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BRIEF REPORT

# 3000 leagues under the sea: the voyages of vagrant walruses (*Odobenus rosmarus*) in temperate Europe

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**Abstract**
Sightings of vagrant walruses in Europe have been known since historic times, yet whether this phenomenon remains constant or changes over time is unclear. In this study, we conducted a comprehensive cross-reference of information on vagrant walruses observed in temperate Europe (below 61° N) between 1923 and 2022 utilising data from the *Global Biodiversity Information Facility* depository. In addition, we conducted an online search of records from the last ten years, resulting in a detailed reconstruction of the movements of the most recently observed individuals. We estimated that between 31 and 36 different individuals have been observed over the last century, with most of these likely originating from the Svalbard region and only a few from Greenland. A comparison in the yearly number of records showed a significant increase over time, suggesting that vagrant walruses reach Europe as a result of a combination of climatic and meteorological events as well as of demographic changes in the populations of the North Atlantic.

**Keywords** Atlantic Ocean · Climate change · Geographic distribution · Migration · *Odobenus rosmarus* · Seasonal movement · Vagrancy

## Introduction

Dispersal and movement are a key part of any animal's ecology, influencing gene-flow, metapopulation dynamics and species distribution (Bowler and Benton 2005). Vagrancy (i.e., the movement of animals outside of their recognized range) is one component of these behaviours (Bloom et al. 2011) and is often considered the preliminary, and necessary, stage of range expansion (Trakhtenbrot et al. 2005). Analysing records of extralimital sightings may thus help in identifying trends that could indicate modifications in species distribution (Bloom et al. 2011; Cárcamo et al. 2019), and establishing links with possible causes such as climate change or extreme meteorological events (e.g., Cunze and Klimpel 2022; Balestrieri et al. 2023). However, while the northward expansion of warm-adapted species is a well-known phenomenon (Parmesan and Yohe 2003), the dispersal patterns of boreal and Arctic species and their response to rising temperatures are less clear (Gilg et al. 2012; Moore and Reeves 2018).

The Atlantic walrus (*Odobenus rosmarus rosmarus*) is a large circumpolar pinniped whose range spans from the eastern Canadian Arctic eastward to the Kara Sea (Born et al. 1995). During winter, when breeding occurs, this highly social species inhabits iced areas of the Arctic whereas during the summer season the males move to ice-free shallow waters where they gather in large groups while the females tend to remain in association with drifting ice (Freitas et al. 2009). Although the species rarely ventures into sub-Arctic waters, it is known to sporadically visit lower latitudes (Born 1992; Gjertz et al. 1993; Van Bree 1997), with vagrant individuals being recorded as far south as Spain (Nores and Pérez 1988). Although reviews of vagrant sightings are available (Born 1988; Gjertz et al. 1993; Cotton 2007; Svanberg 2010), these have never been cross-referenced and a clear picture at continental scale of the cross-border

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movement as well as of the total number of vagrant animals is lacking.

In this study, we used contemporary and historic records of walruses observed in temperate Europe to investigate their presence and describe their vagrancy patterns. Moreover, we examined annual variations in the number of recorded individuals to determine whether there is an increasing trend over time and to speculate about the potential factors driving these movements.

## Methods

We screened the digital repository Global Biodiversity Information Facility (GBIF 2023) to compile a dataset of walruses observed in European waters. We selected 1923 to 2022 as temporal interval, while the geographic limits for the area screened were set between 15° W and 30° E, and between 61° and 41° N. We excluded fossil specimens or deceased animals washed ashore. For records from the last 10 years, we augmented the dataset by conducting an online search of social media, local newspapers and citizen-science platforms for any additional observation within the same geographical boundaries. Language of search included English, French, Dutch, German, Danish, Norwegian, Swedish, Finnish, Polish, Russian, Lithuanian, Latvian and Estonian.

To avoid possible double counts, we firstly discarded all observations that were collected on the same day within a 100-km radius, estimated as the maximum distance a walrus can cover over 24 h (Born et al. 2011). Naturally, the remaining records could still include a possibly large number of double counts, since individuals could either have been remaining in the same region for prolonged periods of time and therefore recorded repeatedly, or they could have travelled long distances and be spotted again in a new location. While for more recent observations (2013–2022) we were able to infer individual IDs based on diagnostic traits retrieved from available photos, social media posts, and local newspapers, for older records (1923–2012), for which digital evidence was generally missing, we followed two different approaches, one conservative and one more aggressive, to estimate the likely number of individuals, based on the location and date of sightings. In the former, we considered walruses seen within 150 days from the previous observation as being the same individual; in the latter, the threshold to treat data as repetition was lowered to 60 days. If two consecutive records were registered at a distance greater than 100 km in one day (Born et al. 2011), they were treated as belonging to different individuals. In any case, due to the nature of the data, these counts must be considered indicative and treated with extreme caution since they are susceptible to possible over- and underestimations.

For walruses observed between 2013 and 2022, thanks to the vast amount of mediatic attention they received, we were able to reconstruct movements at a much finer scale, and to calculate, albeit coarsely, factors such as behaviour and daily movement rate. Walruses exhibit a broad range of movement behaviours, from short-scale ones to long-distance migrations, and swimming speeds differ between the two (Born et al. 2011; Dietz et al. 2014). To account for this variability, we categorized daily movements into two groups: small-scale (< 10 km/day), and large-scale (> 10.1 km/day). We calculated these as the shortest distance between two consecutive observation points divided by the number of days without observations in between. Then, we performed a one-way analysis of variance to compare the daily movement rates of these individuals and test for potential differences related to sex and age, estimated using the tusk-snout width ratio (Monson et al. 2013). Given the small sample size, we grouped individuals into two age classes: sub-adults (< 5 y/o), and mature (+ 5 y/o).

Finally, we conducted a generalized linear model with Poisson error distribution (GLM) to assess the increase in the number of vagrant walruses across the entire time window (1923–2022). The yearly count of observed individuals served as the response variable, while the year and a binary variable accounting for the potential impact of rising social media usage post-2006, which might have resulted in a more frequent documentation and cataloging of these observations, as independent variables. Model significance was assessed using $\chi 2$ tests, while residual diagnostics were inspected using quantile residuals. All analyses were performed using R 4.0.3 (R Development Core Team 2020).

## Results and discussion

The screening conducted on GBIF resulted in a total of 818 walrus sightings in temperate Europe between 1923 and 2022. As 620 observations were registered simultaneously with others, we retained only 198 individual sightings. To these, we added 14 additional historical records that were not found on GBIF (Nores and Pérez 1988; Gjertz et al. 1993; Svanberg 2010; Hussain 2019). The additional online search resulted in 313 records between 2013 and 2022, 38.1% of which referred to days which were not found on GBIF, for a total of 42 new observation events.

For older records (1923–2012), unless explicitly stated by the authors of the observations, inferring an individual ID based on diagnostic characteristics was generally not possible. Based on the dates of sighting and location, we concluded that the real number of walruses observed in temperate Europe between 1923 and 2012 falls between 25 and 30 (for precautionary reasons, hereinafter we will refer to the conservative estimation). On the other hand, thanks to

the identification of diagnostic traits performed using available photos, we narrowed down each of the more recent encounters (2013–2022) to six different individuals, leading to a total number of vagrant walruses between 31 and 36 (Table 1). All the observations retrieved from social media, newspapers and citizen science platforms referred to one of these animals and no other individuals were identified.

Of the six animals observed between 2013 and 2022 (Table 2), four were males and two were females. The first male appeared in the Orkney Islands (Scotland, UK; Fig. 1) at the beginning of March 2013, and was spotted few days later in southern Norway and has not been observed since. A second individual, named "Wally" by local newspapers, was also initially spotted in the Orkney Islands (Fig. 1). It was first seen in March 2018 and was regularly observed along the north Scottish coast for the following four months, generally making small-scale movements (max. 23 km/24 h). A third male, a sub-adult known as "Wally" too, was seen in Ireland, Wales and England between March and August 2021. During this period, the animal made a long detour south and was observed in France and Spain (Fig. 1). The last male, called "Thor", appeared at the beginning of November 2022 in the Netherlands (Fig. 1), although there is a report from southern Norway, unfortunately not supported by photos, of an animal with a matching description dating back to June (Kvalavag 2022). The walrus spent the

**Table 1** Number of vagrant walruses observed in temperate Europe between 1923 and 2022 following the conservative approach

| ID | Countries | First seen | Last seen | Source |
|---|---|---|---|---|
| 1 | DK | January 1926 | | gbif.org |
| 2 | NL, DK, SE | October 1926 | 09/01/1927 | gbif.org, Svanberg (2010) |
| 3 | SE, DE | April 1939 | | Svanberg (2010) |
| 4 | BE | July 1945 | | gbif.org |
| 5 | UK | 1954 | | gbif.org |
| 6 | DE | 27/07/1960 | | gbif.org |
| 7 | NO | 20/12/1971 | | Gjertz et al. (1993) |
| 8 | NL, BE, DK | 23/11/1976 | 20/12/1976 | gbif.org |
| 9 | NL | November 1977 | December 1977 | gbif.org |
| 10 | IE | 01/07/1979 | | gbif.org |
| 11 a | NL, NO, DK, SE, UK | 26/02/1981 | 06/09/1982 | gbif.org; Gjertz et al. (1993), Svanberg 2010; Hussain (2019) |
| 12 | NL | 23/03/1982 | | gbif.org |
| 13 | NO, DE | 20/09/1983 | 01/12/1983 | gbif.org; Gjertz et al. 1993 |
| 14 | IE | 08/01/1985 | 17/04/1985 | gbif.org |
| 15 | IE, UK, FR, ES | August 1986 | 23/10/1986 | gbif.org; Nores and Pérez (1988) |
| 16 | IE | July 1988 | | gbif.org |
| 17 | IE | 11/07/1993 | | gbif.org |
| 18 | IE | 11/06/1994 | | gbif.org |
| 19 | FR | 18/02/1996 | | gbif.org |
| 20 | IE | 04/01/1997 | | gbif.org |
| 21 | NL, DE, SE, NO | 21/01/1998 | 01/03/1998 | gbif.org |
| 22 | IE, UK | 03/04/1999 | 22/04/1999 | gbif.org |
| 23 | DK | 28/11/1999 | | gbif.org |
| 24 | DK, SE, NO | 12/08/2003 | 06/10/2003 | gbif.org; Svanberg (2010) |
| 25 | DK | 05/02/2010 | | gbif.org |
| 26 | UK, NO | 03/03/2013 | 11/03/2013 | gbif.org |
| 27—"Wally 1" | UK | 09/03/2018 | 06/06/2018 | gbif.org |
| 28—"Freya" | DK, NO, NL, DE, UK, SE | 17/02/2021 | 18/08/2022 | gbif.org |
| 29—"Wally 2" | IE, UK, FR, ES | 20/03/2021 | 19/08/2021 | gbif.org |
| 30—"Stena" | NO, DK, SE, DE, PO, RU, LV, FI | 14/04/2022 | 16/07/2022 | gbif.org |
| 31—"Thor" | NL, FR, UK | 05/11/2022 | 31/12/2022 | gbif.org |

Belgium (BE), Denmark (DK), Finland (FI), France (FR), Germany (DE), Ireland (IE), Latvia (LV), Netherlands (NL), Norway (NO), Poland (PO), Russia (RU), Spain (ES), Sweden (SE), United Kingdom (UK).

[a]Gjertz et al. (1993) suggest the presence of a different individual on 26/06/1981

**Table 2** Average daily distances of *Odobenus rosmarus* calculated as the shortest distance between two consecutive observation points divided by the number of days without observations in between

| ID | Age class | Sex | Movement type | |
|---|---|---|---|---|
| | | | Small-scale | Large-scale |
| 26 | Mature | Male | NA | 53.0 km/24 h [b] |
| 27—"Wally 1" | Mature | Male | 3.5 km/24 h | 16.5 km/24 h [b] |
| 28—"Freya" | Sub-adult | Female | 3.9 km/24 h | 31 km/24 h |
| 29—"Wally 2" | Sub-adult | Male | 4.4 km/24 h | 49.9 km/24 h |
| 30—"Stena" | Mature | Female | 2.7 km/24 h | 38 km/24 h |
| 31—"Thor" | Mature | Male | 3.8 km/24 h | 48.1 km/24 h |

[b]Not included in the analysis of variance because sample was too limited ($n < 5$)

following two months cruising in the English Channel until it eventually reemerged in Yorkshire (UK) toward the end of the year.

The first of the females, known by the public as "Freya", was a young individual that was observed for the first time in Denmark in February 2021, although an earlier record suggests her presence outside the species usual range (68°43′ N, 16°49′ E; NO) already in late 2019 (Arvesen 2020). The walrus reappeared in Lower Saxony (DE) in the following September after retreating to Norway during summer (Øksnesavisa 2021). After spending two months on the Frisian shores (NL and BE), she headed north and was spotted in Northumberland and Shetland (UK) before reappearing again in Denmark, Sweden, and finally Norway. There, after spending approximately five months conducting mostly local-scale movements in the Skagerrak (Fig. 1), the animal was euthanised due to safety concerns. The last individual, an old female called "Stena", appeared in Vestland (NO) in April 2022 after having been spotted in Vigra (62°33′ N, 6°04′ E; NO) in March (Anon. 2022). She followed the Norwegian coastline south and entered the Baltic Sea (Fig. 1). Eventually, she reached Finland where she died during a rescue attempt.

The movement rate of these individuals varied widely, spanning from 0.4 to 85.6 km per day (Table 2). While no differences between individuals were detected for small-scale movements, an analysis of variance showed that males covered significantly larger daily distances than females during large-scale ones ($F(1,59) = 8.63$; $p = 0.004$). For these individuals, the average movement speed is comparable to that measured in different contexts (40 km/24 h: Stewart 2008; 46 km/24 h: Dietz et al. 2014; 45.6 km/24 h: Heide-Jørgensen et al. 2017). Vagrant individuals of different species often undergo malnutrition, exhaustion, and eventually death (Greg Hofmeyr and Amir 2010; Balestrieri et al. 2023). Although we do not have direct measures for body condition, movement speed can be used as a proxy for this parameter (Sato et al. 2003) and our results suggest, at least for male walruses, a relatively healthy body condition, similarly to what has been observed in vagrant leopard seals (Hupman et al. 2020).

In total, vagrant walruses had been observed in 14 countries (Table 1), with the highest number recorded in Denmark, United Kingdom, and Ireland (n. 9 each), followed

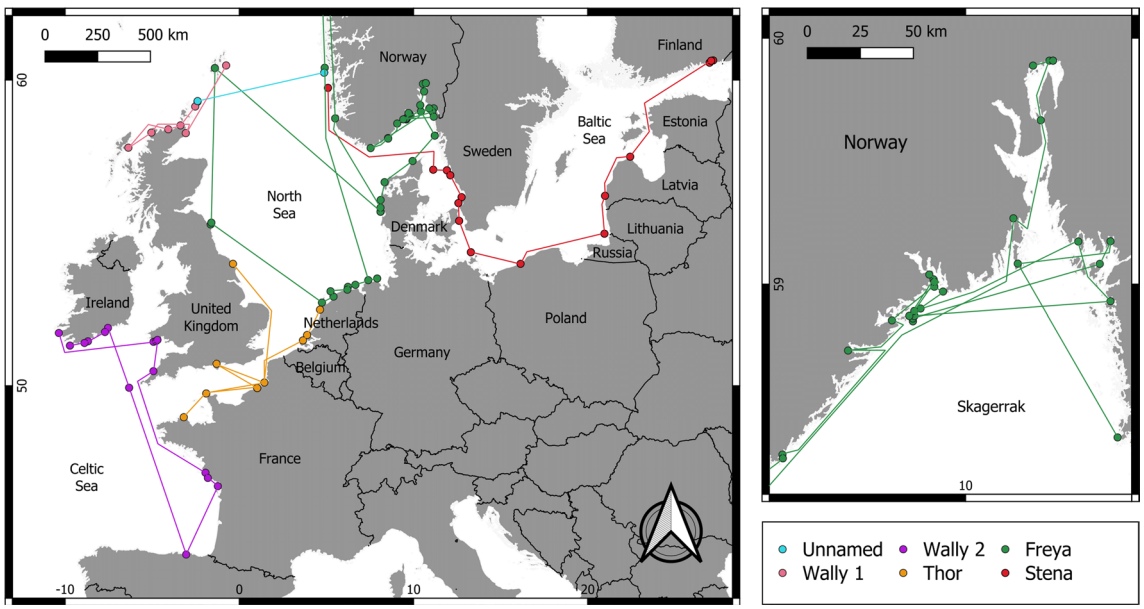


**Fig. 1** Movement routes of *Odobenus rosmarus* observed in temperate Europe between 2013 and 2022. In the small panel, a focus on the movements of "Freya" comprised between 10/03/2022 and 14/08/2022

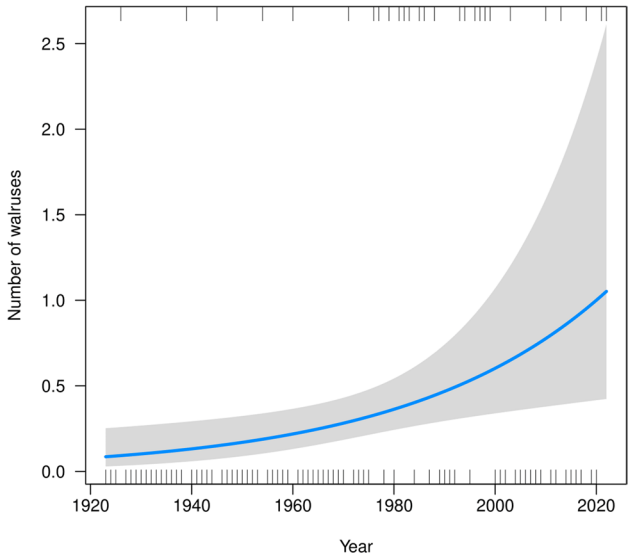


**Fig. 2** Marginal relationships of the number of *Odobenus rosmarus* and the year under the conservative approach. Gray shaded areas show 95% confidence intervals

closely by the Netherlands, and Norway (n. 8 each). Norway, however, is strongly limited by our latitudinal limits and, when considered in its entirety, this is by far the nation with the highest number of records (Gjertz et al. 1993). There are three sub-populations of *O. rosmarus rosmarus* from which these individuals may have originated: that of East Greenland, Svalbard-Franz Josef Land, and Kara Sea–Southern Barents Sea–Novaya Zemlya (Andersen et al. 1998; Born et al. 2011). Although without genetic profiling this must be considered speculative, it has been suggested that vagrant walruses reaching Europe during winter may originate from the Svalbard-Franz Josef Land while those appearing in summer, especially on the western part of the continental shelf, may belong to the East Greenland sub-population (Born et al. 2011). More individuals had been seen for the first time in winter (n. 20; November–April) than in summer (n. 10; May–October). Therefore, it is likely that most of the vagrant walruses reaching temperate Europe originate from the Svalbard-Franz Josef Land sub-population, and that only five individuals first sighted in Ireland during the summer months probably came from the Greenland sub-population.

The GLM showed a significant increase in the number of individuals observed over time (Fig. 2), with the year being a highly explanatory predictor ($\chi^2 = 6.86$; $p = 0.008$). In particular, we observed a change in the frequency of years with positive records rather than in the maximum number of walruses observed per year. Several reasons can explain this trend and without further studies it is impossible to prove any of them but only possible to speculate. Vagrancy in animals could be the consequence of increasingly unsuitable conditions within the species natural boundaries that drives the animals to seek new territories (Derocher et al. 2004). However, a higher number of vagrant individuals could also reflect a numeric increase in nearby populations (Veit 2000) which, in the case of the Svalbard walrus sub-population, has been growing steadily since the 1952 hunting ban (Kovacs et al. 2014). The two theories are not mutually exclusive but can act synergistically: with more and more individuals in the Svalbard population and the prey stock already depleted by warming temperatures (Vincent et al. 2011), it is reasonable to imagine a higher number of animals being forced to move further and further to find new foraging grounds.

On the other hand, one could argue that extensive environmental changes, such as those influencing climate and prey availability, would result in more generalized vagrancy across the population rather than in isolated individuals being observed. Therefore, it is possible that those seen in temperate Europe were simply sick or debilitated animals, possibly disoriented by single meteorological events and pushed out of their natural range (Prado et al. 2016; Siciliano et al. 2020). However, in similar circumstances, animals often show visible injuries or signs of emaciation (Siciliano et al. 2020), which were not recorded in walruses. Moreover, the relatively sustained movement speed exhibited by the observed animals, especially by males, does not suggest these were weakened individuals. Finally, in interpreting our results, it is also important to acknowledge the potential influence of geographic and temporal differences in technological availability, engagement in outdoor activities, and wildlife reporting attitude, which may have contributed to the observed rise in walrus sighting records.

There has been some debate regarding whether with global climate change and rising temperatures the number of dispersing Arctic species will also increase (Born 1988). Overall, a general increase in the number of vagrant pinnipeds reaching lower latitudes in the second half of the twentieth century has been acknowledged (Born 1988; McAlpine et al. 1999; Sardi and Merigo 2006). A similar, yet in opposite direction, expansion has been detected in the Austral hemisphere too, with more and more records of Antarctic species in Oceania, South America and southern Africa (Acevedo et al. 2010; Hupman et al. 2020; Bester et al. 2022). The rising frequency of vagrant walruses reaching temperate Europe is in line with such trends; however, while our study provides valuable insights into the movement patterns of vagrant walruses, caution should be exercised in generalizing trends, and further research is needed to understand the reasons behind these movements and to assess the actual range-expansion potential for this species.

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**Data availability** The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

## Declarations

**Competing interests** The authors declare no competing interests.

**Ethical approval** Not applied.

**Research involving human and animal rights** Not applied.



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