Received: 20 December 2023 | Accepted: 8 September 2024

DOI: 10.1111/mms.13187

NOTE

Marine Mammal Science

First documented movement of wild killer whales (*Orcinus orca*) between Iceland and Norway

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Killer whales (*Orcinus orca*, Linnaeus 1758) are wide-ranging throughout the world's oceans (Forney & Wade, 2006) and can travel over large distances (Dahlheim et al., 2008; Durban & Pitman, 2012). In the North Atlantic, long-distance movements of killer whales have been recorded from the eastern Canadian Arctic to near the Azores (Matthews et al., 2011), from Scotland to Norway (Eve Jourdain, personal communication, November 2022), repeatedly between Iceland and Scotland (Mrusczok & Scullion, 2019; Samarra & Foote, 2015), as well as between Iceland, Scotland, and the Faroe Islands (Scullion et al., 2021; Andrew Scullion, personal communication, November 2022). The longest one-way distance recorded for killer whales was documented with the movement of a male from Iceland via Spain and Italy to Lebanon and Israel traveling over 8,000 km (Mrusczok, Violi, et al., 2022; Mrusczok, von Schmalensee, et al., 2022). An extensive nonstop round-trip movement to subtropical waters has previously been recorded for Antarctic killer whales, with a travel distance of almost 9,400 km from the Antarctic peninsula to the coasts of Uruguay and southern Brazil and back (Durban & Pitman, 2012). The only killer whale previously documented to have swum from Iceland to Norway is the male killer whale Keiko, who was born in the wild near Iceland, captured in 1979, and released back into Icelandic waters in 2002 (Simon et al., 2009). Using satellite telemetry, Keiko was tracked moving from Vestmannaeyjar, southern Iceland, to Kristiansund, western Norway, in 25 days in August 2002 (Simon et al., 2009). The minimum distance between these two locations via sea is 1,390 km. Keiko would therefore have traveled at a minimum average transit speed of 55.6 km per day. Killer whales have been previously documented with an average transit speed of 120–240 km per day (Durban & Pitman, 2012;

Hanson et al., 2017). Keiko's transit speed may have been closer to this average, considering the less than direct route indicated via satellite telemetry (Simon et al., 2009).

As killer whales are listed as data deficient by the IUCN red list (Reeves et al., 2017), studies that compare identification images of individuals between regions are of great importance for improving knowledge on population characteristics, abundance estimates, ecotypic classification, and, ultimately, for the conservation status of killer whales. It has been suggested that at least two populations of killer whales are present in Icelandic waters (Foote et al., 2011), but their genetic, social, and ecological differentiation largely remains unknown (Jourdain et al., 2019). A study on social and genetic connectivity of killer whales in Norwegian waters indicated the presence of one unique population rather than two different populations (Jourdain et al., 2024). A previously established type classification for North Atlantic killer whales has been questioned (Foote, 2023), emphasizing the need for more detailed analyses of data sets of photo-identification images and behavioral observations.

Here, the first photographic match, round-trip, and one-way movement of four wild killer whales between Iceland and Norway are described, with confirmed sightings and observations of these individuals between 2018 and 2024. Georeferenced photo-identification (Bigg, 1982) and behavioral data were obtained by a combination of citizen science and dedicated research cruises along the Icelandic shoreline and in Norwegian waters. In West Iceland, data collection was part of a larger, long-term running photo-identification study (2014–2024; Mrusczok, 2022).

Photo-identification images taken of killer whales in Norway were uploaded to the research collaboration and citizen science web platform Happywhale (Cheeseman et al., 2017, 2021). The Happywhale database primarily contains photo-identification images of humpback whales (*Megaptera novaeangliae*) and opportunistically collects photos of other marine mammal species. The images of the killer whales in Norway were then compared via visual analysis to images from the photo-identification catalog of 987 killer whales in Iceland (Mrusczok, 2022), and to images taken during sightings in West Iceland from 2022 to 2024 that were not yet included in the catalog. Matches were confirmed by two independent researchers trained in photo-identification, which includes analyzing the scarring patterns on the dorsal fin and saddle patch of each individual, the size of the dorsal fin and nicks on the fin, the shape of the saddle patch, and the angle in which the images were taken. Secondary characteristics, such as the size of the dorsal fin, were also used to determine the sex of the individuals (Ford et al., 2000). Subsequently, sightings of the matched individuals in Icelandic waters were added from the West Iceland database and from reports and images from whale watching guides and members of the public in different parts of Iceland.

Two of the four individuals matched were listed in the West Icelandic photo-ID catalog: an adult male (Iceland ID number: SNOS1310, former SN1310, nicknamed "Sundfoerr"), and a second individual (SNOS1309, former SN1309, nicknamed "Kisa"), likely to be a female due to body size and the nonchanging size of the dorsal fin over a 5-year period (Figure 1). A third individual, another adult male (SNOS1316, nicknamed "Gwaihir") and a fourth individual (SNOS1317, nicknamed "Svana"), likely to be another female due to close association with a young calf, were found in unpublished images taken in West Iceland in 2022 and 2024 (Figure 1). Individuals matched were confirmed a total of six times in several areas along the Icelandic coast between 2018 and 2024, but only once in Norway in June 2022 (Figures 1 and 2, Table 1). No further accounts of the four killer whales were found in the Happywhale database. No previous records of the four individuals exist in the Norwegian killer whale database holding photo-identification images of 1,325 individuals for the period 2005–2022, nor in the historical Norwegian killer whale photo-ID catalog for the years 1986–2005 (Eve Jourdain, personal communication, September 2024).

Three of the four killer whales were photographed in West Iceland in April 2022, before being sighted again 45 days later in Norway in June 2022 (Figure 2, Table 1). During this time, the whales traveled a minimum distance of 1,740 km which would equate to 38.7 km per day, if the whales traveled the shortest possible route along the north coast of Iceland (Figure 2). The same individuals were then observed again in March 2023 in North Iceland, having traveled at least 1,330 km from Norway over 264 days. In this round trip from Iceland to Norway and back, the three killer whales covered a minimum distance of 3,070 km in a maximum time span of 309 days, calculated from the last day they were seen in Iceland in 2022, to the first day they were observed in Icelandic waters again in 2023 (Figure 2, Table 1). It is possible that SNOS1309, SNOS1310, and SNOS1316 are more regularly present in

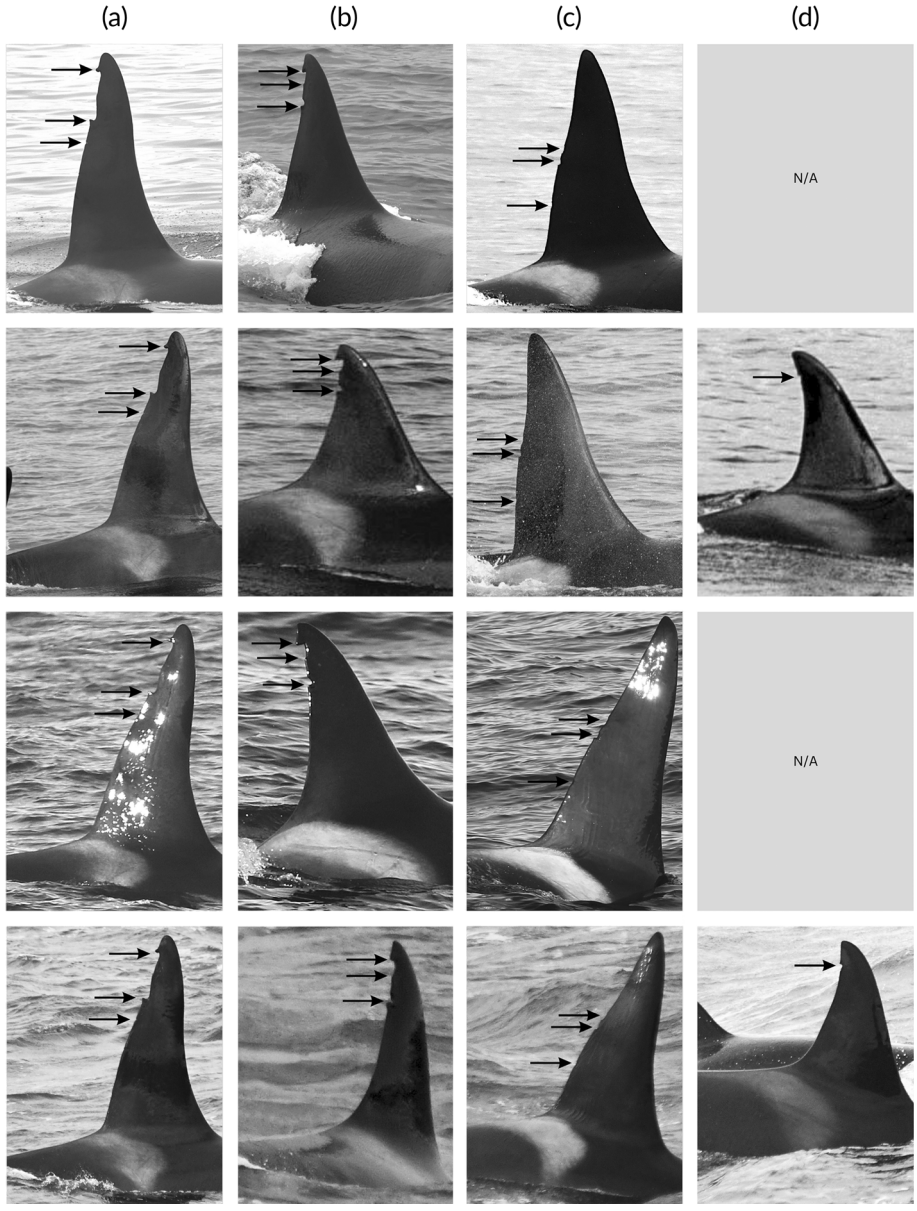

FIGURE 1 Comparison of identification images for SNOS1310 (a), SNOS1309 (b), SNOS1316 (c), and SNOS1317 (d). Top images taken by M.-T.M. near Snæfellsnes, Breiðafjörður, West Iceland, on April 27, 2022; top center images taken by J. Cotín (a, c) and J. Coleman (b, d) near Aldgården, Norwegian Sea, Central Norway, on June 11, 2022; bottom center images taken by C. Schmidt in Skjálfandi, North Iceland, on March 2, 2023; bottom images taken by M.-T.M. near Snæfellsnes, Breiðafjörður, West Iceland, on March 26, 2024.

Icelandic than in Norwegian waters, as they were spotted along the Icelandic shoreline several times between 2018 and 2024 but were documented in Norway only once, in 2022. Sightings success may, however, largely depend on how regularly those areas have been surveyed. Whereas regular data collection is conducted onboard Icelandic whale watching vessels in the areas in which these individuals were spotted, and dedicated research surveys have been carried out in West Iceland, the sighting in Central Norway was entirely opportunistic. A fourth individual,

FIGURE 2 GPS positions for confirmed sightings in Iceland and Norway. Alphanumeric codes correspond to those in Table 1 and reflect the chronological order of sightings. The shortest possible route traveled from Iceland to Norway between April and June 2022 is indicated via a dotted line.

SNOS1317, was only photographed twice, in Norway in June 2022 and in Iceland in March 2024, confirming at least one transit from Norway to Iceland (Figure 2, Table 1). It is possible that SNOS1317 was present in previous encounters in Iceland but may have been undocumented because not all individuals were photographed during encounters in Iceland from 2022 to 2023 (Table 1).

The four matched individuals were observed as part of larger groups of killer whales both in Iceland and Norway (Table 1). How SNOS1309, SNOS1310, SNOS1316, and SNOS1317 relate to any of the additionally documented individuals or to each other is unknown. SNOS1317 was photographed with a young calf in the echelon position in the 2024 Iceland encounter, but the calf was not documented in any of the photographs from Norway.

Both the Icelandic and the Norwegian photo-identification databases hold images of over 1,000 wild killer whales (Mrusczok, 2022; M.-T.M., unpublished data; Eve Jourdain, personal communication, November 2022), but this is the first time the same individuals could be found in both Icelandic and Norwegian waters, despite previous efforts (Foote et al., 2010). Notwithstanding the great number of individuals documented in both databases, they may only be a fraction of the individuals occurring in Iceland and Norway, and round trips between the two countries may have taken place previously and may not be as rare as currently suggested. Though acoustic studies suggest a lack of or little connection through call types between killer whales from Icelandic and Norwegian waters (Bellon, 2023; Selbmann et al., 2020), the photo-identification matches of the four individuals may indicate more spatial overlap between killer whales in Iceland and Norway than previously thought. Range overlap between populations previously thought to be isolated could imply that total killer whale abundance assuming closed populations has been overestimated. In West Iceland, individual killer whales have been photographed and added to the data set each year between 2014 and 2024 (Mrusczok, 2022; M.-T.M., unpublished data), but the total number of individuals regularly occurring in Icelandic waters is still unknown.

Ongoing efforts for data collection, to determine the regularity of long-distance and round-trip movements through international collaboration, will aid in our understanding of killer whale populations and their conservation status in the North Atlantic. Increased sharing of data through publicly accessible photo-identification catalogs and collaboration between scientists, engagement from platforms of opportunity (e.g., whale-watching vessels), as well as contributions from the public via citizen science, are invaluable to our understanding of these far-ranging animals.

TABLE 1 Sightings data available for the individual killer whales SNOS1309, SNOS1310, SNOS1316, and SNOS1317. Estimates were given when not all individuals could be photographed.

A/N[a]	Date	SNOS1309	SNOS1310	SNOS1316	SNOS1317	Estimated total number of killer whales in encounter	Previously identified individuals (for Iceland)	Newly identified individuals (for Iceland)	Special remarks on foraging/feeding behavior	Organization/person recording data (vessel type)
E1	March 7, 2018	1	1	0	0	3	0	3	None	Helen Alexander (whale-watching vessel)
E2	April 25, 2022	1	1	0	0	20	9	3	Foraging[b]	Orca Guardians (whale-watching vessel)
E3	April 27, 2022	1	1	1	0	15	6	4	Feeding[c]	Orca Guardians (whale-watching vessel)
E4	June 11, 2022	1	1	1	1	20	3	N/A	None	Andrew Peacock, Javier Cotín, Jamie Coleman (expedition cruise ship)
E5	March 2, 2023	1	1	1	0	15	3	2	None	Christian Schmidt (whale-watching vessel)
E6	March 16, 2023	0	0	1	0	15	3	7	None	Christian Schmidt (whale-watching vessel)
E7	March 26, 2023	1	1	1	1	20	5	6	None	Orca Guardians (whale-watching vessel)

[a]A/N refers to the corresponding alphanumeric codes in Figure 2.
[b]Foraging: Individuals were observed moving in a nondirectional manner in a loose constellation and spread out over a large area, with birds hovering above occasionally, but with no prey species visible above the water surface.
[c]Feeding: Several other individuals were observed with lumpfish (*Cyclopterus lumpus*) in front of the mouth and displaying sharking behavior, with rapid dorsal fin movements close to the surface, while changing speed and directions frequently (Shedd, 2018). SNOS1309 was observed with unidentified prey in the mouth.

ACKNOWLEDGMENTS

Data collection in West Iceland was possible only thanks to the past and ongoing support of Láki Tours whale watching and Gísli Ólafsson, who provided a platform for Orca Guardians' research from the very beginning of our efforts. Thank you to Lindblad Expeditions for facilitating data collection onboard the National Geographic Resolution in Norway, and to all citizen science contributors of North Atlantic killer whale images, especially naturalist guides. We would like to thank Helen Alexander and Christian Schmidt for additional images and sightings information, as well as Elding Adventure at Sea and North Sailing for permitting data collection onboard their whale watching vessels in Icelandic waters. We are grateful to Eve Jourdain and Andrew Scullion for sharing insights into their respective data sets. Thank you to Stefan Wrabetz for grammatical corrections.

The authors declare there are no competing interests. The authors have no relevant financial or nonfinancial interests to disclose. No funding was received for conducting this study. Data generated or analyzed during this study are provided in full within the article.

AUTHOR CONTRIBUTIONS

Marie-Thérèse Mrusczok: Conceptualization; data curation; formal analysis; investigation; project administration; visualization; writing – original draft. **Emma Luck:** Conceptualization; data curation; formal analysis; investigation; writing – review and editing. **Ted Cheeseman:** Data curation; investigation; writing – review and editing. **Jamie Coleman:** Investigation; writing – review and editing. **Javier Cotín:** Investigation; writing – review and editing. **Andrew Peacock:** Investigation; writing – review and editing. **Robert A. Stefansson:** Supervision; writing – review and editing. **Menja von Schmalensee:** Supervision; writing – review and editing.

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REFERENCES

Bellon, G. (2023). *Playing hide and seek underwater: Evidence of orca* (Orcinus orca) *presence in offshore Icelandic waters through acoustic analysis* [Master's thesis]. University of Iceland. https://skemman.is/bitstream/1946/43323/1/Bellon_Final_Thesis.pdf

Bigg, M. A. (1982). An assessment of killer whale (*Orcinus orca*) stocks off Vancouver Island, British Columbia. *Reports of the International Whaling Commission*, *32*, 655–666.

Cheeseman, T., Johnson, T., Southerland, K., & Muldavin, N. (2017). *Happywhale: globalizing marine mammal photo identification via a citizen science web platform*. Paper SC/67A/PH/02 presented to the Scientific Committee of the International Whaling Commission. https://cabowhaletrek.com/wp-content/uploads/2017/06/Cheeseman-et-al-2017-Happywhale-for-IWC-SC_67A_PH_02.pdf

Cheeseman, T., Southerland, K., Park, J., Olio, M., Flynn, K., Calambokidis, J., Jones, L., Garrigue, C., Frisch Jordán, A., Howard, A., Reade, W., Neilson, J., Gabriele, C., & Clapham, P. (2021). Advanced image recognition: a fully automated, high-accuracy photo-identification matching system for humpback whales. *Mammalian Biology*, *102*, 915–929. https://doi.org/10.1007/S42991-021-00180-9

Dahlheim, M. E., Schulman-Janiger, A., Black, N., Ternullo, R., Ellifrit, D., & Balcomb III, K. C. (2008). Easter temperate North Pacific offshore killer whales (*Orcinus orca*): Occurrence, movements, and insights into feeding ecology. *Marine Mammal Science*, *24*(3), 719–729. https://doi.org/10.1111/j.1748-7692.2008.00206.x

Durban, J. W., & Pitman, R. L. (2012). Antarctic killer whales make rapid, round-trip movements to subtropical waters: evidence for physiological maintenance migrations? *Biology Letters*, *8*(2), 274–277. https://doi.org/10.1098/rsbl.2011.0875

Foote, A. D. (2023). Are "Type 2" killer whales long in the tooth? A critical reflection on the discrete categorization of Northeast Atlantic killer whales. *Marine Mammal Science*, *39*(1), 345–350. https://doi.org/10.1111/mms.12964

Foote, A. D., Similä, T., Vikingsson, G., & Stevick, P. T. (2010). Movement, site fidelity and connectivity in a top marine predator, the killer whale. *Evolutionary Ecology*, *24*, 803–814. https://doi.org/10.1007/s10682-009-9337-x

Foote, A. D., Vilstrup, J. T., de Stephanis, R., Verborgh, P., Nielsen, S. C. A., Deaville, R., Kleivane, L., Martín, V., Miller, P. J. O., Øien, N., Pérez-Gil, M., Rasmussen, M., Reid, R. J., Robertson, K. M., Rogan, E., Similä, T., Tejedor, M. L., Vester, H., Víkingsson, G. A., … Piertney, S. B. (2011). Genetic differentiation among North Atlantic killer whale populations. *Molecular Ecology*, *20*(3), 629–641. https://doi.org/10.1111/j.1365-294x.2010.04957.x

Ford, J. K. B., Ellis, G. M., & Balcomb, K. C., III. (2000). *Killer whales: The natural history and genealogy of* Orcinus orca *in British Columbia and Washington State*. University of British Columbia Press.

Forney, K.A., & Wade, P. R. (2006). Worldwide distribution and abundance of killer whales. In J. A. Estes, D. P. Demaster, D. F. Doak, T. M. Williams, & R. L. Brownell, Jr. (Eds.), *Whales, whaling and ocean ecosystems* (pp. 145–162). University of California Press.

Hanson, M. B., Ward, E. J., Emmons, C. K., Holt, M. M., & Holzer, D. M. (2017). *Assessing the movements and occurrence of Southern Resident killer whales relative to the U.S. Navy's Northwest Training Range Complex in the Pacific Northwest*. Final Report for U.S. Navy by NOAA, Northwest Fisheries Science Center under MIPR N00070-15-MP-4C363.

Jourdain, E., Karoliussen, R., Fordyce Martin, S. L., Langangen, Ø., Robeck, T., Borgå, K., Ruus, A., & Foote, A. D. (2024). Social and genetic connectivity despite ecological variation in a killer whale network. *Proceedings of the Royal Society B: Biological Sciences*, *291*, Article 20240524. https://doi.org/10.1098/rspb.2024.0524

Jourdain, E., Ugarte, F., Víkingsson, G. A., Samarra, F. I. P., Ferguson, S. H., Lawson, J., Vongraven, D., & Desportes, G. (2019). North Atlantic killer whale *Orcinus orca* populations: a review of current knowledge and threats to conservation. *Mammal Review*, *49*(4), 384–400. https://doi.org/10.1111/mam.12168

Matthews, C. J. D., Luque, S. P., Petersen, S. D., Andrews, R. D. & Ferguson, S. H. (2011). Satellite tracking of a killer whale (*Orcinus orca*) in the eastern Canadian Arctic documents ice avoidance and rapid, long-distance movement into the North Atlantic. *Polar Biology*, *34*, 1091–1096. https://doi.org/10.1007/s00300-010-0958-x

Mrusczok, M.-T. (2022). Killer whales of Iceland (2011–2021). Photo-identification catalogue with an emphasis on West Iceland. *Report of the West Iceland Nature Research Centre (Náttúrustofa Vesturlands)*, *21*. https://doi.org/10.13140/RG.2.2.28771.22566

Mrusczok, M.-T., & Scullion, A. (2019). *North Atlantic killer whales* (Orcinus orca) *migrating between Iceland and Scotland. A short identification catalogue* [Technical Report]. Orca Guardians Iceland and Orca Survey Scotland, Grundarfjörður, Iceland. https://doi.org/10.13140/RG.2.2.35482.11200

Mrusczok, M.-T., Violi, B., Fakhri, M., Calogero, G., Biasissi, E., Jaouhar, A., Scullion, A., & Würtz, M. (2022). Long-distance movements of North Atlantic killer whales (*Orcinus orca*) from Iceland via Spain and Italy to Lebanon. *Marine Mammal Science*, *38*(2), 778–787. https://doi.org/10.1111/mms.12866

Mrusczok, M.-T., von Schmalensee, M., Scullion, A., Harrop, H., Munro, K., Violi, B., Scheinin, A., Mevorach, Y., Galili, O., & Stefansson, R. A. (2022). *Occurrence of killer whales* (Orcinus orca) *along the Snæfellsnes Peninsula, West Iceland: A decade of photo-identification (2011–2021) reveals travel routes* [Poster presentation]. 33rd Conference of the European Cetacean Society. https://doi.org/10.13140/RG.2.2.12879.56486

Reeves, R., Pitman, R. L., & Ford, J. K. B. (2017). *Orcinus orca*. *IUCN Red List of Threatened Species*, e.T15421A50368125. https://doi.org/10.2305/IUCN.UK.2017-3.RLTS.T15421A50368125.en

Samarra, F. I. P., & Foote, A. D. (2015). Seasonal movements of killer whales between Iceland and Scotland. *Aquatic Biology*, *24*, 75–79. https://doi.org/10.3354/ab00637

Scullion, A. J., Harrop, H. R., Munro, K., Truluck, S. R., & Foote, A. D. (2021). *Scottish killer whale photo identification catalogue*. https://doi.org/10.13140/RG.2.2.23096.88325

Selbmann, A., Deecke, V. B., Fedutin, I. D., Filatova, O. A., Miller, P. J. O., Svavarsson, J., & Samarra, F. I. P. (2020). A comparison of Northeast Atlantic killer whale (*Orcinus orca*) stereotyped call repertoires. *Marine Mammal Science*, *37*(1), 268–289. https://doi.org/10.1111/mms.12750

Shedd, T. (2018). Characterization of surface foraging behaviors of Southern Resident killer whales from aerial photographs. *Center for Marine Biodiversity and Conservation*. https://escholarship.org/uc/item/0hb1w3pz

Simon, M., Hanson, M. B., Murrey, L., Tougaard, J., & Ugarte, F. (2009). From captivity to the wild and back: An attempt to release Keiko the killer whale. *Marine Mammal Science*, *25*(3), 693–705. https://doi.org/10.1111/j.1748-7692.2009.00287.x

How to cite this article: Mrusczok, M.-T., Luck, E., Cheeseman, T., Coleman, J., Cotín, J., Peacock, A., Stefansson, R. A., & von Schmalensee, M. (2025). First documented movement of wild killer whales (*Orcinus orca*) between Iceland and Norway. *Marine Mammal Science*, *41*(2), e13187. https://doi.org/10.1111/mms.13187