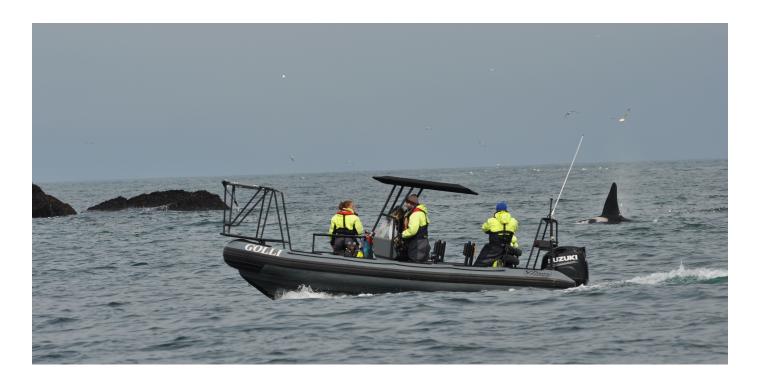![earthwatch logo]

Killer Whales and Their Prey in Iceland

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June-August 2019

Letter to volunteers

Dear Earthwatch volunteers,

Our third year of the "Killer whales and their prey in Iceland" expedition was amazing thanks to your help and participation we were able to successfully keep monitoring this population - we are so happy to have welcomed you to our project!

This was our third year running an extended field season from June to August and we were very curious to see if we would find some of the same patterns as in the previous years. The weather is always a challenge when doing field research in Iceland and influenced our ability to be in the field and collect data. However, we were able to find killer whales throughout the summer and we sighted a number of other cetaceans, including blue whales at the end of the season and exciting interactions of pilot whales with killer whales.

We really appreciated the enthusiasm and dedication that you demonstrated for participating in all aspects of the work, from the boat to the land station and office. We were able to continue our monitoring project and collect valuable new information about species occurrence in the area, as well as killer whale feeding behavior throughout the summer months. During office days, you helped us analyzing killer whale sounds and photographs collected for photo-identification.

We feel very privileged to have shared this experience with you and we sincerely hope that you enjoyed the experience of sub-arctic fieldwork, even with all its challenges! Thank you for all your help and for being a part of our team, takk fyrir! Our very best wishes to you all.

Filipa Samarra

Summary

This was the third field season of the "Killer whales and their prey in Iceland" project and we were joined by 5 teams totaling 29 volunteers. Through land- and boat-based observations during June, July and August we were able to confirm that killer whales occur in the Vestmannaeyjar archipelago (South Iceland) throughout the summer, mostly observed feeding on herring. We also observed other cetacean species, including several sightings of pilot whales interacting with killer whales and once again towards the end of the season we saw blue whales. This data will help us assess the feeding ecology of killer whales and, more broadly, the importance of this marine ecosystem for marine mammals.

Goals, Objectives, and Results

Understanding the vulnerability of top predators to environmental changes requires understanding their ecology and diet preferences. Killer whales are apex predators that can have significant impacts on the ecosystems they inhabit (e.g. Estes et al. 1998). Although generalist as a species (Hoyt 1994), killer whale populations usually specialize on specific prey types, such as fish or marine mammals (Ford et al. 2000; Ford and Ellis 2006), and the survival of some killer whale populations is dependent on the abundance of specific target prey species (Ford et al. 2010).

Killer whales have long been known to commonly occur in Iceland but the Icelandic Orca Project represents the first long-term research program dedicated to understanding their ecology, behavior and conservation status.

Our work to date suggests that within this population there are remarkably different feeding strategies; while some whales appear to follow the herring migration and feed specifically on it, others appear to switch between herring and other prey types, including marine mammals (Samarra and Foote 2015; Samarra et al. 2017a, b). Such prey switching is unlike the specialization characteristic of many other killer whale populations. A generalist feeding strategy might be advantageous if prey resources vary substantially in time and space and individuals adopting such a strategy may be better adapted to a changing ecosystem. However, the extent to which different whales may be adopting different strategies is unknown.

Understanding if a large proportion of the Icelandic killer whale population is herring specialist is particularly relevant in the face of changing environmental conditions and will impact our ability to predict how these whales might be able to cope with future climate change or other human impacts.

This project aims to understand variations in the behavioral ecology amongst killer whales observed in Iceland, as well as the importance of herring as prey. This information is crucial to the assessment of the Icelandic killer whale population and will allow us to evaluate which proportion of the population is highly dependent on herring stocks and consequently the threats this population may face. More broadly, the monitoring of different cetacean species will also allow us to help characterize the local marine ecosystem, as well as its importance for different top predators. The Vestmannaeyjar archipelago is not only an important ground for various fish species but also home to the Surtsey Nature Reserve, a UNESCO World Heritage site and thus an area of significant cultural and biological importance.

In this section we report the preliminary findings of the third field season of this project, relative to each of the main goals.

1) Monitor the overall temporal and spatial variation in presence of killer whales in the study area

Weather had a large effect in the data collection this year and was the main limiting factor affecting data collection. Land-based observations occurred in a total of 32 days resulting in over 136 hours of observation (Figure 1). Once again, killer whales were observed throughout the season, suggesting little temporal variation in occurrence. However, observations suggested differences in the number of whales sighted throughout this period; some days involved observations of large aggregations of whales (>50) and in other days only smaller groups were found. Further analysis will investigate variations in the spatial occurrence of whales throughout the season. Other species observed included harbor porpoises (*Phocoena phocoena*), white-beaked dolphins (*Lagenorhynchus albirostris*), long-finned pilot whales (*Globicephala melas*), humpback whales (*Megaptera novaeangliae*), minke whales (*Balaenoptera acutorostrata*) and and blue whales (*Balaenoptera musculus*).

Figure 1. Volunteers and staff at the land station. The land station is located at the top of a hill providing an expansive view of the archipelago, the core study area.

2) Assess inter-individual or inter-group differences in behaviour and how that relates to age/sex class and sighting history

We collected a total of 44,187 photographs over 21 boat survey days where occasionally we could use two vessels. To date the photo-identification catalogue contains over 400 whales (Samarra et al. 2017c) and the data collected during the summer of 2019 will now be added to the long-term sighting history dataset to understand how often individuals are seen (sighting frequency). This will allow us to analyze the site fidelity of different whales and groups. Behavioral observations onboard the research vessel were collected on 21 days, 18 of which included observations suggesting feeding behavior.

Figure 2. Photograph of whale IS055 seen in the summers of 2017, 2018 and 2019. Note the features used for photo-identification are the dorsal fin shape and nicks or notches, as well as the saddle patch pattern (the light grey area below the dorsal fin) and scars.

3) Assess individual temporal residence in the area and how that correlates with sighting history

Once the photo-identification analysis has been completed we will calculate the amount of time the study area was used by different individuals (i.e., the temporal residence). This will provide information on the importance of this area and how habitat use may vary across different individuals. Together with the behavioral observations of feeding events and prey collected, this will allow us to assess likely specialization upon herring.

4) Understand if the observed whales strictly feed on herring

We collected a total of 29 prey samples consisting of 8 samples of fish scales, 4 samples of fish parts and 17 whole fish, all of which were of herring except one whole mackerel that was collected. This is the first time we have collected a mackerel prey sample. We also collected 11 biopsy samples. Using the patterns of site fidelity and prey samples collected, complemented by biological sampling providing long-term dietary markers, we will be better able to assess if killer whales observed are long-term herring specialists. This will form the basis for our assessment of the vulnerability of this population to fluctuations in prey availability and the threats it may face.

Project Impacts

1. Increasing Scientific Knowledge

a) Total citizen science research hours

Volunteers were trained for a period of about 1.5 days at the start of the project. From then onwards, on average, work days started at 9am and finished at 6pm and volunteers were involved in working in the field (boat or land-based) or in the office every day, except for the recreational day. This resulted in a total of approximately 2088 hours of citizen science research for the 2019 field season.

For the following items, provide full references for publications and material resulting from or supported by your Earthwatch project, indicate the status of the publication (in press, published, etc.) and whether Earthwatch was acknowledged. Include papers/material from all staff, whether or not the PI is a co-author.

b) Peer-reviewed publications

The third Earthwatch expedition season was conducted this year and in-depth analysis will continue on much of the data collected. This season will contribute towards the long-term study that we have been carrying out in this area, which has resulted in several publications to date (see www.icelandic-orcas.com/research) . Further publications are planned for 2020.

c) Non-peer reviewed publications:

Technical reports, white papers, articles, sponsored or personal blogs

Several social media posts updating on the project's work have been published on the project's Facebook page (https://www.facebook.com/icelandic.orcas/). We have also started an Instagram account in 2019 (@icelandic.orcas) to further reach out to the general public.

We participated in the European Researchers Night (Vísindavaka 2019), a night where researchers present their work to members of the public and especially aimed at families. We had a booth with information about whale photo-identification and the project in general, in collaboration with a colleague working on humpback whales in Iceland.

d) Books and book chapters

e) Presentations:

- Samarra FIP, Eleman A, Pinfield R, Ólafsdóttir AH, Óskarsson GJ, Gunnlaugsson T and Víkingsson GA (2019) Killer whale dietary preferences during a period of contrasting availability of prey resources. World Marine Mammal conference, Barcelona, Spain, 9-13 December 2019 (poster)
- Selbmann A, Deecke VB, Fedutin ID, Filatova OA, Miller PJO, Svavarsson J and Samarra FIP (2019) A comparison of Northeast Atlantic killer whale (*Orcinus orca*) stereotyped call repertoires. World Marine Mammal conference, Barcelona, Spain, 9-13 December 2019 (speed talk)
- Lyal R and Samarra FIP (2019) Quantifying habitat use of killer whales (*Orcinus orca*) in Vestmannaeyjar, Iceland. World Marine Mammal conference, Barcelona, Spain, 9-13 December 2019 (poster)
- Samarra FIP, Halldórsson SV and Víkingsson GA (2019) Feeding ecology of Icelandic killer whales. Icelandic Biological Society conference, Reykjavík, Iceland, 17-19 October 2019 (poster)
- Samarra FIP (2019) A decade investigating a top marine predator: the Icelandic Orca Project. Honorary talk upon receipt of the Early Career Researcher Award at the Icelandic Biological Society conference, Reykjavík, Iceland, , 17-19 October 2019 (invited talk)

- Samarra FIP, Eleman A, Pinfield R, Ólafsdóttir AH, Óskarsson GJ, Gunnlaugsson T and Víkingsson GA (2019) Killer whale associations with herring and mackerel in Iceland. VistÍs - Icelandic Ecological Society conference, Hólar, Iceland, 28-29 March 2019 (oral)

2. Outreach and Mentoring

a) Graduate students

This summer we had several students visiting our project and involved for different periods of time doing research towards their degrees and one PhD student.

Student Name	Graduate Degree	Project Title	Anticipated Year of Completion
Tatiana Marchon	Ph.D.	Social and behavioural context of the acoustic communication of Icelandic killer whales	2021

b) Community outreach

Most outreach to date has been through the project's social media pages for the broader audiences. We are also working towards building a permanent exhibition about killer whales with local partners in our study area. This will be a form of information sharing with the local community and also with tourists, raising awareness about killer whales in Iceland. We are also aiming to reach the wider community in Iceland. In September 2019 we participated in the European Researchers Night (Vísindavaka) in Reykjavík.

Name of school, organization, or group	Education level	Participants local or non-local	Estimated number of participants	Details on contributions/ activities

3. Partnerships

Partner	Support Type(s)[1]	Years of Association (e.g. 2006-present)
Páll Jónsson, þekkingarsetur Vestmannaeyja	Provides logistical support, as well as office space where we are based	2008-present
Icelandic Research Fund (RANNIS)	Funding	2012-present

[1.] Support type options: funding, data, logistics, permits, technical support, collaboration, academic support, cultural support, other (define)

4. Contributions to management plans or policies

At the moment, there is no estimate of population size of killer whales in this area, or in Icelandic coastal waters, making it very difficult to assess its conservation status or whether any management plans or policies might be needed. In 2018, the first ever assessment of all species of mammals occurring in Iceland, including cetaceans, was completed. Based on a population size of 5-7 thousand killer whales estimated for a large area of ocean including Icelandic and surrounding waters, the species is considered at little risk. However, this estimate does not take into account diverse ecological strategies that may separate the total number of whales into separate communities, thus a more thorough understanding of population structuring within these waters is necessary to provide a better understanding of the conservation status of killer whales. One of the primary goals of this project is to collect the information that will contribute to this assessment, allowing us to understand the local conservation status for this species. Blue whales, which appear to occur regularly in the study area, are classified as vulnerable and future monitoring of the occurrence of this and other species will help towards our understanding of the importance of this area to top predators such as marine mammals.

Plan/Policy Name	Type[2]	Level of Impact[3]	New or Existing?	Primary goal of plan/policy[4]	Stage of plan/policy[5]	Description of Contribution

[2] Type options: agenda, convention, development plan, management plan, policy, or other (define)

[3] Level of impact options: local, regional, national, international

[4] Primary goal options: cultural conservation, land conservation, species conservation, natural resource conservation, other (define)

[5] Stage of plan/policy options: proposed, in progress, adopted, other (define)

5. Conserving natural and sociocultural capital

a) Conservation of taxa

> *i. List any focal study species that you did not list in your most recent proposal*

Species	Common name	IUCN Red List category	Local/regional conservation status	Local/regional conservation status source

> *ii. In the past year, has your project helped conserve or restore populations of species of conservation significance? If so, please describe below.*

Species	IUCN Red List category	Local/regional conservation status	Local/regional conservation status source	Description of contribution	Resulting effect[6]

[6] Resulting effect options: decreased competition, improved habitat for species, range increased, population increase, improved population structure, increased breeding success, maintained/enhanced genetic diversity, other

b) Conservation of ecosystems

In the past year, has your project helped conserve or restore habitats? If so, please describe below.

This project will contribute in the long term to the assessment of the status of the Icelandic killer whale population and also its potential impacts on the local ecosystem. More broadly, by monitoring the occurrence of other marine mammals in this area we will also provide a better understanding of the local ecosystem, which includes the Surtsey nature reserve and UNESCO World Heritage site. Understanding the species that occur in this habitat, as well as their use of the habitat, will help towards assessing its conservation needs.

Habitat type	Habitat significance[7]	Description of contribution	Resulting effect[8]

[7.] Habitat significance options: nursery, breeding ground, feeding site, corridor, migration path, refuge, winter range, summer range, spring range, fall range or other (define)

[8.] Resulting effect options: extent maintained, condition achieved, restored, expanded, improved connectivity or resilience

c) Ecosystem services

*Indicate which ecosystem service categories you are **directly studying** in your Earthwatch research and provide further details in the box below as needed.*

Provisioning Services

☐Fisheries (Fresh & Marine)
☐Energy (Fuelwood/hydropower)
☐Livestock grazing
☐Material extraction (e.g. resin, grass)
☐Timber
☐Water supply
☐Other food (crops, wild foods, spices)
☐Pharmaceuticals

Regulating & Support Services

☐Carbon sequestration/storage/"blue"
☐Coastal protection
☐Erosion control
☐Flood regulation/protection
☐Pest and disease control
☐Pollination
☐Seed dispersal
☐ Water purification/quality
☐ Nutrient cycling

Cultural Services

☐Cultural/historical values
☐Health (mental & physical)
☒Research & knowledge
☐Recreational
☐Spiritual/aesthetic values

Other Services

☒Biodiversity
☐Employment/Livelihoods

Details:

> In this project, we monitor the occurrence and biodiversity of marine mammals in the study area. As top predators that can act as sentinels for environmental change, monitoring such species allows us to improve our knowledge of changes in the ecosystem. This could include changes in economically important fish stocks, such as herring. Although we are not directly studying these ecosystem services, sharing information on the occurrence of marine mammals in the area with the local community supports recreational activities and tourism, as well a more in-depth understanding of the biodiversity of the sea that surrounds the islands.

d) Conservation of cultural heritage

Provide details on intangible or tangible cultural heritage components that your project has conserved or restored in the past year.

We are working towards building a permanent exhibition about killer whales with local partners in our study area. This will be a form of information sharing with the local community and also with tourists, raising awareness about killer whales in Iceland. Sharing our findings with the local community through our exhibition will also raise awareness locally of the wildlife richness inhabiting their seas, which we hope will contribute to an increased interest in the environment and its protection.

Cultural heritage component[9]	Description of contribution	Resulting effect

[9.] Cultural heritage component options: traditional agriculture, artifacts, building(s), hunting ground or kill site, traditional ecological knowledge and practices, monument(s), oral traditions and history, spiritual site, traditional subsistence living

e) Impacting local livelihoods

Provide details on how livelihoods were impacted by your project. This includes persons hired to assist Earthwatch teams (field assistants, guides, cooks, drivers, etc.) and any economically applicable training provided to local community stakeholders.

Local livelihood impact(s)	Description of contribution	Number of people impacted
Economic help to local research center	Hiring of boat and boat driver	

f) Please provide any other measurable actions that you conducted within the local community(s) where your research takes place.

Research Plan Updates

Report any changes in your research since your last proposal/annual report. For any 'yes' answers, provide details on the change in the 'Details' box. This section will not be published online.

1)   Have you added a new research site or has your research site location changed?   ☐ **Yes**   ☒ **No**

2)   Has the protected area status of your research site changed?   ☐ **Yes**   ☒ **No**

3)   Has the conservation status of a species you study changed?   ☐ **Yes**   ☒ **No**

4)   **Have there been any changes in project scientists or field crew?**   ☒ **Yes**   ☐ **No**

5) Details – provide more information for any 'yes' answers

After the 2019 field season, two new students have joined the project to conduct their PhD degrees: Anna Selbmann and Ayça Eleman.

6) Provide details on any changes to your objectives, volunteer tasks, or methods, include reason for the change.

Acknowledgements

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