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Suitability of two adjacent sites for seal observation in a tourism-like and citizen science context in Húsavík, Iceland

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With the decline of the pinniped population in Iceland alongside increasing wildlife watching tourism, monitoring seal colonies is of critical concern. Close to the world-class whale watching spot of Húsavík, sandbanks in the river Skjálfandafljót serve as a hauling area to a colony of harbour seals (*Phoca vitulina* Linnaeus, 1758). We documented two sites, on both banks of the river, for seal observation. Seal watching, as a touristic activity, was specifically considered. We observed pinnipeds without specific equipment designed for science but with equipment tourists and amateurs might use. This pilot observation was designed around a 2-days long fieldwork, simulating the length of stay tourists might spend near Skjálfandafljót. Data processing revealed that both sites appear to be poorly suitable for accurate and comprehensive behavioural observation (e.g., unfavourable for nursing behaviour) or amateur/general public photo-identification (PID). Access through a private area or distance from the bank to pinnipeds are the more important limiting factors. However, specific equipment might allow a proper PID alongside alternative ways to approach the colony. We recommend only conducting basic behavioural studies or population monitoring. Seal watching tourism might also be considered despite the necessity to keep this activity low, according to local specificities, or the potential threats biodiversity tourism can lead to.

Introduction

In Iceland, the population of harbour seals (*Phoca vitulina* Linnaeus, 1758) has declined over the years, with many factors contributing to this trend (Granquist 2022). Despite the lack of sufficient evidence for the causes of this decline, interactions with fisheries and tourism are considered principal threats (Granquist 2022). Indeed, tourism increased by 150% in 2013, compared to the previous decade (Óladóttir 2013), one of the main reasons being the increase in opportunities to observe wildlife, such as whale watching. With no official seal watching guidelines, the impact of tourism on pinnipeds remains unregulated despite recommendations of the Icelandic Seal Centre (Selasetur Íslands) and the possibility for wildlife watching boats to agree to a voluntary code of conduct (Selasetur Íslands 2011, Clack 2016). Consequently, tourists or local communities might lack proper information and good practices on how to safely observe and interact with pinnipeds. Pinnipeds usually suffer from direct and indirect anthropogenic disturbance and might change their behaviour (e.g., increased vigilance, avoid encoun-

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ters) or their haul-out pattern as a consequence (Kovacs *et al*. 2012). Examples of threats faced by pinnipeds include habitat loss, overfishing, and environmental degradation (Johnson & Lavigne 1999). In the case of harbour seals, anthropogenic disturbance might decrease their resting or foraging time. Disturbance can also cause the separation of mother and offspring, leading to starvation of the young if prolonged (Renouf *et al*. 1983, Carney & Sydeman 1999, Osinga *et al*. 2012). In 2019, the Icelandic Ministry of Industry and Innovation requested that stakeholders in the tourism industry develop a strategy for 2030. In response, the Icelandic Tourist Board (Ferðamálastofa) released a policy framework for tourism until 2030. The framework emphasizes the importance of basing decisions on research (Ferðamálastofa 2020). Therefore, monitoring the pinniped population remains a prerequisite to proper development of management and conservation strategies.

Factors driving the resting behaviour of seals are already widely documented. Wind speed and direction, tide and temperature are examples of such factors (Pauli & Terhune 1987a, b, Brasseur *et al*. 1996, Watts 1996). While the body of literature around seal haul-out behaviour is plentiful (Bishop 1967, Hamilton *et al*. 2014, Granquist & Hauksson 2016), it is known that seals can exhibit important regional variability depending on parameters such as habitat (Hauksson 2010) or anthropogenic disturbance (Henry & Hammill 2001, Granquist & Sigurjonsdottir 2014, Andersen *et al*. 2014). Hence, observations in Vatnsnes (North-North-West Iceland) may not be applicable to Húsavík (North-North-East Iceland). Furthermore, the increase in tourism (Hoover-Miller *et al*. 2013) can alter haul-out behaviour and site selection. One might also consider the effects of aerial technology such as drones, that tend to frighten individuals and trigger a fleeing response (Palomino-González *et al*. 2021). Hence, it remains useful to document seal watching sites that are likely to offer development opportunities, whether it is for science or tourism.

In Iceland, the population of pinnipeds is evaluated through aerial censuses. Each year, different haul-out areas are sampled and surveyed by a small plane (Hauksson 2010, Granquist & Hauksson 2019a, 2019b). Seals are counted along the coastline, despite visibility bias being described by Pollock and Kendall (1987): vegetation, weather, rocks, observer fatigue or the type of camera (when applicable) are factors that can lead to missed animals. Therefore, land-based or boat-based observations of pinnipeds remain possible solutions to study animal behaviour and underlying regional specificities and variations. Thus, assessing observation sites might provide alternative options to the main aerial counting method in Iceland, and allows recording the characteristics of observation sites. Moreover, land-based observation remains the most likely activity to be experienced by tourists, compared to recreational aviation.

In this study, we rapidly assessed two land-based observation sites (Fig. 1). Both are also accessible by row boats or zodiacs and are close to tourism accommodation. Located near Húsavík, often considered as the European capital for whale watching, the river Skjálfandafljót offers several sandbanks used by pinnipeds as hauling areas. Tourist activities and infrastructure may bring tourists to two observation sites, called 'Berg' and 'Björg', which are named after nearby locations. Despite being located in a remote area, a hostel and a guesthouse are in a 500-m radius of the sandbanks used by pinnipeds as haul-out sites. Wildlife watching is increasing in Iceland, even in remote areas such as the one investigated in this study (Hoover-Miller *et al*. 2013). Consequently, we took into consideration that the observation sites may be, if not already, of tourist and commercial interest, in addition to its scientific interest.

Considering the above, this paper acts as a preliminary study for pinniped-tourist interactions in the region of Húsavík by having a number of aims, first of which is the collection of data in an area known by the community but unrecorded by science. These serve as a steppingstone for the creation of basic recommendations for seal observations in the Húsavík vicinity, as well as encouraging careful interactions with wild fauna under the Icelandic Tourist Board framework (Ferðamálastofa 2020). In a more general setting, it provides researchers, policymakers, the tourism industry, as well as a larger audience, information about two pinniped observation sites in Skjálfandafljót. Finally, this

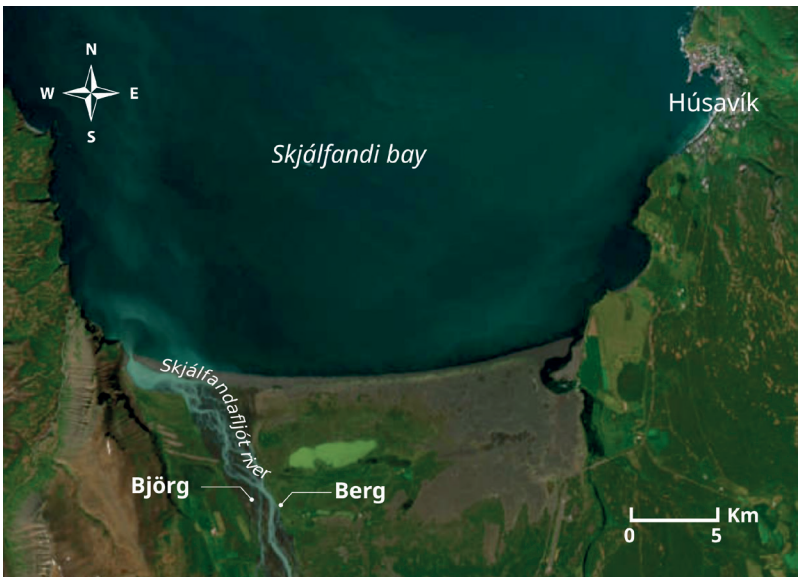

Fig. 1. Location of the two studied sites Björg and Berg in Iceland (Imagery courtesy of the U.S. Geological Survey).

pioneer study explores the feasibility of photo-identification (PID) and extended behavioural studies in both Berg and Björg. We hypothesise that differences in time, and in accessibility and visibility between the two sites, will be associated with differences in the occurrences of different observed seal behaviours.

Material and methods

We decided to allow only 2 days of observation in this study to simulate the conditions in which tourists might observe pinnipeds in Skjálfandafljót. With an average length of stay of 6.5 nights (between July 2017 and June 2018), we assume that it is quite unlikely that tourists spending roughly a week in Iceland will dedicate more than 2 days to seal watching (Óladóttir 2018). Especially since the studied sites remain close to Húsavík, which is a major tourist spot and provides different activities through organised and advertised touristic circuits, involving whale watching or geothermal activities.

To observe as many individuals as possible, fieldwork was done in June 2021, during the latter part of the pupping season in Iceland (May–June) (Clack 2016, Thompson *et al*. 1997). For two days, we observed a colony of harbour seals hauling on sandbanks in Skjálfandafljót, using a scope, binoculars, and a camera. Particular attention was paid to the use of equipment tourists or amateurs might possess, excluding de facto high-technology solutions which are less likely to be manipulated by a wide audience outside of the scientific community.

Selection of the two observation sites

We discovered the two observation sites by word of mouth. Information was cross-checked between the distribution of the haul-out sites along the Icelandic coastline (Hauksson 2010) and local knowledge from researchers from the Research Centre of the University of Iceland in Húsavík. One major hauling site was identified in the estuary of Skjálfandafljót, with a privileged spotting point on the right bank, near the Berg Hostel, later called ‘Observation site Berg’. The left bank, part of the Björg farm, was also investigated to assess any dissimilarities in visibility and in accessibility. Both sites also host tourism facilities, although no information about tourism patterns in the area, or profiles of people staying overnight in close-by accommodations, were found. While Berg is accessible through a public dirt road, access to Björg requires permission from the owner of the farm. The observation site can only be reached by crossing a sheep pasture seemingly occupied

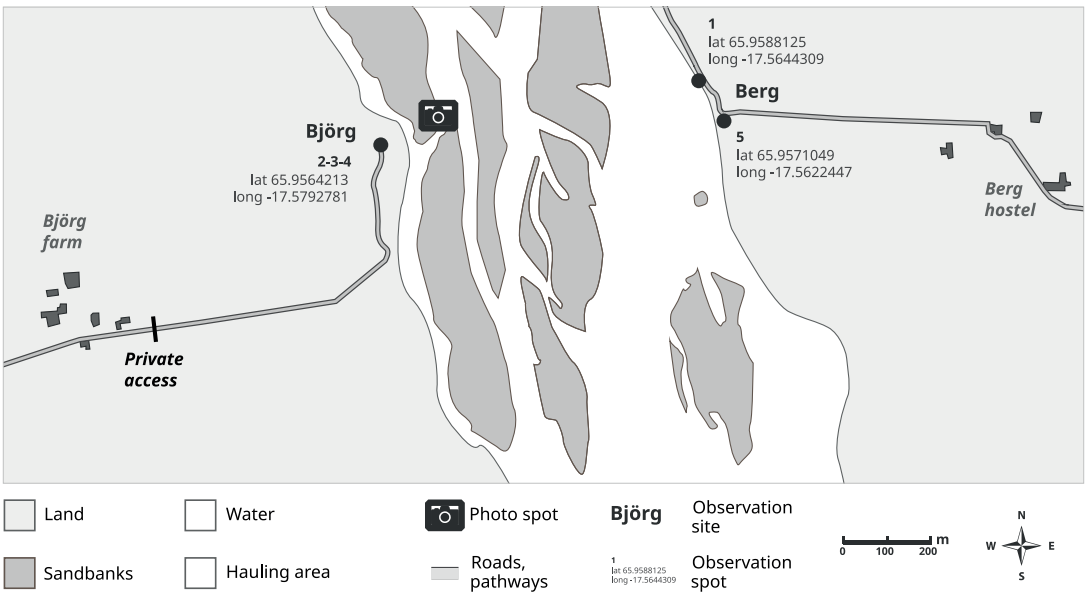

Fig. 2. Location of the 2 pinniped observation sites in Skjálfandafljót.

all-summer long. Figure 2 provides further details on the study sites.

Selection of the time of observation

We decided to select the time at which pinnipeds were observed according to the tide forecast in Húsavík (Tide Forecast 2021). Each observation session started after high tide since seals are expected to respond to tides, hauling out at low tide and leaving when the rising or high tide floods the haul-out area (Bishop 1967, London *et al*. 2012). However, the relevance of tide forecasts was limited for the two observation sites as they are located inland. Therefore, the impact of the tide was expected to be low and delayed. Since Björg requires entering a private property and to drive through a sheep pasture, we decided not to conduct fieldwork late in the evening (later than 19:30) to avoid disturbing beyond reason both sheep and people living in and around the farm.

Behaviour

To properly document the behaviour and temporal trends of seals through the day, we monitored a herd of 20 to 30 seals over 2 days (19 and 20 June 2021). While the duration can be deemed too short, we used the following method to replicate tourist-like disturbances, in order to observe seal behaviour in a touristic environment, as seal watching rarely exceeds two days in the context of tourism (Óladóttir 2018). Multiple parameters were considered throughout the day (Table 1). The tide was labelled as 'High', 'Declining', 'Low' or 'Rising', and the weather noted as one of the following: sun, wind, cloudy, fog, raining, snowing. Observation sessions were conducted for a minimum of 2 h and a maximum of 6 h, which is the equivalent of a full tidal change. Observations were made by two observers, each being assigned to a part of the colony, with regular inter-observer controls. The behaviour of each individual of the herd was continuously monitored with cross observer checks (communication on the number and position of each seal) every 10 min using Monk Nereus 7×50 binoculars and an Apo-Televid 77 scope on a tripod. Each recorded behaviour was given a time code and categorised in one of eight different behaviour classes (Table 2). In the case of behaviours occurring during extended periods of time (e.g., resting), the behaviours were counted during cross observer checks. Behaviours with short time span (e.g., scanning, leaving, arrival) were flagged at time of occurrence. Nursing behaviour was

recorded with duration. Considering this study took place during the end of the nursing season, specific adult-pup interactions were expected, among which antagonism, tolerance, or fear (Bishop 1967). No observation time at arrival/departure was removed. Likewise, all seal behaviours triggered by the observers were recorded. We assumed that observers were part of the study and could impact seals anytime (e.g., binoculars reflectance, sneeze, etc.). All statistical analyses (i.e., Fisher test for time, tide and site separately) were done using R 4.0.1 (R Core Team 2023).

The number of patches and spreading of the herd was also quantified arbitrarily to evaluate the age and/or relation between individuals. Close couples presenting an important size difference and nursing behaviour were reported as Mother and Pup observation; Groups of three and more individuals with less than 1 m in between, possibly exposing playing behaviour, were designated as 'Yearlings' in accordance with Bishop (1967). Finally, individuals more than 2 m apart were considered Adults (Bishop 1967, Hamilton *et al*. 2014).

Photo-identification (PID)

In addition to behaviour monitoring, we photographed each hauling individual using a Canon EOS7D Mark2 camera with a 100–400 mm lens. Each photograph aimed to show specific patterns on the fur of *P. vitulina* for identification. The photographs were later sorted by date and individuals to visualise any redundancy (a.k.a. identification) over the sampling period. No specific validation methods were used for the PID after reviewing the quality of the images.

Results

The two sites present both similarities and important differences (Table 3).

Table 1. Parameters measured during observations.

Parameter	Unit	Update frequency
Date	DD/MM/YYYY	Beginning of the observation
Time	HH:MM:SS	Beginning, end, events
Tide	Character string	Every hour
Weather	Character string	Every hour, visible change
Cloud coverage	Percent	Every hour
Geographicalcoordinate (observer)	Degree, decimal degree	Beginning of the observation
Distance to herd parts	Metres	Beginning of the observation
Angle to herd part	Degree to North	Beginning of the observation

Table 2. Definitions of seal behaviours (amended from Granquist & Sigurjonsdottir 2014).

Behaviour	Definition
Resting	Lying either on the back, the stomach or on the side, without moving and with the head down
Play	Playing with one or more other seals, no visible aggressive reaction
Nursing	Pup laying with head close to the teats of the mother
Vigilance	Lifting the head up with eyes open and/or moving the head from side to side
Vocalising	Any vocal manifestation (e.g., crying, growling)
Antagonism	Fighting, biting, hitting with head/tail/flippers
Locomotion	All visible movements within the colony, where an individual was moving from one place to another on land or in/out of the water
Leaving	All visible movement where an individual is leaving the hauling area/colony without visible signs of stress, haste
Flush response	Rushing to the water

We recorded 9 specific behaviours on the 19th and 17 on the 20th of 2021 (Table 4). Despite being more freely accessible, Berg did not allow proper observation because of the relief of the sandbanks. Several sandbanks, characterized by their small hill-like form, obstructed visibility of seals situated in proximity to the waterline on the opposite slope, thereby resulting in partial obstruction of the view from the riverbank. However, the position and shape of sandbanks may fluctuate over time due to the formation of sedimentary deposits and accumulations (Soulsby 1998). Observing the colony from Berg precluded us from seeing many individuals. All behaviours and actions taking place close to the water were almost impossible to observe. Expectedly, the 8 occurrences of nursing were only observed from Björg, where we had clear visibility of the colony (Table 4). In order to test the difference in observation capability between sites, a Fisher test was used. A χ^2-test of partition was considered, but we did not proceed due to the low frequency of some behaviours (Table 4). This was also conducted to determine if the behaviour might have changed from one day to the next because of two static observers being present for extended periods of time. Fisher tests were used to compare behaviour frequency based on date, site and tide separately. The behaviours are judged similar between the two observation days ($p = 0.734$). For Berg, only 7 specific behaviours (i.e., excluding leaving and resting) were recorded, whereas 17 were recorded from the Björg site ($p = 0.018$). Similarly to days, the effect of tide was non-significant ($p = 0.249$).

As shown in Fig. 3, the herd located in Skjálfandafljót presented a steady number of individuals on both days and sites. We observed a maxima of 36 and 35 individuals on the 19th and 20th respectively, with associated minima of 1 and 0 seals at the end of the observation period. As for variation between sites, maxima of 35 and 36 seals were observed in Björg and Berg respectively, along with minima of 1 and 0 individuals. The herd showed a steady decline as the tide rose.

Photo-identification (PID)

PID on the herd of Skjálfandafljót was not successful. The reason for this was that distance to the observer (over 200 m) was too far considering the equipment at our disposal, thus leading to poor data collection (Fig. 4).

Discussion

Through this preliminary study, we were able to assess the suitability of the two seal-watching sites located in Skjálfandafljót for further study, such as PID. Among the two sites, Björg appears to be the most appropriate option to monitor population behaviour and to acquire photographs for a possible PID catalogue. Nevertheless, access to this site remains limited. Located on private property, observing seals from Björg implies obtaining permission from the owner of the farm and paying special attention not to disturb their activities or that of the sheep herd. These parameters make the site unsuitable for daily surveys or tourism. The second site, Berg, remains the most accessible since it can be reached via a public

Table 3. Characteristics of the two observation sites.

Characteristics	Berg	Björg
Latitude	65.9588125	65.9564213
Longitude	–17.5644309	–17.5792781
Type	Land-based	Land-based
Access	Dirt road	Grass road
Permission to access	Public	Private
Tourism activity	Hostel	Guesthouse
Sight quality	Medium	Excellent
PID suitability	Poor	Poor

Table 4. Occurrences of each seal behaviour observed in the two sites Berg and Björg, near Húsavík.

Behaviour	Day 1 19.06.2021	Day 2 20.06.2021	Site Berg	Site Björg
Antagonism	4	4	3	5
Flush response	1	3	1	3
Leaving	25	26	24	27
Locomotion	2	2	4	0
Nursing	2	6	0	8
Other	2	1	1	2
Play	2	1	1	2
Resting	17	30	23	24

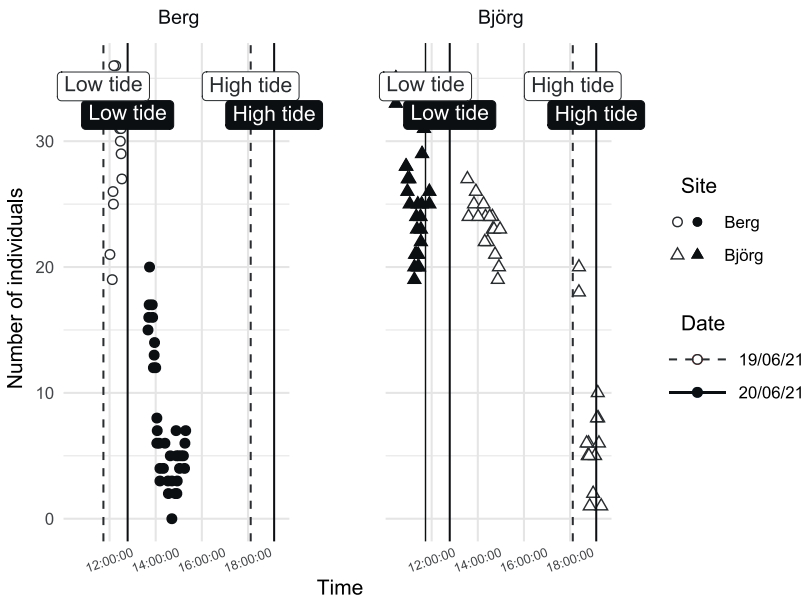

Fig. 3. Variation in the relative abundance of *P. vitulina* in Skjálfandafljót sandbanks through time depending on the observation point. Low and high tides are indicated by vertical lines.

pathway. However, it also implies using a dirt road, which is not suitable for non 4×4 vehicles. Moreover, the relief of most sandbanks does not allow for proper observation of the colony as was shown by our comparison between the two sites. The topography of the sites was sufficient to prevent us from seeing nursing behaviours, which occurred near the water on the lowest part of the hauling area. This latter point is of critical importance for any further study on nursing behaviour or pups who usually need to increase their hauling time since they are limited in their capacity to regulate body temperature (Henry & Hammill 2001).

A specific aim of this pilot study was to determine if the two sites were suitable for PID of seals so that tourists or amateur photographers can contribute to seal research. Both from Berg and Björg, we were unable to come closer than 200 m from the colony, thus leading to poor photograph quality. While head shape ID works regardless of the orientation of the animal's face (Birenbaum *et al*. 2022) by comparing multiple images, photographs of each individual must be captured from multiple angles for pattern ID in order to increase identification success. Despite moving from one site to the other is possible on the same day, the journey represents approximately 35 km (circa 40 min drive), including gravel/dirt roads and frequent sheep encounters, thus preventing PID data collection from both sides of the river, in addition to the previously mentioned sandbank topography. Furthermore, an increase in traffic on the tractor path for touristic reasons could harm the herd and agricultural activity. Water reflectance, depending on the time of observation, can also affect photograph quality and should be considered. Further studies should evaluate the possibility of a science driven PID, with more specific and efficient equipment. Another solution could be to get closer to seals with, for example, a rowboat or a zodiac. However, approach and watching behaviour can be extremely stressful (Granquist & Sigurjonsdottir 2014), especially since the use of a kayak to approach pinnipeds is assessed as a disturbance (Hoover-Miller *et al*. 2013).

Our findings indicate that Berg and Björg are mostly suitable for basic observations of behaviours, to population monitoring, or, for example, punctual educational field trips. But these observation sites remain limited for seal watching tourism, PID studies or investigations that require long periods of data collection. Indeed, collecting data during an important period would imply regularly accessing private property and disturbing a sheep herd. Despite being publicly accessible, the access path to Berg is of

Fig. 4. Examples of photographs obtained for PID (A. Lhériau-Nice, Canon EOS7D Mark2, 100-400 mm lens).

significant length without cover or topographic structure able to mitigate the sound of incoming tourists. This may provoke flush responses if the observers are not aware of the presence of seals (Granquist & Nilsson 2016), forcing the latter to flee to the sea or to search a new hauling site, less accessible to tourism or scientific observation. However, few anthropogenic sounds were recorded during the two days of observation. During fieldwork, our presence was sufficient to trigger vigilance and 'scanning' behaviour towards us during the first 0.5 to 1 h after arrival. This scanning behaviour was observed during the study but not documented as it was not the primary focus of the study. Nevertheless, a complete flush response (disappearance of the entire herd in less than a minute) was observed in the evening of the 19th of June, suggesting that one seal was triggered during its scan and provoked a fleeing response of the entire herd (Terhune

1985). The origin of the flush response, however, remains unknown.

Only one of the three tests on behaviour showed statistical significance (Site; $p = 0.018$). We suspect that the duration of the study was too short to properly document any behavioural pattern on the Skjálfandafljót herd. However, although the data collected were limited in quantity, it provided a dataset that could not have been obtained through aerial survey (Hauksson 2010). Further studies should extend the time of observation and the number of sessions beyond two days. This could allow the identification of the Skjálfandafljót herd specificities, potential regional variation, and lead to assessing the relevance of monitoring the colony population through land-based methods instead of yearly aerial survey. Our study is also limited by the quality of the equipment used. This fieldwork was designed with tourism activities in mind, in a way it can be reproduced by tourists and amateurs both in terms of time and equipment. Despite being obviously limiting, the short time of 2 days of field observation aimed to simulate the time tourists might dedicate to seal watching, or the time amateurs can spend watching seals on a weekend, for example. As stated earlier, it remains unlikely to see tourists spending more than 2 days observing seals while the average length of stay is 6.5 days (Óladóttir 2018). Additionally, the nearby city of Húsavík provides important touristic activities such as whale and dolphin watching, sailing tours and geothermal activity. This pilot study highlights, through its short fieldwork, both the quantity and quality of data expected from tourism-based research or from contributions from amateurs and nature lovers. Nevertheless, better equipment would have made observations easier, particularly to distinguish seals that are resting close together, to monitor individuals resting in remote areas of the sandbanks, or to conduct comprehensive research.

Björg and Berg sites offer a low-quality environment for observers willing to undertake extensive and comprehensive studies of a pinniped colony. However, both observation spots are suitable for basic research such as hauling patterns of the colony, quick population surveys or observations on behaviour. Seal watching, as a touristic activity, is possible but should be developed to respect both the Code of conduct for seal watching (Selasetur Íslands 2011) and the local environment and residents. A good example of a management framework is presented by Aquino *et al*. (2021), where the idea of community management is used as a core value. In that respect, giving the owners of Berg and Björg responsibilities over the seal watching area would increase communication with locals and bring a sense of ecological engagement to the forefront of the community around Húsavík. Nevertheless, the impact of tourism around the two sites must be the object of further studies. With a hostel nearby Berg and a guesthouse in Björg, the harbour seal colony might already experience encounters with tourists and be the object of seal watching, at least to a certain extent. The 2 days of observation of this study remain insufficient to assess any potential impact of tourism of the above-mentioned touristic accommodations. During fieldwork, the presence of tourists has not been documented, and no occurrence was observed. Also, further studies should be developed to evaluate, in a more holistic way, the potential of Skjálfandafljót hauling area for research and seal watching considering the interactions with wildlife (other than pinnipeds), farming activity and the local population. Furthermore, quantifying the extent to which seal watching can be developed as a commercial touristic activity, should be the subject of a dedicated study. While both the Skjálfandafljót environment and the pinniped herd are poorly documented, we recommend not to expand activities other than research. We thus invite visitors of the two sites to be respectful of the harbour seal colony and other animals observed in this habitat (e.g., birds), as advised in the Code of conduct for seal watching by Selasetur Íslands (The Icelandic Seal Centre).

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