yes.

The most common encounter is *swooping/intimidation*, 34% stated it occurs often and 36% sometimes, while 19% reported it rarely happens and 10% answered with never. Less frequent seems to be a *physical attack*, 14% stated it occurs often and 27% sometimes. The majority answered with rarely (27%) or even never (33%). The biggest stake for *bird droppings* holds holds „never“ which accounts for 37% of all answers. The by far least named frequent encounter is the *collision while driving*, 4% stated it occurs often, while 71% answered it never happens (figure 23).

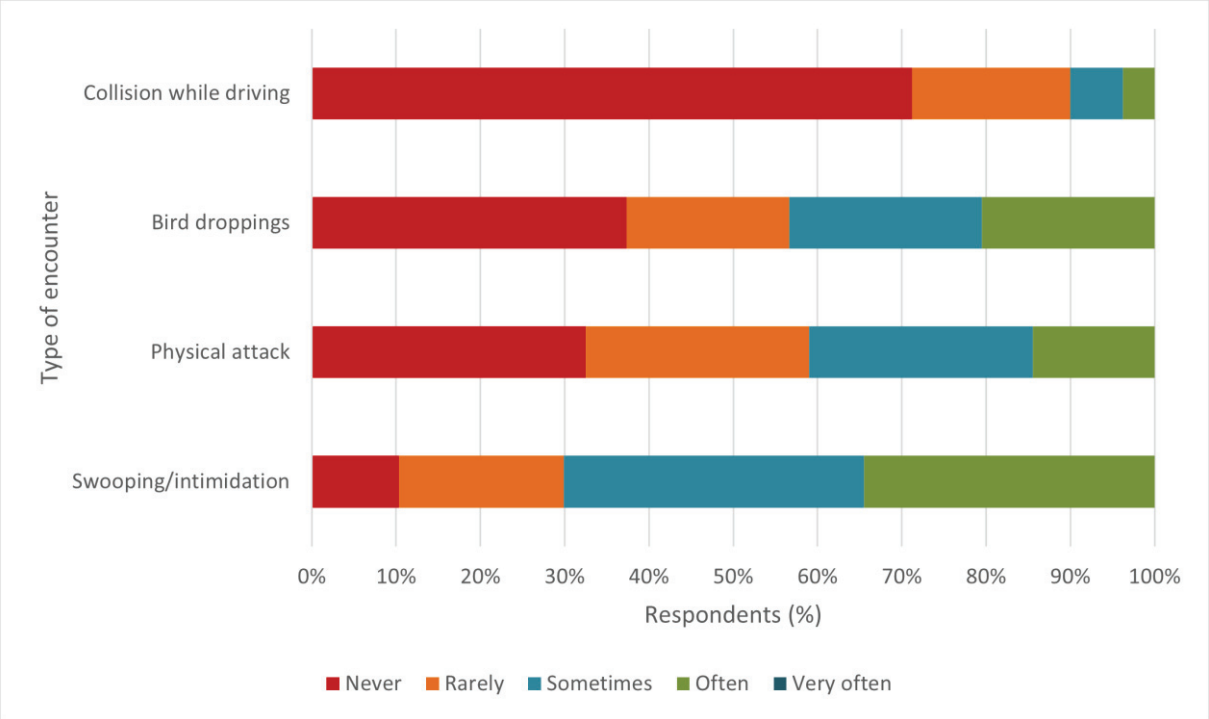

Figure 23: Responses to the question “ What kind of encounter was it and how often does it occur ?”,possible encounter types are collision while driving, bird droppings, physical attack, swooping/indimidation

3.2.7 Public knowledge and perception of Arctic terns

Two questions were asked to explore the knowledge residents have about *Sterna paradisaea* and inform those who are not aware. The first is, “Are you aware that Arctic terns are listed as vulnerable in the Icelandic red list for threatened species?” 73% of responders answered with yes, while 27% replied no. The second question is “Did you know that Arctic terns travel from Antarctica to the Arctic and back every year, which is the longest known migration of any bird species—up to 90,000 km?” The vast majority knew and stated yes (84%), while 16% replied with no.

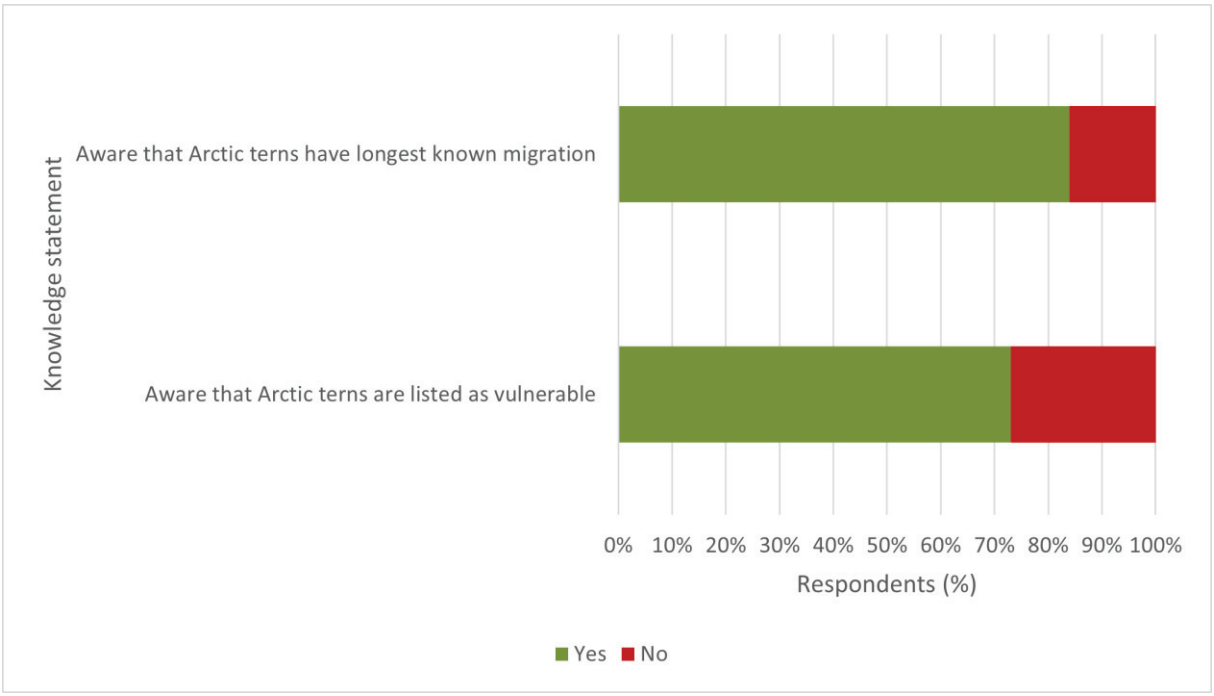

Figure 24: Responses to the two questions “ Are you aware that Arctic terns are listed as vulnerable in the Icelandic red list for threatened species? “ and “Did you know that Arctic terns travel from Antarctica to the Arctic and back every year, which is the longest known migration of any bird species - up to 90 000 km ?”

The perceived reasons why Arctic terns are attacking humans are showing a clear trend (figure 25). The vast majority replied with egg/chick protection (84%), much less with human disturbance (9%), and that Arctic terns are aggressive birds the least with 7%.

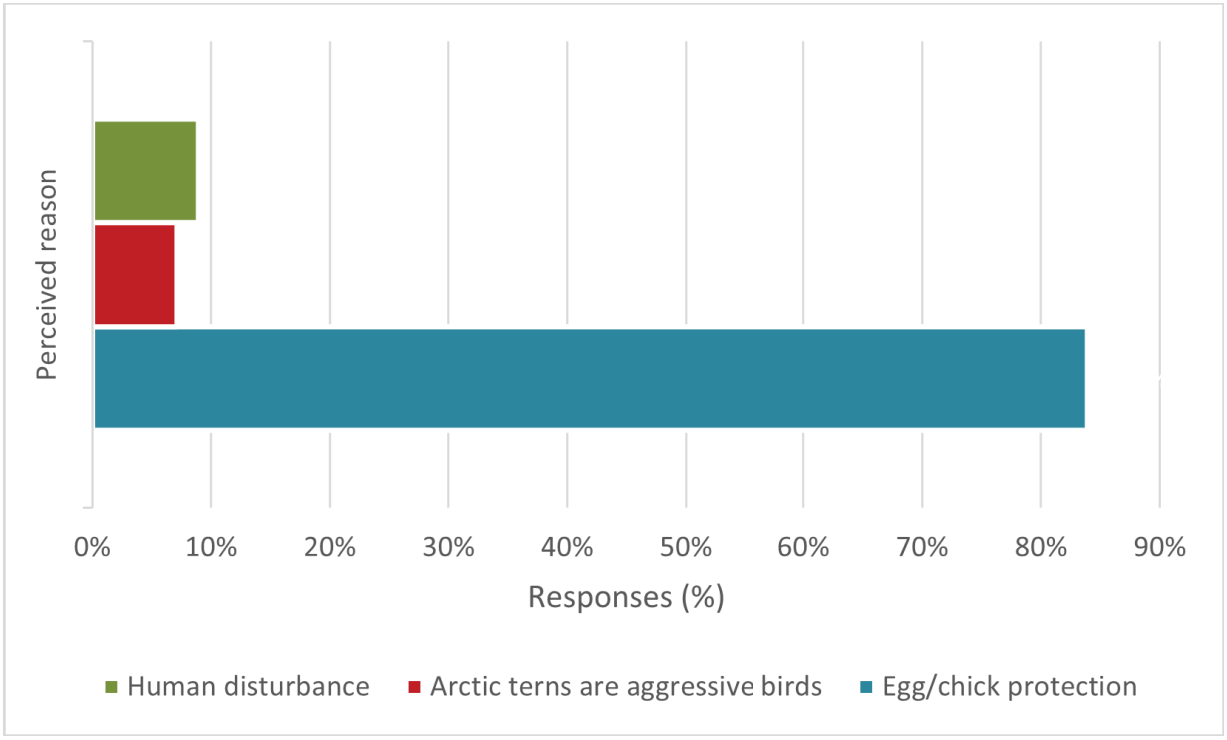

Figure 25: Responses to the question " Why do you think Arctic terns attack people ?" 1) Human disturbance 2) Arctic terns are aggressive birds 3) Egg/chick protection

3.2.8 Support of management (actions)

Figure 26 portrays the level of agreement among respondents with two different protection priorities: (1) protecting Arctic terns and their breeding habitat and (2) protecting humans and human activities.

For "Protect Arctic terns and breeding habitat," the majority of respondents expressed support; 52% replied they *strongly agree* and 34% *agree* with this protection focus, together accounting for 86% of responses. Only 14% of respondents *strongly disagreed*.

The priority "Protect humans and human activities" received more mixed responses. While around 40 percent *agree* and about 20 percent *strongly agree*, there was also a portion of 31% of participants who *strongly disagreed*.

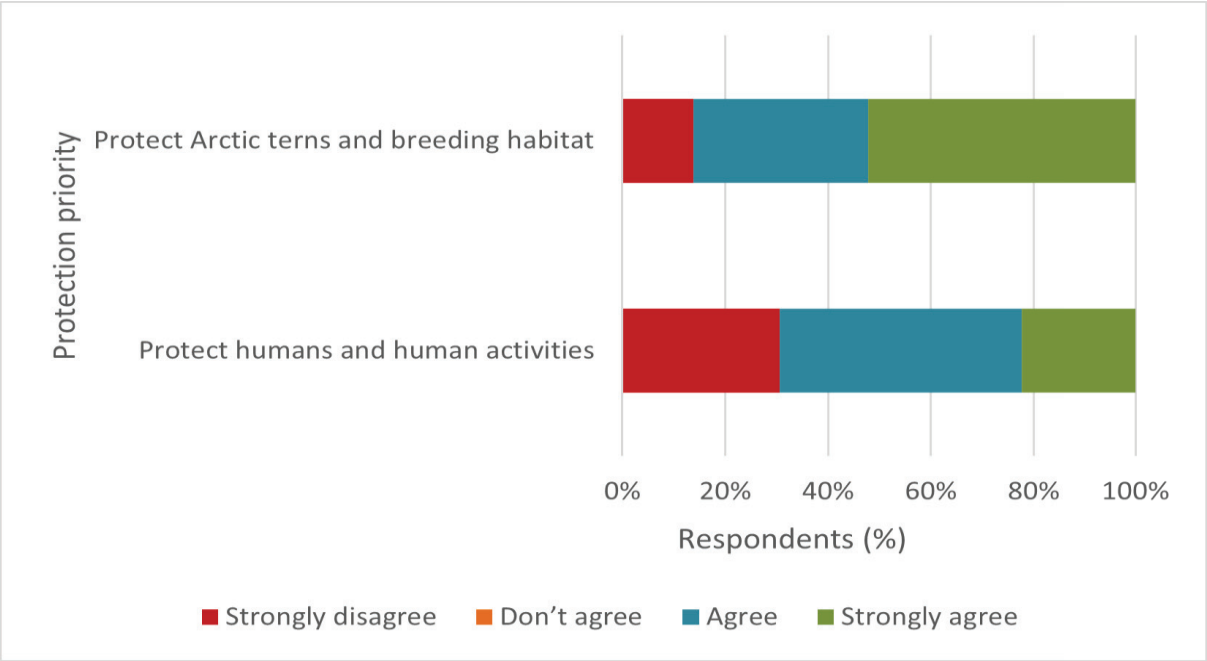

Figure 26: Responses to the question " We should take actions to manage human-tern interactions to… 1) Protect humans and human activities 2) Protect the Arctic terns and their breeding habitat

The action with the highest amount of support is educational/warning signs; 75% answered yes, they would support it (figure 27). 17% maybe, and only 8% no, they would not support it (figure 27). Another supported action would be to plant trees next to the walking path to shelter those who use it; 53% of respondents said yes, 39% answered maybe, and 8% are against it. Taking no measurements and not interfering with the terns is support by half of the responders; 51% replied with yes, 18% maybe, and for 31% this is not an option.

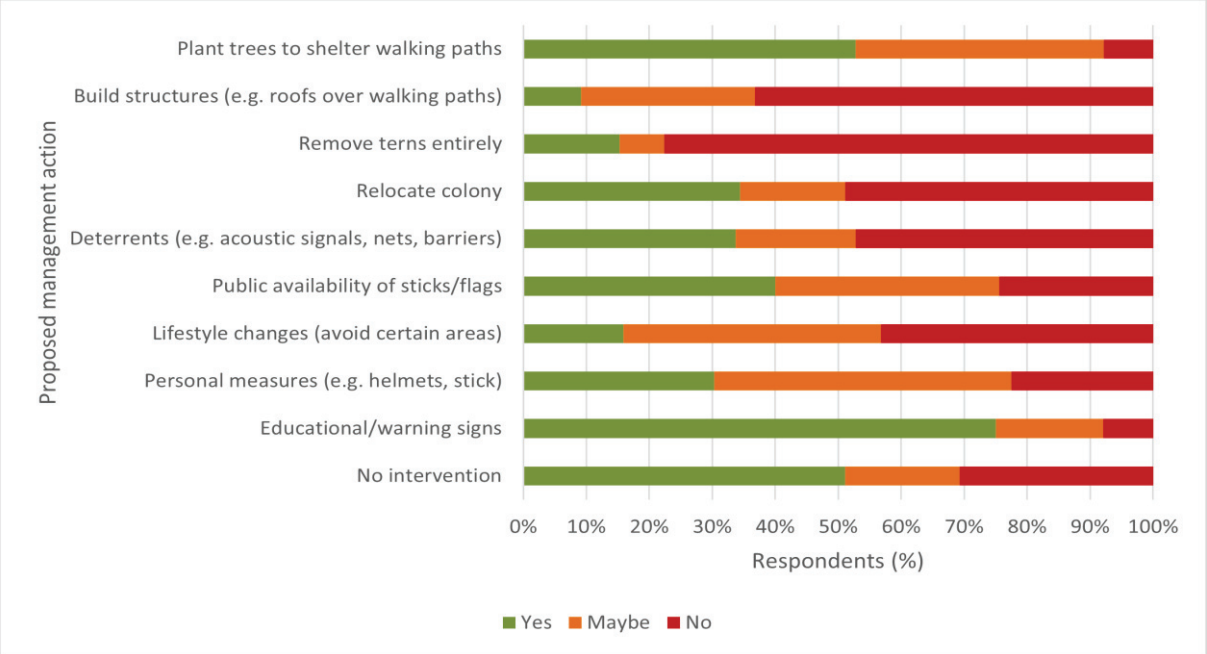

Figure 27: Percentual support of management measures by respondents, possible answers are Yes, Maybe and No. 10 possible measures

3.2.9 Factors influencing residents' perceptions of Arctic Terns

Negative attitudes may come from prior negative experiences with the birds (figure 28).

The left box (1) represents respondents who stated they had negative experiences with the Arctic terns. The median is around 0.5, which corresponds to neutral (1) to negative (0) feelings. The overall spread indicates that most of these respondents rated their attitude between 0 and 1, meaning generally unfavorable perceptions. A few still have a positive attitude.

The right box (0) represents respondents who did not report negative experiences. The median attitude is higher, around 1.5, corresponding to positive perceptions. The box extends mostly between 1 and 2, showing that most of these respondents feel neutral to positive about the Arctic terns.

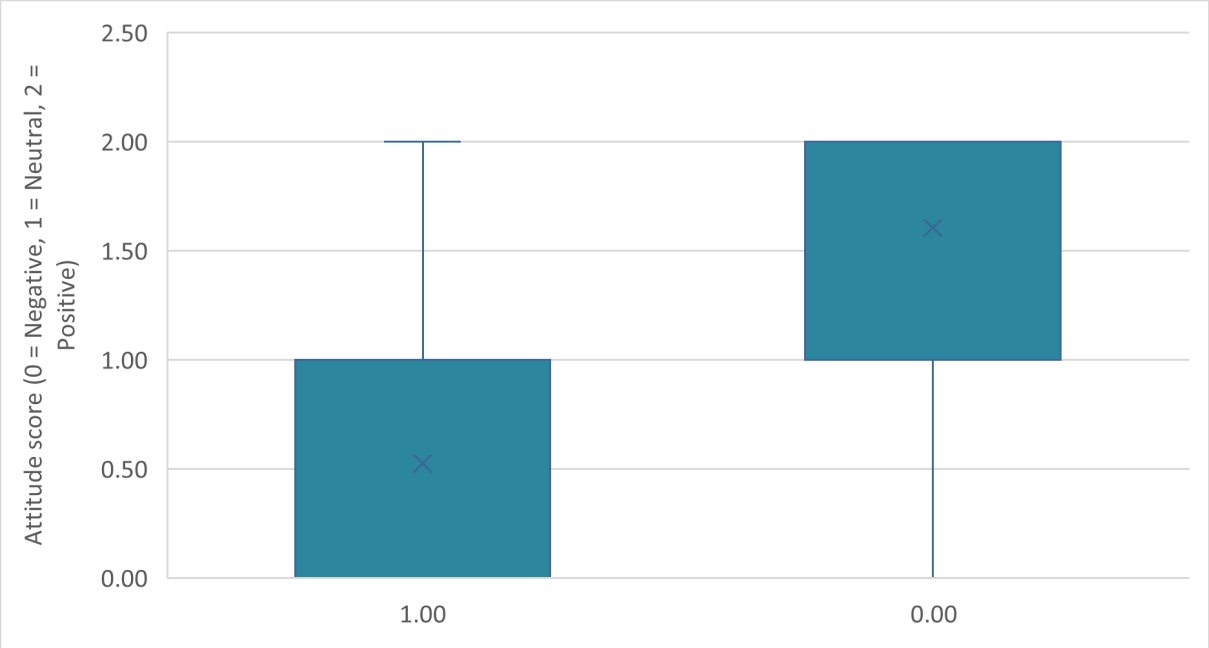

Figure 28: Attitude towards Sterna paradisaea based on the answer if encounters with Arctic terns were negative

Another aspect that seems to influence the attitude about the Arctic terns is the language the respondents chose to answer the survey in. It is presumable that everyone who answered in Icelandic was born in Iceland or at lived there a long time, while respondents who answered in English are newer residents of Iceland.

The Icelandic-speaking respondents, who represented the majority of participants (79 out of 101), expressed a much higher proportion of negative opinions about Arctic terns, while English-speaking respondents were predominantly positive (figure 29). Several factors may explain this difference, like scientific or ecological backgrounds. Second, long-term Icelandic residents may have more negative experiences with Arctic terns over the years compared to more recent residents, which could contribute to greater frustration about this conflict.

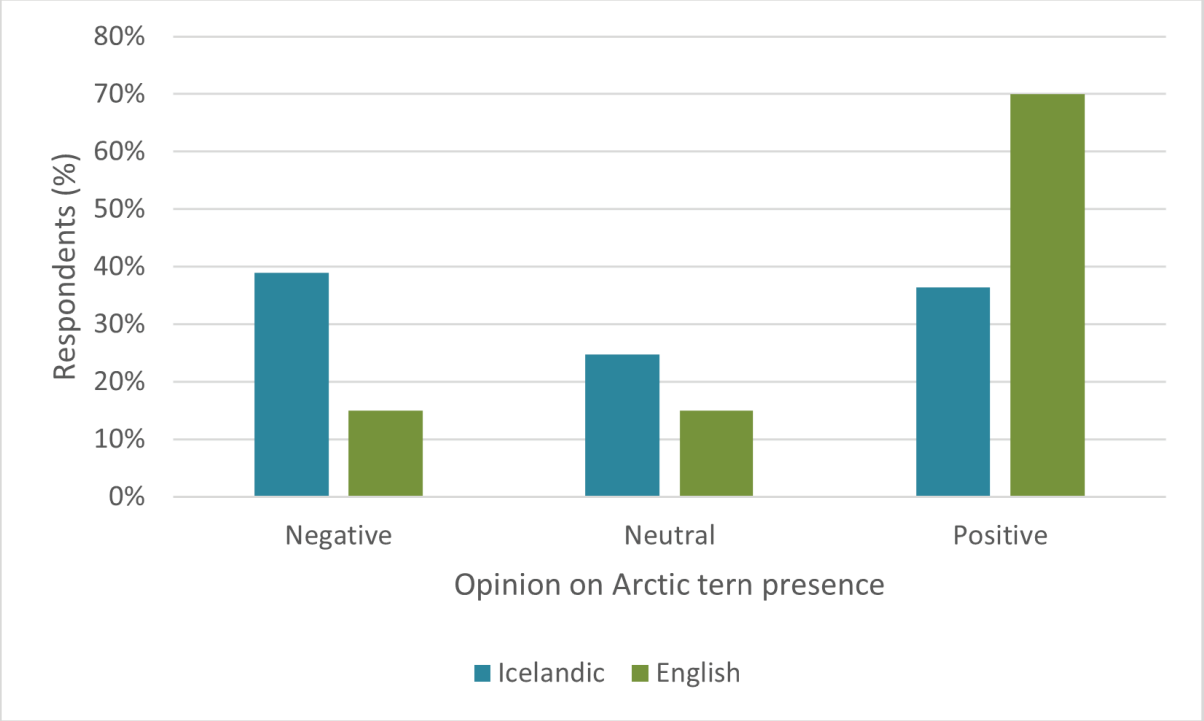

Figure 29: Attitude (negative, neutral, or positive) towards Sterna paradisaea based on whether respondents answered the survey in Icelandic or English

The responses about the attitudes toward Arctic terns shifted across age groups (figure 30). While overall, positive opinions are quite high across all age groups, it is especially extreme among those under 18, who show only positive responses. However, this data might not be representative to show the actual differences across the age groups because of the lack of data. Only 1 person under 18 answered this survey. The 18–30 group remains mostly positive as well, though with a notable minority of neutral and some negative sentiment. In the 30–60 and over 60 groups, negative views become more common with around a third of respondents. The results may suggest a trend across age groups; however, this cannot be confirmed due to the limited amount of available data.

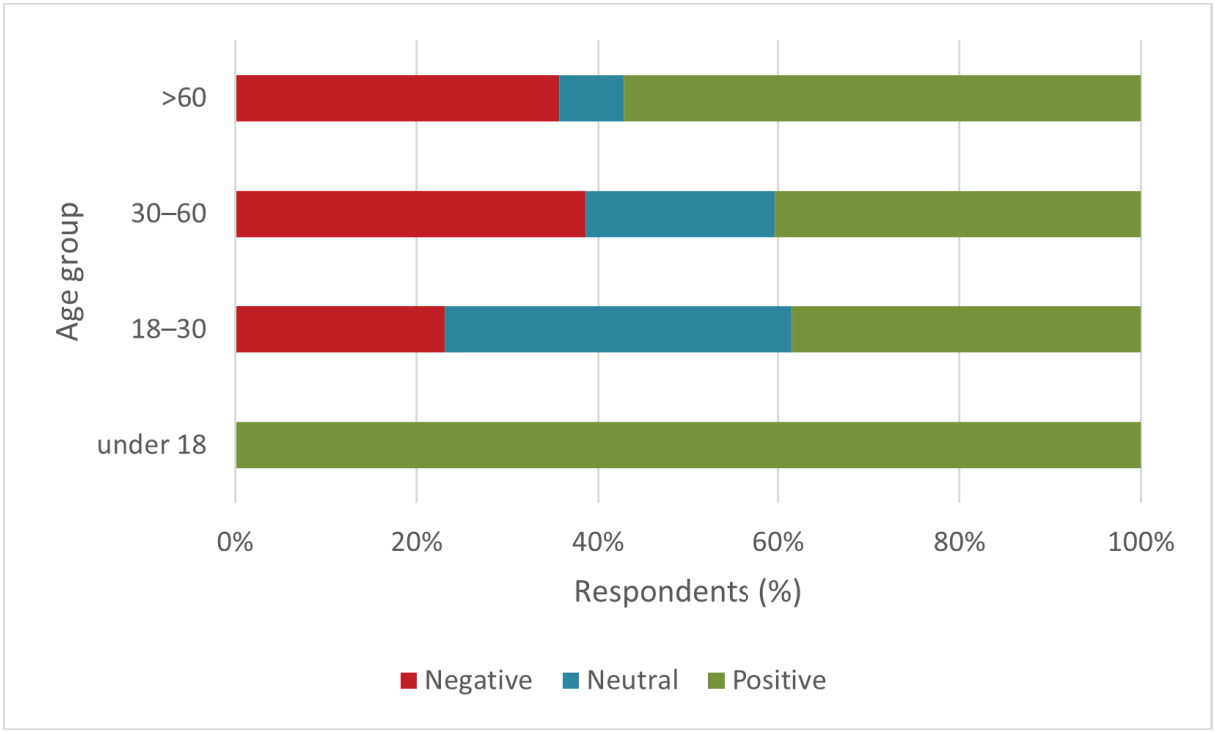

Figure 30: Attitude (Negative, neutral or positive) towards Sterna paradisaea based on respondents stated age-groups

3.2.10 Comments

At the end of the survey, the option of leaving an open comment was given; several were made. Most comments show a strong wish to protect the Arctic terns and improve coexistence and safety for the birds. Many say they have to adapt their lifestyle choices in order to the terns but that they do not mind doing so. On the other hand, they also highlight the inconvenience many inhabitants experience. Some comments mention that they do not walk close to the breeding ground, that children and pets are too scared to play in the garden all summer long, and one person even mentioned they would not have bought a house in this area if the Arctic tern had been breeding there then. Some were also mentioning that the breeding ground has been changing in the past years because they were forced to leave their former breeding ground. Participants offered several recommendations, including the construction of a new walkway, the relocation of the playground to an alternative site, and the creation of additional breeding habitat.

4. Discussion

4.1 Factors influencing the terns aggression

The results of the field observations show that during the breeding period the level of aggression changes with the breeding stage. The day with the most observed attacks is the 21st of July, the same time the juvenile Arctic terns left their nests and were on the walking path and the street. Several birds were killed by cars during that period. The colony was visibly in distress, and an increase in attacks occurred. After they were able to move away from the frequently used path and street, no more attacks occurred. Those results align with results of previous studies that have shown that Arctic tern nest defense increases with the breeding stage (Lemmetyinen, 1971). The findings highlight the importance of considering breeding phenology when finding solutions for the human-tern conflict. However, low disturbance is also relevant to the birds before the main breeding season, because it is influencing the territory establishment (Bötsch et al., 2017).

Also, a very clear spatial difference within the sections can be seen in **3.1.2 Spatial patterns**. Section 1, the one furthest away from the main breeding ground, has the least percentage of strong reactions; section 2 also has very low levels of attacks. Sections 1 and 2 are by far the most frequently used sections. Since over 90% of all encounters were in those two sections, the average level of strong reactions, including attacks, is relatively low. Section 3 has by far the highest percentage of attacks; the Arctic terns may feel the most threatened by human activity in this section. However, when the total number of encounters in Section 3, 35 over the entire observation period, is taken into account, the relative significance of this section diminishes. Whether sections 3 and 4 are used less frequently due to Arctic Tern attacks cannot be conclusively demonstrated; however, it remains a plausible explanation, as several survey respondents reported avoiding certain areas because of the terns (see figure 20).

Another factor that seems to influence the reaction of the terns is the activity humans perform. As seen in figure 12, the activities with the highest percentage of strong reactions are walking and running, while faster activities like biking, skating, and the use of electrical low-speed vehicles like e-scooters or mobility aids show less strong reactions. Biking is the most common activity in the observed area; almost 50% of all encounters were with bikers. Since walking is among the most frequent activities and is

associated with a high rate of strong reactions, they are most likely to be most affected, and improving the situation for pedestrians should be a priority. Those observations align with the tested hypothesis that vehicles cause less disturbance than walkers (Guay et al., 2014). The data from the field observations also add up with the survey answers, as activities like walking, biking, and running were listed as the most negatively impacted activity type (figure 21). Educational messaging can focus specifically on how different movement patterns influence tern behavior, helping residents and visitors adjust their behavior more effectively for example, advising pedestrians to keep a steady pace and not to stop when passing through nesting areas.

Walking a pet seems to be one of the strongest triggers for the terns during this study, showing much higher levels of strong reactions (seen in figure 17). A study of beach-nesting shorebirds shows that birds frequently interpret dogs as threats. The birds are more likely to flush, and at greater distances, from people walking with dogs, especially if the dogs are off-leash (Lord et al., 2021; Gómez-Serrano, 2021). Dogs could influence the survival of the Arctic tern by flushing away the adults and leaving the eggs unattended or even act as predators themselves (Lord et al., 2021).

4.2 Impact of human disturbance on breeding success

While the impact the human disturbance had on the breeding success was not studied in this project, other studies suggest that human disturbance can have negative effects on ground-nesting birds. Nests close to footpaths might have lower hatching success; incubating adults potentially do not become habituated to human disturbance and record larger flight initiation distances than those further away from footpaths (Frid & Dill, 2002).

Disturbance during the breeding season can have particularly severe effects, as it may cause adults to temporarily leave their nests, exposing eggs to cold and increasing the risk of predation. Terns nesting in high-disturbance sites not only reduce overall nest attentiveness but also display heightened restlessness and vigilance while on the nest; furthermore, both total sleep duration and average sleep-bout length are significantly shorter in high-disturbance colonies, potentially reducing the fitness of the adult (Hromádková et al., 2023). Disturbed adults often reduce feeding trips to avoid

attracting attention to the nest, lowering chick growth and fledging success (Remacha et al., 2016).

Human-driven habitat changes often degrade or fragment suitable ground-nesting habitats; this reduces cover or safe nesting sites, making nests more exposed and more vulnerable to predation (Langgemach & Bellebaum, 2005).

4.3 Actual severity of conflict

The documented encounters were dominated by non-physical interactions, with mostly no reaction at all from both humans and terns, as seen in figure number 18. If there was a reaction, it was mainly mild, such as swooping and intimidation, typical defensive behaviors of Arctic terns during nesting. Physical attacks were comparatively rare. As seen in the results, several aspects influence the reaction of the tern and might affect how individuals experience the presence of Arctic terns. Someone who walks their dog daily next to the breeding ground will feel more affected than someone who never uses this specific path or only uses it with fast-moving vehicles. The individual severity of influence that the terms have will fluctuate.

These findings align with previous research indicating that the severity of perceived wildlife conflicts often exceeds the actual severity (Marchini & Macdonald, 2012; McMahon, 2024). One aspect that is not to be underestimated is the influence of the emotional perspective; emotions, values, and personal experiences are central drivers of bird–human conflict, often outweighing ecological facts. Fear of physical attack and irritation from repeated encounters have a strong influence on how communities feel about the presence of birds. As McMahon et al. note, emotions “shape the understanding of a conflict as well as the acceptability of conservation strategies,” meaning that any attempt to promote coexistence with Arctic terns must address not only biological realities but also the emotional responses triggered by their aggressive nest defense (McMahon, 2024); even if few attacks occur, they trigger fear. Conflicts like this are not just about birds attacking people; they have many dimensions, like the influence they have on the enjoyment of nature and outdoor activities. Residents’ expectations for “quiet” neighborhoods and effects on tourism (McMahon, 2024).

For the terns, on the other hand, the situation is critical. The Arctic terns experience both stress and losses under the current conditions; the nesting site is too close to the road and walking path, leading to roadkill and strong reactions to human disturbance. While not observed personally, the negative attitude of residents can harm the terns, as eggs get purposefully destroyed from frustration and reduce the support of residents for their protection.

4.4 Management options for future

Possible management actions were listed in the survey; they differ in their feasibility and potential effectiveness in improving human–tern coexistence. Overall, a strategy can be considered successful not only when it reduces conflict and improves coexistence but also when it strengthens local involvement in conservation and improves the attitudes toward wildlife and nature (Distefano, 2005).

Bird populations naturally fluctuate from year to year, with changes in colony size, nest placement, and behavior introducing a degree of unpredictability. It is important to acknowledge this uncertainty for building trust and managing community expectations. Clearly communicating the seasonal variability of Arctic tern behavior and nesting locations can help reduce misunderstandings and prevent unrealistic assumptions about management outcomes (McMahon et al., 2024).

Survey findings suggest that the public supports coexistence-oriented management actions. The majority agreed or strongly agreed that protecting Arctic terns and their breeding habitats should be prioritized (figure 26). At the same time, about 60% supported the protection of human activities, showing that people are looking for a balanced approach that meets both human and wildlife needs, while the tern needs get prioritized more.

The management action with the highest amount of support is the educational/warning signs about the Arctic terns. There are already signs located at the study site. However, they could be improved; at the moment the text is way too long; most people will not read everything. Also, is the text only in Icelandic. An addition in English could be

helpful. Compared with other measures, signs are very inexpensive and easy to set up. It could help to inform those who are unaware of the defensive behavior of the adults to protect their brood. Many people are unaware of how their actions affect breeding birds, but useful information can successfully change behavior and reduce impacts (Sterl et al. 2008; Marion & Reid 2007, as cited in Batey, 2013). Studies on terns and other shorebirds demonstrate that these measures can improve breeding outcomes when they are clearly communicated and consistently maintained (Burger 2003; Medeiros et al. 2007; Weston et al. 2012; as cited in Batey, 2013). This will mostly be the case for tourists or people who have not been in Iceland for a long time. The results regarding the knowledge of Arctic terns (figure 24) and the perceived reason for attacks (figure 25) show that most residents of Ísafjörður are aware that they attack in order to defend their brood and also about the status and migration of the Arctic tern; however, the knowledge about the influence humans can have on the birds might be deficient and could be targeted.

“In one way or another, as conservationists we are often trying to change someone’s behavior” (Rare and The Behavioural Insights Team, 2019).

A study from a wildlife-visitor context in Iceland suggests that well-designed signage can influence behavior. Marschall (2015) found that visitor behavior generally improved in the presence of signs, especially teleological signs, that provide explanations in addition to instruction. However, the study also revealed that over one-third of visitors did not look at the signs at all, and only about half engaged with them for more than three seconds. While signage has a positive effect, it may not be sufficient on its own to fully reduce wildlife disturbance, and other measures are needed (Marschall, 2015).

A surprising outcome of the survey was the high level of awareness regarding the Arctic tern’s biology and conservation status. The majority of respondents knew that the species is listed as vulnerable in Iceland, and an even higher proportion were aware of its long-distance migratory journey. Species knowledge often correlates with positive conservation attitudes and willingness to support the protection (Ruan et al. 2022; Randler & Koch 2024).

In line with the conclusions of Martell (2019), who emphasizes the need for further development of citizen science in Iceland and for increased public inclusion in bird conservation, it is recommended to implement public engagement strategies,

particularly citizen science initiatives. Establishing more robust citizen science programs nationwide would not only benefit participating citizens and the general public but also expand the country's capacity for bird monitoring. Supporting organizations already involved in citizen science, such as Fuglavernd, would further enhance public commitment to bird conservation across Iceland (Martell, 2019). Although the present study focuses specifically on Arctic Terns, broader educational and engagement activities could have positive impacts on other avian species as well, many of which are experiencing population declines.

Three overarching categories of strategies can be identified as drivers of human behavior that can be used: 1) motivating change by appealing to personal values, humanizing messages, designing behaviorally informed incentives, and leveraging emotions and cognitive biases; 2) socializing change by drawing on social norms, peer expectations, and social identities; and 3) easing change by reducing practical barriers, supporting intention-to-action planning, identifying timely moments for intervention, and shaping environments that facilitate desired behaviors (seen in figure 31; Rare and The Behavioural Insights Team, 2019). These approaches are not intended to replace conventional tools such as regulation, incentives, or education, but rather to complement or refine them, particularly in contexts where voluntary behavior change is essential (Rare and The Behavioural Insights Team, 2019).

Figure 31: Strategies for applying behavioral science to conservation, Source: Rare and The Behavioural Insights Team, (2019)

Education does not have to be limited to only information; it can imply artistic or entertaining elements. Education can come in various forms, such as movies, art installations, music, or projects for residents. It is especially important to start to expose residents to those types of projects and ideas when they are young—in elementary school or kindergarten (Marković & Petrović, 2021).

Another option is to install deterrents, including sound deterrents or other barriers like nets, to keep Arctic terns away from their current breeding ground. The answers regarding the support for this option were mixed. The biggest share, however, does not support this action. The reason for this could be that sound deterrents have been installed in Ísafjörður and nearby towns and might have created the perception that they have shown little effect. In the case of this colony in Ísafjörður, a movement of a few meters might have occurred; birds have been observed to breed in a slightly different location than the last known breeding ground, where the sound deterrent was installed. But the actual influence the deterrents had is not provable. Multiple measures have been used at the same time, like sound deterrents and nets as barriers, at the same time there was an increase in vegetation (lupins). The use might also have been inconsistent.

In some other studied cases deterrents have been used successfully; the success rate seems to be influenced by the target species and type of deterrent (Micaelo et al., 2023). There is no deterrent that is effective for all species and situations (Micaelo et al., 2023). Aiming to keep terns away with only deterrents could create some difficulties; Arctic terns have a high nest-site fidelity, often returning to the same 2 × 2 m square (Redfern & Steel, 2024). Additional barriers or deterrents may cause the birds to shift their location slightly, but they do not guarantee any improvement. The new breeding site the birds might choose could be just as unsuitable and problematic for both humans and terns.

The installation of fences around either single nests or larger areas of the breeding ground would have the advantage that the juvenile Arctic terns could not wander off and walk on the street and walking/cycling paths; this could reduce stress and road kills.

Enclosures may offer improvements to the current situation. Evidence from two replicated, randomized, controlled studies in Sweden indicates that nest exclosures can provide certain benefits for ground-nesting birds, usually by reducing predation (Isaakson et al., 2007; Pauliny et al., 2008). One study reported that protected nests exhibited higher average daily survival rates compared to unprotected nests, although it also noted increased predation on adult birds (Isaakson et al., 2007). Another study found that nests within exclosures had higher hatching success than unprotected nests. However, this study detected no differences in the number of fledglings, breeding adults, or new recruits between periods with and without nest protection (Pauliny et al., 2008).

Barriers could also cause stress and injuries, as recorded in the bird monitoring in the Westfjords project, carried out by Náttúrustofa Vestfjarða (Gallo et al., 2023). Every chick showed some signs of stress in the enclosure. There are also various aspects that must be considered; without the possibility of moving into more sheltered parts, hiding spots must be given within the enclosures for the chicks. The type of material that is used for the fence is also important. The fence netting used in this project caused abrasions; a safe option is necessary. The recommendation is to only fence nests in areas with limited human disturbance to reduce stress, so it is not a suitable solution for this specific breeding area.

Another possible option is to install fencing only along the sides of the walking path and road. This would prevent the birds from wandering onto the path while still allowing them access to the surrounding habitat. Such a measure could reduce direct disturbances and safety risks for both people and birds, without creating unnecessary barriers across the entire area. Depending on the material of the fence, it could impact the qualities of breeding habitats; habitats with high visibility are preferred by ground-nesting birds to maximize their ability to visually detect predators (Lemmetyinen, 1971; Dorsey et al., 2025). Fences that reduce the visibility could therefore influence where the terns initiate nesting. The feasibility and price costs must be evaluated for this area. Fences or other barriers are not always an economical management practice since they frequently require additional labor (Distefano, 2005).

Another idea is to plant trees, a measure highly supported by the residents. Over half of the respondents were positive, with less than 10% against this measure. Trees are usually appreciated because of the positive effect on the environment and mental well-being, even though studies in Iceland revealed a rather mixed attitude (Neukirch, 2019).

Besides the positive side effects the planting of trees could have in this area, they could protect pedestrians from attacking terns. On the other hand, is an open terrain safer for the breeding Arctic terns. On open terrain predators are spotted quicker and more effectively driven off (Lemmetyinen, 1971). Several raven (*Corvus corax*) attacks on colony were observed during the breeding period. The raven had limited hiding spots, and the Arctic tern colony acted quickly and defended their brood.

Tree planting in Iceland has to be carefully planned to avoid negative influence on the biodiversity (Pálsdóttir et al., 2022). Similar to fences would trees influence the visibility in the area, which is important to detect predators (Lemmetyinen, 1971; Dorsey et al., 2025). Based on this, ground-nesting birds like Arctic terns most likely do not profit from trees. So while trees might improve the situation for us humans, they could increase the predation for the Arctic terns or cause them to relocate uncontrollably.

Instead of trees, it is also possible to build a structure that protects pedestrians and cyclists on the path, most likely a roof. Same as the trees, it would protect those that are using the path while potentially not increasing the predation as much as trees. This measurement received little support from the survey respondents; only 9% were in favor of this idea. It might protect walkers in this specific area effectively and might even reduce stress for the Arctic terns, creating a barrier between the birds and humans.

Nevertheless, it does come with a few practical difficulties. It does not protect people in their garden or on the playground. Its effectiveness is limited; if the birds move even a few hundred meters, the measure no longer provides protection. It might also not be aesthetically pleasing and reduce the enjoyment of those who walk there or carry out sports activities. Another aspect is that the financing for this measure might be quite high.

The public availability of sticks is something that has already been approached (as described in 1.4 Current situation). The container to hold sticks is there; just the actual sticks are missing. Nobody seems to be responsible for this matter. I added some sticks I found in the area at the beginning of the breeding season. There were a few humans who used sticks or something else (personal items or flowers like lupines) to protect themselves from the birds during my observations. As seen in figure 18, being *protective* was the most common reaction when being attacked by Arctic terns. In contrast to those observations might seem the survey results seen in figure 22. The distraction method, including carrying a stick, was reported less frequently than other responses. But the option to cover/protect the head can be included in those results since this response is also considered as protective during field observations (figure 18). Covering the head was reported frequently, with about one-third doing it very often and most others doing so at least occasionally (figure 22).

From personal experience this summer, using a stick, is an effective way to shield yourself from being attacked. Arctic terns always attack the highest point if a human is perceived as a threat (Špička, 2022). A stick or other item above the head can prevent injuries, though the experience may still be uncomfortable. Sticks provide short-term relief but do not resolve the deeper issue that leads to repeated attacks. Not everyone is willing or able to use a stick, and in Iceland's windy conditions these objects can easily blow away. Someone would also need to maintain them. It does not reduce the safety problem that is given in this area for the Arctic tern chicks, but it is an effective short-term solution for pedestrians.

Relocating the colony to a more suitable habitat requires careful consideration of multiple factors. The terns must be attracted to a new breeding habitat that meets the species-specific requirements of arctic terns. The new site must offer sufficient food sources. It should be a site with low predation and protection from roads and other human-related dangers, a minimum buffer zone of 200 m is recommended to protect Arctic tern colonies from pedestrian disturbance (Goodship et al. 2022).

Another factor to consider is that Arctic terns are breeding close to human settlements intentionally. Even if humans are causing disturbance, they are also providing safety from wild predators. Personal communication with residents revealed that, when

human settlements moved in the Westfjords, the terns followed. Those stories align with "the human shield hypothesis," which explains the increase in the abundance of certain bird species in urban areas because of a decrease in native predators (Berger, 2007). Therefore, the human presence may create a safe situation that prevents predation of birds. To move the breeding ground entirely away from the town seems unlikely since the birds are choosing the breeding ground based on its proximity to humans.

However, there are cases of successful relocation. A suitable alternative breeding habitat was created, attraction methods were used, and the nesting in the previous breeding ground was discouraged. By the third breeding season, the entire colony had successfully relocated. Nesting success was consistently higher at the new site (Daniel et al., 2002). Decoys can be used to attract the birds to habitats and encourage nesting between the decoys (Kotliar & Burger, 1984).

Instead of attracting birds to an already existing habitat, new ones could also be created if no suitable habitat can be found. A potential solution if habitats are limited could be floating platforms that can be used for breeding (Manikowska–Ślepowrońska et al., 2022; Burgess & Hirons, 1992). The platforms could be installed in the nearby fjord. The feasibility has to be examined, since Iceland weather conditions are often turbulent. Evidence from Little Terns further suggests that the *design* of artificial breeding sites is important: the protection or creation of relatively small, slender islands positioned at moderate distances from shore can effectively increase available nesting habitat; it appears to be relevant for species that prefer sites adjacent to water (Eason et al. 2012).

One example of the successful use of platforms is those created for terns and waders as part of the LIFE FORESTALL project in Oasis of Valle Averto (figure 32), which contributed to increasing the presence of nesting terns with 10 floating artificial rafts (LIFE FORESTALL, 2025).

Figure 32: Artificial rafts used to increase nesting habitats for tern species as part of the LIFE FORESTALL project in Oasis of Valle Averto

There are several risks that have to be considered when initiating relocation. Forced relocation might reduce the investment in reproduction (Salas et al., 2020). The loss of stability can trigger either a decrease in clutch size or even skipping breeding seasons (Salas et al., 2020). Birds that recently relocated to a new habitat might also struggle to adapt to a change in food sources and travel further distances for foraging (Kavelaars et al., 2020). Whether animals take the risk to relocate depends on the relative costs and benefits of leaving their current site for a new one (Frid & Dill, 2002).

To remove the Arctic tern entirely is neither ethical nor realistic. Unless breeding conditions deteriorate significantly, these birds tend to return and breed again at the same site. Many individuals return to the same site year after year, provided conditions remain suitable. If alternative habitats are too distant or of low quality, no relocating will occur (Gillet et al. 2001; cited in Frid & Dill, 2002). Even if the current breeding ground is decreasing in attractiveness for the birds, they will most likely still breed within the area, especially if you consider the human shield hypothesis. However, with careful planning and the involvement of experts, it is a realistic option to choose or create a suitable habitat in proximity.

The results shown in Figures *13* and *14* indicate that section 3 of the walking path has significantly higher aggression and more tern attacks than the other sections. Restricting access to this area could potentially reduce the number of attacks.

A barrier that leads pedestrians away from bird habitats has been found useful; it reduced disturbance rates by more than half (Lafferty et al., 2004). In this studied case Snowy Plovers increased in abundance over the course of the season, and their spatial distribution contracted to within the protected area. Also, individuals that were located outside the protected zone in the early morning moved into it as human activity on the beach increased (Lafferty et al., 2004).

However, such restrictions would have consequences: everyone who regularly uses this section, including people walking their dogs, children, or cyclists, would be pushed onto the street or into the parking lot. However, when considering the total number of recorded encounters in section 3—35 over the entire observation period, the inconvenience that restriction would cause, it would likely affect only few people.

Residents may oppose restrictions, as seen in figure 26, which shows that the majority does not support avoiding specific areas. Even though it is seen in figure number 20 that Arctic terns influence human behavior already to some extent, about half of the respondents agreed or strongly agreed to already avoid specific areas because of the Arctic terns. One of the main drivers of opposition to access restrictions is likely the limited availability of alternative walking and cycling routes in Ísafjörður. The path adjacent to the breeding ground is one of the few multifunctional paths in the town and serves as an important connection between the town center and nearby residential areas and supermarket. The lack of alternative pathways therefore reduces the feasibility of imposing restrictions. The development of additional routes could help reduce disturbance by offering residents alternative options during the breeding season; however, such a measure would require action on the part of the municipality. It is plausible that residents would support the creation of additional paths, irrespective of the tern issue, given the wider benefits for mobility.

Another challenge became apparent when chicks dispersed from the breeding ground and moved onto nearby streets and parking areas. During this phase, tern attacks increased not only within the observed sections but also in nearby areas, including the parking lot, which cannot reasonably be restricted due to its essential function.

Thus, even if access to one section were limited, this would likely reduce attacks only locally and would not eliminate disturbance or conflict across the broader area.

Given these considerations, access restrictions are not currently feasible. Restrictions could potentially be implemented in the future—such as during the critical fledging period or limited to Sections 3 or 4—if the town were to develop additional alternative routes. However, it remains difficult to impose restrictions in advance due to the unpredictability of tern behavior. Clear warning signage or other educational measures may therefore be more appropriate and socially acceptable at this stage, with access restrictions considered only as a last resort if other approaches prove ineffective.

Since dogs are a strong trigger for Arctic terns (see Figure 17), restricting access for dogs or at least requiring them to be kept on a leash appears reasonable. Unleashed dogs could pose a threat to the terns (Lesberg et al., 2000), if they run into the breeding area, they may harm the brood and could also be injured themselves. Such encounters create stress for the birds, the dog owners, and the animals. Keeping dogs on a leash can significantly reduce potential disturbance and therefore serves as an important management measure (Thomas et al., 2024). However, because the site is close to the road, most dogs are leashed already. During the observations only one case of an unleashed dog was observed. It is therefore recommended to provide information about the terns' heightened defensive responses when walking a dog and to implement a clear leash requirement to minimize disturbance, also if the colony might relocate.

No intervention is supported by half of the respondents, as shown in figure 27. This approach would mean allowing the terns to stay in the current breeding ground or adjust their nesting locations naturally without human interference. There would be no costs or labor needed for that unless monitoring is conducted in the future. However, choosing not to intervene could have negative effects. If the birds stay on the current breeding ground, the same scenario as this year might occur, and the chicks will remain vulnerable.

Many people continue to experience discomfort or fear when passing by the nesting site. Over time, persistent conflicts may also increase negative attitudes toward the terns, potentially weakening the support for their protection. One possible benefit is that the colony might naturally relocate to a more suitable breeding ground if there is one close by. Even if the terns are known to be nesting-site faithful, they can adapt if the breeding conditions are bad and move to another suitable breeding habitat (Henri et al., 2020).

4.5 Suggestions for future actions

A combination of proven measures usually leads to the most effective management outcomes (Batey, 2013). For this situation there are several actions that could improve the coexistence.

The easiest first step is to improve the current signs, since this option received the highest support and is inexpensive. A shorter text, English translations, and clearer information about the seasonal behavior of Arctic terns could help with the understanding and how to protect yourself, especially useful for visitors. Maintaining the availability of sticks as a short-term protective measure would also make sense here, since people already use them and they can prevent injuries very effectively. This measure has strong potential if it is carried out correctly, at least for improving the situation for humans. However, signage and simple protective measures alone will not address the deeper social dimension of the conflict. Broader educational efforts, including targeted outreach and the active involvement of local residents, could help build a shared understanding of tern behavior and conservation needs. Engaging residents in co-developed solutions may shift perceptions of the colony from being merely a source of disturbance to being a valued part of the local environment, thereby fostering greater tolerance and long-term support for coexistence.

Another action would be to introduce a clear leash requirement for dogs and warn dog owners during the breeding season, as dogs were shown to trigger the Arctic terns. If these measures do not reduce the conflict enough, partial fencing along the road or walking path could be considered to prevent chicks from wandering into dangerous

areas, while avoiding the stress linked to fully enclosed nest fencing. Important would be to use fence material that does not cause harm to the chicks if they are pushing themselves against the fence. Long-term ideas such as improving alternative breeding habitats or allowing the colony to relocate naturally remain possible and could improve the situation for both: humans and terns. But the outcome is uncertain due to the strong nest-site fidelity of Arctic terns and has to be carefully planned. If relocation is initiated a monitoring about the breeding success and population trends should be conducted. Another alternative would be to have infrastructure changes in the town, if the terns are not relocating, the human activity could be moved. Alternative paths for walks and activities might be a supported change for by residents. Deterrents such as sound devices or nets are not recommended as measures alone, since they have already shown little effect in the area and may push the birds into even less suitable places but might be considered as part of the relocation.

4.6 Limitations

This study has several limitations that should be acknowledged. Although observations covered the full breeding cycle, continuous monitoring was not feasible, and rare events may have been missed. Weather conditions may have influenced the results, as observations were avoided on rainy or very windy days, potentially introducing sampling bias. The survey also carries limitations; with only 100 respondents, the sample size is relatively small and may not be representative of all residents. Additionally, participation was unbalanced across demographic groups, which may affect the generalizability of the findings. Furthermore, the study lacks long-term data for comparison with previous years, making it difficult to assess whether the observed conflict patterns are consistent over time.

5.Conclusion

The discoveries of this study show that human–tern interactions in Ísafjörður have several conflict points**.** Some residents hold negative attitudes toward Arctic terns, often caused by personal experiences of being attacked or feeling threatened. These encounters can influence daily life in the summer; areas or activities get avoided by some. Although the field observations show that aggression levels are generally low, a few specific triggers consistently lead to stronger defensive responses. These include dogs, running and walking, and approaching too close to nest sites. In such situations, simple protective measures like helmets or sticks, along with clear warnings, can reduce stress for both people and birds**.** The strongest reactions were measured when the chicks left the breeding ground and were wandering around between the cars and people—a very stressful and deadly situation for the birds.

Negative feelings towards the Arctic terns are understandable; it is uncomfortable, sometimes painful, and people worry about their children and animals getting attacked. Yet it is important to recognize that the terns' behavior is instinctive to defend their chicks. A broader understanding of this natural defensive strategy may help ease frustration and increase empathy for the species. The current breeding situation causes stress for the colony, and frequent disturbance and the continued loss of birds to vehicles is an unsafe breeding environment.

Several potential management strategies were explored during this study. For the best result, a combination of measures is recommended. Improved educational signs and the availability of sticks provide an effective short-term solution for people passing through the area. In the longer term, one possibility is to make the current breeding ground less attractive while offering a safer and more suitable site nearby. However, this requires careful consideration and planning. Given that the past years have been challenging for the colony, the birds might choose to relocate naturally, but actively attracting them toward an appropriate site could help prevent the same conflict from simply moving to another area. The high nest-site fidelity could be problematic for this action. Another measure to consider is the installation of partial fencing along the road and pedestrian path to protect the chicks from wandering on the road and reduce attacks on people.

Residents should also be included in future management efforts, as many are willing to help with protection measures and have useful knowledge and ideas.

A fully peaceful coexistence is unrealistic, because the Arctic terns' strong defensive behavior will always be unpleasant for people at times. Even with careful planning, management might not always go exactly as intended, since living animals are unpredictable and influenced by many factors. Not everyone will start to be fond of the terns, but a better understanding and good management could reduce the disturbance, which might help to ease negative feelings and increase the safety for the Arctic terns, which travel all around the world to raise their chicks in the Westfjords.

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Appendix

A: Field work data collection table

Field observations Sterna paradisaea N.Rother

Date: Session time:

Cruiseship day: ☐ Tide times:

Weather: Status of Colony:

Time	# Persons	Type persons	Pet	Activity	Sec 1		Sec 2		Sec 3		Sec 4		Sec 5		Comment
					T	H	T	H	T	H	T	H	T	H	

B: Survey

Winging It Together: Arctic Terns & Us

Hello! My name is Nadine, I am a bachelor's student currently collaborating with Náttúrustofa Vestfjarða. We are conducting a study on the interaction between local residents of Ísafjörður and Arctic terns that are nesting near Bónus.

Arctic terns are known for aggressive behavior during the breeding season—often dive-bombing or pecking at people who come too close.

We would greatly appreciate your participation in this **quick anonymus survey**, which will help us to understand your experiences and opinions on this matter. It will only take a few minutes. Your responses will contribute to recommendations for the management of the Arctic terns' breeding grounds in a way that supports both - the birds and the community.

Thank you!

For more information about the survey feel free to contact me: rother.nadine@gmx.net

1. 1. What is your age group ?

   Markieren Sie nur ein Oval.

   - ◯ under 18
   - ◯ 18-30
   - ◯ 30-60
   - ◯ over 60

2. 2. Are you a resident of Ísafjörður ?

Markieren Sie nur ein Oval.

- Yes, I live here all year
- Yes, I live here part-time of the year
- No, I am a visitor

3. 3. If you are a resident of Ísafjörður where do you reside ? (if you are **not a resident of Ísafjörður** skip to question 4)

Markieren Sie nur ein Oval.

- 1
- 2
- 3
- 4
- 5

4. 4. If you are **not** a resident of Ísafjörður, where do you reside ? (skip if you are a resident of Ísafjörður)

   Markieren Sie nur ein Oval.

   - ◯ Other part of the Westfjords
   - ◯ Other part of Iceland
   - ◯ Outside of Iceland

5. 5. How do you feel about the presence of Arctic terns ?

   Markieren Sie nur ein Oval.

   - ◯ Positive, I am happy about it
   - ◯ Neutral, they don´t bother me
   - ◯ Negative, I don´t enjoy their presence here

6. 6. Have you had direct encounters/interactions with Arctic terns? (**If** the answer is **no** skip to **question 13**)

   Markieren Sie nur ein Oval.

   - ◯ yes
   - ◯ no

7. 7. If **yes**, have these encounters been a negative experience or negatively impacted you?

   Markieren Sie nur ein Oval.

   - ◯ yes
   - ◯ no

8. 8. What kind of encounter was it and how often does it occur ?

Markieren Sie nur ein Oval pro Zeile.

	never	rarely	sometimes	often
Physical attack	◯	◯	◯	◯
Swooping or intimidating behaviour	◯	◯	◯	◯
Bird droppings	◯	◯	◯	◯
collision with birds while driving	◯	◯	◯	◯

9. 9. During which activities do they negatively affect you? (select all the apply to you)

Wählen Sie alle zutreffenden Antworten aus.

- ☐ Activities/sports (e.g. running, cycling, walking)
- ☐ During work
- ☐ Bird/wild life watching
- ☐ Going shopping/filling petrol
- ☐ Commute to school, work and other occasions
- ☐ Around my home/garden
- ☐ At the playground
- ☐ Walking a pet

10. 10. What is your reaction if you get attacked?

Markieren Sie nur ein Oval pro Zeile.

	never	sometimes	often	very often
I ignore the Arctic terns	⬭	⬭	⬭	⬭
I move faster through area to limit interaction	⬭	⬭	⬭	⬭
I cover/protect my head	⬭	⬭	⬭	⬭
I use distraction methods (e.g stick over head)	⬭	⬭	⬭	⬭

11. 11. Because of the Artic terns i change my behavior..

Markieren Sie nur ein Oval pro Zeile.

	strongly disagree	don´t agree	agree	strongly agree
I avoid certain areas	⬭	⬭	⬭	⬭
I avoid certain activities	⬭	⬭	⬭	⬭

12. 12. If Artic terns change your behaviour, which activities do you avoid near bónus ? (Skip if they don´t affect you and/or choose multiple if it applies)

Wählen Sie alle zutreffenden Antworten aus.

- [ ] walking my dog
- [ ] gardening
- [ ] using the playground
- [ ] walking in the area
- [ ] cycling in the area
- [ ] Sonstiges: _____

13. 13. We should take actions to manage human-tern interactions to...

Markieren Sie nur ein Oval pro Zeile.

	Strongly disagree	disagree	agree	strongly agree
Protect humans and human activities	⬭	⬭	⬭	⬭
Protect the Arctic terns and their breeding habitat	⬭	⬭	⬭	⬭

14. 14. What measures would you support regarding the management of human-tern interactions

Markieren Sie nur ein Oval pro Zeile.

	yes	maybe	no
No Intervention	◯	◯	◯
Educational/warning signs	◯	◯	◯
Personal measures (e.g. wearing helmets or other protective gear, bringing own stick)	◯	◯	◯
Lifestyle changes (e.g. avoid certain areas)	◯	◯	◯
Public availability of sticks/flags	◯	◯	◯
Deterrents (e.g. acoustic signal, nets, barriers)	◯	◯	◯
Relocate the colony to a different area of Ísafjörður	◯	◯	◯
Remove the terns from Ísafjörður entirely	◯	◯	◯
Build structures (e.g. roof over walking paths)	◯	◯	◯
Plant trees to shelter the walking path	◯	◯	◯

15. 15. Why do you think Artic terns attack people ?

Wählen Sie alle zutreffenden Antworten aus.

- [ ] Egg/chick protection
- [ ] Competition for food
- [ ] Human disturbance
- [ ] Arctic terns are aggressive birds

16. 16. Are you aware that Arctic terns are listed as vulnerable in the Icelandic red list for threatened species?

Markieren Sie nur ein Oval.

- ◯ Yes
- ◯ No

17. 17. Did you know that Artic terns travel from Antarctica to the artic and back every year, which is the longest known migration of any bird species - up to 90 000 km ?

Markieren Sie nur ein Oval.

- ◯ Yes
- ◯ No

18. Do you have any further comments,suggestions or questions ? Let me know!

Statutory declaration

I hereby declare that I have written this paper independently, that I have not previously submitted it to any other university or in any other degree program as an examination paper, and that I have not used any sources or aids other than those indicated. All passages in this paper that have been taken verbatim or in substance from publications or other external sources are identified as such.

Wuppertal, 12.12.2025

place, date

Eidesstattliche Erklärung

Hiermit erkläre ich, dass ich die vorliegende Arbeit selbstständig verfasst habe, dass ich sie zuvor an keiner anderen Hochschule und in keinem anderen Studiengang als Prüfungsleistung eingereicht habe und dass ich keine anderen als die angegebenen Quellen und Hilfsmittel benutzt habe. Alle Stellen der Arbeit, die wörtlich oder sinngemäß aus Veröffentlichungen oder aus anderweitigen fremden Äußerungen entnommen wurden, sind als solche kenntlich gemacht.

Wuppertal, 12.12.2025

Ort, Datum