

ICELAND

PROGRESS REPORT ON MARINE MAMMALS IN 2022

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I INTRODUCTION

The following is a brief summary of research on marine mammals in Icelandic and adjacent waters in 2022. The studies were conducted by the following research institutes: Marine and Freshwater Research Institute (MFRI), Húsavík Research Centre (HRC), Húsavík Whale Museum (HWM), Keldur, Institute for Experimental Pathology (KIEP), The National University Hospital of Iceland, The Icelandic Institute of Natural History (INH), University of Iceland (UI), University of British Columbia in Canada, University of Barcelona in Spain, University of St Andrews in Scotland, The Icelandic Seal Center (ISC), Hólar University Collage, Natural History Museum of Denmark, Maine University, University of Aarhus, RIF research center, North West Iceland Nature Research Centre, West Iceland Nature Research Centre, Orca Guardians Iceland (OGI) and University of Potsdam. Queries for information on research were sent to all offices, individuals and private commercial platforms such as whaling and whale watching companies known to have been involved in marine mammal research or data collection during the period.

II RESEARCH BY SPECIES 2022

Fin whale

Studies continued at the MFRI on the biology and ecology of fin whales based on data from commercial catches in 2022 and recent years. Fin whale research conducted at the whaling station in Hvalfjörður is wide ranging and includes i.a studies on age, reproduction, feeding ecology, energetics, pollutants, genetics, hybridization, anatomy and physiology and involves several research institutions including the National University Hospital of Iceland, University of British Columbia in Canada, University of Barcelona and Keldur, Institute for Experimental Pathology.

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Research on the functional anatomy of the fin whale respiratory and digestive tracts was completed (Gil et al 2022a, 2022b) and comprised a PhD thesis. This work showed how the fatty nasal plugs are retracted by muscle contraction during breathing and automatically seal the air passages after exhalation. This also demonstrated the importance of the oral plug in preventing water incursion into the pharynx while controlling food passage

In 2022, research on the anatomy of blood supply to the brain and hemodynamic modelling of attenuation by a vascular rete of cerebral pulsation originating from swimming movements was published (Lillie et al. 2022).

Several papers on pollutants in fin whales came out in 2022. First evidence for transplacental transfer of plasticizers and flame retardants in fin whales was published in 2022, based on samples taken in Hvalfjörður (Sala et al. 2022), while phthalates concentrations were also estimated from samples taken there (Garcia-Garin et al 2022).

Sulfur stable isotope ratios were used for the first time to provide insights into movements of fin whales in a study using samples from baleen plates collected in Iceland (García-Vernet et al. 2022).

The anatomy of two fin whale fetuses was examined in 2021. These scans are being used to create a #D model of the muscle organization of the pharynx to elucidate how the oral plug is controlled.

The HRC in Húsavík updated their long-term photo-identification data bases to include fin whales.

Common minke whale

Collaboration between the MFRI and the University of Potsdam on common minke whale genetic research continued during 2022. Population genetics analyses across the entire North Atlantic were performed, including samples from Iceland, Greenland, Canada, Norway, and the North Sea, to be finalized in 2023. Microsatellite data were used to infer Parent-Offspring (PO) pairs which informed about regional and ocean-wide movements. Final analyses are to be performed in 2023.

Using the ddRAD protocol, over 50,000 new nuclear Single Nucleotide Polymorphisms (SNPs) have been developed for 45 NA minke whales, including 8 samples from Iceland. Further SNPs are currently developed by Whole Genome Resequencing of a representative set of minke whales. These SNPs will form the basis for the development of an informative minke whale SNP panel for population structure assessment across the entire North Atlantic.

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The HRC in Húsavík continued their long-term photo-identification of minke whales. Additionally, one master's student is currently investigating entanglement scarring on minke whales around Iceland, while another completed a study on minke whale habitat preference in Skjálfandi Bay which is pending publication (Lechwar et al. in press)

Blue whale

The HRC in Húsavík continued their long-term photo-identification and sightings studies of blue whales in Skjálfandi bay.

A collaborative acoustic study using soundtrap long-term recorders was initiated in 2022 by HRC in Húsavík and UI in Vestmannaeyjar to compare blue whale arrival time and calling behaviour between North vs. South Iceland.

Humpback whale

The MFRI's long-term humpback tagging program continued in 2022.

The MFRI continued their photo-identification studies and the development of the national humpback whale photo-id database (ISMN Catalogue): <https://www.hafogvatn.is/en/research/whale-research/whale-photo-id>. This Catalogue is a product of a national collaboration with various contributors, including Universities, Whale Watching companies, citizen scientist, and dedicated surveys conducted by MFRI. The ISMN catalogue has more than 10900 sightings recorded in total and records over 1540 unique individuals seen in Icelandic waters (79 of these have also been reported in locations outside of Iceland). The ISMN Database records an additional 1118 individuals from various international partners (Guadeloupe (449), Norway (320), Azores (6771) Irish (70), Scotland (5) Capo verde (81), Bermuda/Samana Bay (62) and Greenland (30)).

A special effort has been made in comparing the ISMN Catalogue to the NAHW Catalogue (North Atlantic Humpback whale) especially to the known breeding grounds population.

The HRC in Húsavík continued their long-term photo-identification and sightings studies of humpback whales in Skjálfandi Bay. Additionally, a long-term project on factors effecting humpback whale vocalization rate in Skjálfandi Bay was initiated in 2022 with the implementation of student interns analyzing past acoustic recording data.

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The UI in Vestmannaeyjar continued studies during the wintertime with humpback whales including photo-identification mainly from land, many of which are contributed by citizen scientists, and sound recordings. In addition, a study on the year-round occurrence of humpback whales in South Iceland, based on acoustic detections, as well as vocal behaviour in this region was completed as a Masters thesis.

Ongoing research on subarctic humpback whales behavioural ecology called “Icelandic Winter Whales” at the University of Iceland has continued. Biopsy samples of epidermis and dermis tissue including blubber of life individuals have been collected and analysed to investigate the genetics, isotope niche and endocrinology of humpback whales in Iceland. The isotope research is done in collaboration with MFRI and University of Barcelona. The genetic study is done in collaboration with the University of Grönigen and MFRI. The endocrinology study is done in collaboration with the University of St Andrews and MFRI.

Behavioural data has also been collected using suction cup digital archival tags and catcam tags, with images and videos from UAVs, from land-based stations and photo-ID data from vessels. Data has been collected in Faxaflói (SW-Iceland), Steingrímsfjörður and Ísafjarðardjúp (Westfjords of Iceland), Eyjafjörður and Skjálfandaflói (NE-Iceland). The photo-ID data has been shared with the Icelandic Humpback Whale catalogue curated by MFRI. A master student is using the tag and land-based data to investigate the energy use of humpback whales in the wintertime.

Killer whale

In 2022, the UI and the Icelandic Orca Project conducted a field season in Vestmannaeyjar during June, July and August, continuing the long-term project on killer whales started in 2008. The current focus of the project is to investigate dietary specialization on killer whales, to observe interspecific interactions with pilot whales and to investigate the acoustic behaviour of killer whales. Tagging with Dtags was also conducted during the summer field season as well as playback experiments of pilot whale sounds to killer whales to investigate their interspecific interactions. Land-based observations also allowed for broader monitoring of variations in the occurrence of killer whales and other cetaceans in the local marine ecosystem.

Tatiana Marchon finished the Húsavík killer whale catalogue.

In 2022, the West Iceland Nature Research Centre and Orca Guardians Iceland continued their collaboration and year-round systematic data collection on killer whales via photo-identification and behavioral observations in Breiðafjörður Bay and along the Snæfellsnes Peninsula. The focus is on recognizing individual killer whales and documenting their associations and travel routes.

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Efforts of comparing identification images of killer whales from Iceland to photographs received from collaborators in other areas of the North Atlantic are ongoing. Data collection and analysis will potentially aid in identifying critical habitat, feeding behavior and prey types, as well as natural mortality and behavioral patterns of Icelandic killer whales. The project started in 2014 in collaboration with Láki Tours whale watching and is conducted both onboard whale watching vessels and via land-based observations.

Northern bottlenose whale

Continued research on northern bottlenose whales by UI in Vestmannaeyjar (Hypmo project) this year included deployments of mono and stereo acoustic recorders in deep waters off the east and northeast of Iceland to study acoustic occurrence and movement directions, analyses of satellite tag data and stomach contents, and photographic analyses for understanding individual movement, group compositions, and age-sex distributions. Data collection in 2022 included several fieldtrips in the north of Iceland for satellite tagging and collection of other information on individual whales. The project aims to increase understanding about the species' movement ecology in the NE Atlantic, and is in collaboration with MFRI, University of St Andrews and IMAR Portugal.

HRC in Húsavík worked on creating an updated northern bottlenose whale catalogue for Skjálfandi Bay, building upon the initial catalogue created in 2018.

Long-finned pilot whale

A comprehensive research project on pilot whales that started in 2019 continued compiling photo-identifications, studying their behaviour in Vestmannaeyjar during interactions with killer whales and investigating the ecology of pilot whales through stable isotopes of carbon and nitrogen. The project aims to gather knowledge on this species in Iceland, such as understanding its occurrence in Icelandic coastal waters, the prey targeted by the species and whether that has changed in recent times. The project is conducted by UI in collaboration with MFRI.

Research on the endocrinology and toxicology of stranded pilot whales in Iceland was conducted in collaboration between UI and MFRI resulting in a MSc thesis.

In 2022, efforts on data collection for long-finned pilot whales, conducted since 2019 by Orca Guardians Iceland and the West Iceland Nature Research Centre, and onboard Láki Tours, continued in Breiðafjörður Bay and along the Snæfellsnes Peninsula. The emphasis is on photo-

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identification and behavioral observations, with special attention to killer whale – pilot whale interactions, to aid in the understanding of pilot whale behavior and occurrence in the waters of West Iceland, and to potentially identify critical habitat for this species.

White-beaked dolphins

The HRC in Húsavík continued their long-term photo-identification and sightings studies of white-beaked dolphins in Skjálfandi bay. A sound trap was out in Skjálfandi Bay to record sounds of white-beaked dolphins and used by a Master student from the University of the Westfjords for his Master thesis

Samples of white-beaked dolphins from stranded or bycaught individuals from the MFRI tissue bank collected from the 1980s until the present were analysed for stable isotopes of nitrogen and carbon to investigate their trophic ecology, as part of a study to investigate the diet composition of killer whales undertaken by UI and MFRI. The results of these analyses were published in a study investigating isotopic niche overlap with harbour porpoises in the journal Marine Ecology Progress Series in 2022.

Harbour porpoise

Collaboration between the MFRI and the University of Potsdam on harbour porpoise genetic research is ongoing (Lah et al. 2016), where samples of bycaught and stranded animals are used.

New analyses on nuclear Single Nucleotide Polymorphisms (SNPs) have been performed on 150 harbour porpoise specimens from the North Atlantic, including 12 specimens from Iceland. These analyses yielded 26,320 informative SNPs which were used for population structure assessment across the entire North Atlantic. A manuscript draft was submitted in late 2022.

Whole Genome Resequencing was completed for 74 harbour porpoises, including specimens from Iceland, Canada, Norway and the North and Baltic Sea. These efforts yielded around 6 million high quality SNPs. The analyses assign Icelandic harbour porpoises to a large North-Atlantic/North Sea population, with closest affinities to Norwegian porpoises. There is no genetic indication of a population decline or inbreeding. A manuscript has been submitted. The preprint is available at <https://www.authorea.com/doi/full/10.22541/au.167120655.52464008/v2>.

Efforts to estimate bycatch of harbour porpoises in fisheries continued at the MFRI.

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Samples of harbour porpoises from stranded or bycaught individuals from the MFRI tissue bank collected from the 1990s until the present were analysed for stable isotopes of nitrogen and carbon to investigate the trophic ecology of harbour porpoises, as part of a study to investigate the diet composition of killer whales undertaken by UI and MFRI. This was published in a study investigating isotopic niche overlap with white-beaked dolphins in the journal *Marine Ecology Progress Series* in 2022.

Other (multi) cetacean species

A total of 24 stranding events of cetacean was recorded by the MFRI including five single strandings of sperm whales.

Northern bottlenose whales and other toothed whales are of interest in two ongoing EU projects (SUMMER and MESO) on the ecology and potential utilization of resources of the mesopelagic zone which the MFRI is a part of.

The Húsavík Research Centre continued long-term photo-id studies in Skjálfandi bay and initiated a new PhD project using drones to estimate body condition of cetaceans in the bay.

The occurrence of cetaceans within the Surtsey Nature Reserve, in Vestmannaeyjar, South Iceland, was published in the new edition of the Surtsey Research journal in 2022.

The MinTag project, which is a collaboration within NAMMCO that which aims to develop tags to be able to track large whale species continued and testing of tags took place at the whaling station in Hvalfjörður, Iceland.

The effects of global warming on global baleen whale populations historically were estimated in a recent genetics study (Cabrera et al. 2022), based partly on samples collected in Iceland.

Work was carried out within a working group on marine mammal bycatch to develop a tool to help managers set limits on bycatch rates of marine mammals in relation to the newly enforced US MMPA import provision rule. The tool, which consists of both R package and an online shiny application can estimate PBR for populations and can solve for maximum bycatch the population can sustain based on some initial parameters from the published literature (Siple et al. 2022).

One study reviewed mercury exposure in Arctic marine and terrestrial mammals (Dietz et al. 2022), using data from the literature.

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Harbour seals

No new harbour seal census has been conducted in Iceland since 2020, when the population size was estimated to 10,319 (CI 95%= 6.733-13.906) (Granquist 2022).

Efforts are taken by MFRI and ISC to improve knowledge on population demographics and factors contributing to mortality and/or affecting the status of the population. Research on timing of pupping period and monitoring of local pup production at important sites in North west Iceland, South Iceland and North east Iceland was initiated in 2009 and analysis and manuscript preparation continued during 2022. A new project was initiated in 2018, where haul-out behaviour was monitored by using camera traps and analysis continued during 2022. The results from the project will increase knowledge on factors affecting haul-out behaviour and will assist in improving census design.

A study on the effect of land- and boat-based tourism on the spatial and behavioural haul-out patterns of harbour seals was initiated by ISC and MFRI in 2008 and continued during 2022, with the aim to investigate effects on the population and to pinpoint solutions to reduce disturbance. The study is carried out in several areas of Iceland including important haul-out sites in North west Iceland and the Westfjords. The study includes interdisciplinary and international cooperation with researchers from Hólar University Collage, University of Iceland and Griffith University in Australia. The interdisciplinary research focus on research on best practice, management of seal watching and development of an ethical framework.

Harbour seal diet and interactions with the fishing industry has been studied at MRFI in cooperation with ISC since 2008. Currently, dietary studies using stable isotopes and fatty acids is ongoing and data analysis was carried out during 2022.

Efforts to estimate bycatch of harbour seals in fisheries and research on mitigation methods continued.

A study conducted in co-operation between MFRI, ISC and UI on vocalisations and behaviour of Icelandic harbour seals during the pupping, moulting and mating season was initiated during the year.

A study of harbour seal genetics was initiated in 2016, in cooperation between MFRI, ISC and the Natural history museum of Denmark and a manuscript was published in 2022 (Liu et al. 2022).

Grey seals

To estimate the current status of the Icelandic grey seal population, an aerial census was carried out by MFRI in cooperation with ISC during the pupping period in 2022 and the analysis will be finalised in 2023.

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A study of the effect of grey seals and seabirds on plant succession on the volcanic island Surtsey in the southern archipelago of Iceland was carried out in cooperation with the Icelandic Institute of Natural History. Monitoring will continue the following years.

A study of grey seal genetics was initiated in 2016, in cooperation between MFRI, ISC, the Natural history museum of Denmark and Main University, and analysis continued during 2022.

Efforts to estimate bycatch of grey seals in fisheries and research on mitigation methods continued.

Other (multi) pinniped species

A project investigating environmental toxicants in pinnipeds in Icelandic waters was initiated by MFRI during 2017 continued in 2022. Very little is known about contaminants in Icelandic seal populations. The focus of the project is to investigate the contents of new contaminants of concern in marine mammals, including new brominated flame retardants and PFAS (per- and polyfluoroalkyl substances). A recently published paper based on results from the study show low levels of PFAS in Icelandic harbour seals and grey seals compared to levels in mammals in other countries included in the study. Analysis and manuscript preparation on results regarding new brominated flame retardants continued during 2022. The project is an international cooperation between Sweden (Naturhistoriska Riksmuséet and Stockholm University), Greenland (Grönlands Naturinstitut) and MFRI (Iceland).

III ONGOING (CURRENT) RESEARCH

Pinnipeds

A harbour seal aerial census is planned in 2023.

IV ADVICE GIVEN AND MANAGEMENT MEASURES TAKEN

Cetaceans

Based on assessments conducted by the Scientific Committees of NAMMCO and the IWC, the MFRI recommended in 2017 that annual catches in 2018-2025 do not exceed 161 fin whales on the East Greenland – West Iceland management area and 48 fin whales in the East Iceland-Faroes management area. On the same basis the MFRI recommended in 2018 maximum annual takes of 217 common minke whales in the Icelandic continental shelf (CIC) area during 2018-2025. In 2019, Icelandic authorities issued a regulation on catch limits according to this advice for the

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period 2019-2023 (annual catch of 161 fin whales and 217 common minke whales). The whaling quotas have not been fully utilized in recent years due to economic reasons and the Covid-19 pandemic. In 2022, 148 fin whales were caught in Icelandic waters, but no minke whales were caught.

Pinnipeds

A new legislation was initiated in 2019, where seal hunting is banned in Iceland. However, seal hunters can apply for exemption from this ban to the Directorate of Fisheries, to hunt seals for own utilization. The governmental management objective states that the Icelandic harbour seal population should be kept above 12.000 animals. Based on the population assessment carried out in 2020 which resulted in an estimated population size of 10.319 animals, MFRI advises that direct hunt should be limited and that actions must be taken to reduce by-catch of seals in commercial fisheries to enable the population size to reach management objective. MFRI further advises that attempts to minimize anthropogenic disturbance of harbour seal colonies are initiated, in particular during breeding and moulting seasons between May and August. The governmental management objective from 2006 states that the Icelandic grey seal population size should be kept above 4100 animals. A new advice will be released only after the new population estimate for 2022 has been finalized in 2023.

V PUBLICATIONS AND DOCUMENTS

Peer-reviewed publications in 2022

Albrecht, S., Jung, J. L., Lémeray-Peissik, D., Lazar, L., Baithe, M., Eider, D. and Rasmussen, M. H. (2022). Minke whales' distribution dependence on food, their small-scale site fidelity in North Iceland and its implications regarding a distribution shift northward in the Atlantic. *Marine Biology Research*, DOI: [10.1080/17451000.2021.2016839](https://doi.org/10.1080/17451000.2021.2016839)

Cabrera, A. A., Schall, E., Bérubé, M., Anderwald, P., Bachmann, L., Berrow, S., ... & Palsbøll, P. J. (2022). Strong and lasting impacts of past global warming on baleen whales and their prey. *Global Change Biology*, 28(8), 2657-2677.

Celemín, E., Autenrieth, M., Roos, A., Pawliczka, I., Quintela, M., Lindstrøm, U., Benke, H., Siebert, U., Lockyer, C., Berggren, P., Öztürk, A., Öztürk, B., Lesage, V., Tiedemann, R. (2022). Evolutionary history and seascape genomics of Harbour porpoises (*Phocoena phocoena*) across environmental

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gradients in the North Atlantic and adjacent waters. *Submitted manuscript, preprint available at <https://www.authorea.com/doi/full/10.22541/au.167120655.52464008/v2>*

Chauvat, C. M., Granquist, S. M. and Aquino, J (2023). Gender difference in biospheric values and attitudes towards nature management actions: the case of seal watching in Iceland. *Accepted for publication in Ocean and Coastal Management*.

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Gil, K.N., Vogl, A.W. and Shadwick, R.E. (2022). Anatomical mechanism for protecting the airway in the largest animals on earth. *Current Biology*, 32, 1-6. <https://doi.org/10.1016/j.cub.2021.12.040>.

Gil, K.N., Vogl, A.W. and Shadwick, R.E. (2022b). Morphology and mechanics of the fin whale esophagus: the key to fast processing of large food volumes by rorquals. *PlosOne* (submitted)

Granquist, S. M. (2022). The Icelandic harbour seal (*Phoca vitulina*) population: trends over 40 years (1980–2020) and current threats to the population. *NAMMCO Scientific Publications*, 12.

Hamilton, C. D., Lydersen, C., Aars, J., Acquarone, M., Atwood, T., Baylis, A., ... & Kovacs, K. M. (2022). Marine mammal hotspots across the circumpolar Arctic. *Diversity and Distributions*.

Kebke, A., Samarra, F.I.P. and Deros, D. (2022). Climate change and cetacean health: impacts and future directions. *Philosophical Transactions of the Royal Society B*, 377: 20210249

Laute, A., Grove, T., Rasmussen, M. H., Smith, A., Loisa, O., Fournet, M. E. H. (2022). Impact of whale-watching vessels on humpback whale calling behavior on an Icelandic foraging ground

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Liu, X., Schjøtt, S. R., Granquist, S. M., Rosing-Asvid, A. et al. (2022). Origin and expansion of the world's most widespread pinniped. *Molecular Ecology*. <https://doi.org/10.1111/mec.16365>

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Samarra, F. I. P. and Esteban, R. (2022) Killer whale *Orcinus orca* (Linnaeus, 1758). In: Hackländer K, Zachos FE (eds.) Handbook of the Mammals of Europe, doi: 10.1007/978-3-319-65038-8_100-1

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VI APPENDIX 1 - CATCH DATA

Catch data for pinnipeds are under re-evaluation and should not be considered reliable at this stage.

VII APPENDIX 2 - BY-CATCH DATA

a. Short narrative

Bycatch of marine mammals was monitored in all major fisheries in Icelandic waters in 2022, through logbook submissions, reports from onboard inspectors from the Directorate of Fisheries and in the MFRI annual gillnet survey.

By-catch in research surveys and when observed by inspectors on fisheries vessels is reported in Appendix 2. By-catch by fishermen now comes from electronic logbooks only. It should be noted that reported numbers of by-catch is underrepresented to an uncertain extent and hence numbers should not be regarded as reliable. There may be some overlap in the by-catch reported by fishermen and reports from the inspection. Numbers are given as requested in a separate sheet.

VIII APPENDIX 3 - STRANDINGS

a. Short narrative

According to the Icelandic stranding protocol, the MFRI is responsible for documentation and biological investigations related to cetacean strandings. Therefore, all strandings should be reported to the MFRI, that subsequently organizes autopsies and/or biological sampling depending on circumstances. Genetic samples are stored in the genetic database at the institute and other biological samples stored at the MFRI or sent to cooperating institutes/scientists.

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Live-strandings and associated actions (rescue/euthanasia etc) are managed by the Veterinary Authorities (MAST).

Stranding numbers for 2022 are given as requested in a separate sheet.

No systematic records are kept of pinniped strandings at the MFRI.

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