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An Investigation into How Marine Mammal Distribution Is Being Affected by Climate Change, with a Focus on out of Habitat Marine Mammals, Based on Expert Opinion

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Abstract

Climate change is altering the marine environment in many ways, including increasing sea surface temperatures and decreasing sea ice. Species distributions are changing and 'out of habitat' marine mammals are being recorded. 'Out of habitat' (OOH) refers to individuals recorded outside of their natural range or within environments unsuitable for their survival. This phenomenon is currently understudied. This study aimed to identify the scale of the issue, identify consensus opinions on trends and possible causes of these OOH events, as well as assessing the preparedness of local authorities and rescue networks in responding to OOH marine mammals. This study is the first to assess and quantify this issue through a formal consultation process, conducted through an online questionnaire and a detailed examination of two case studies, from the UK and Peru. Sixty-three questionnaire responses were received from six different continents and the majority (60%) reported OOH events in their region. Through the questionnaire and case studies, 44 different marine mammal species were reported to be affected. This clearly indicates this is a global phenomenon, affecting at least 34% of all known pinniped and cetacean species. Most participants (77%) also believed these OOH events are increasing, and 55% believe these events are forerunners to distribution changes. Data from Peru showed an endangered species, the Galápagos fur seal (*Arctocephalus galapagoensis*), had made a range shift. Of the reported OOH species, four are classified as either endangered or critically endangered. The consensus opinion was that climate change is the leading driver of these OOH events, with sea surface temperatures and changes in prey distribution reported as the most important factors. The success of OOH responses was reported as highly inconsistent and, in many cases, requires specialist training, e.g., in human–wildlife conflict. The information derived from this study can be used to advise conservation plans, as well as provide a foundational step for future research into the possible trends in these OOH movements.

Keywords: climate change; marine mammals; out of habitat; distribution shift; sea surface temperature; prey distribution

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1. Introduction

Earth's climate has been rapidly changing in recent decades, notably since the industrial revolution [1–3]. Climate change (CC) is a global problem primarily caused by increased levels of greenhouse gas emissions related to anthropogenic activity [1–3]. The marine environment has been impacted by the warming atmosphere and is estimated to have absorbed over 90% of atmospheric heat created through CC [2,3]. CC is altering marine environments through increased sea surface temperatures (SST), increased extreme weather events, rising sea levels, ocean acidification, loss of sea ice, changes in salinity, and changes in ocean circulation and currents [2–5]. These changes negatively impact the abundance, behaviour, welfare state, survival rate, and distribution of many marine species, with marine mammals being particularly vulnerable [2–4,6].

Changes in marine mammal distribution associated with CC are beginning to be documented, with evidence that species reliant on ice, i.e., for hauling out, are being noticeably affected first [4,6–9]. Changes in distribution can refer to changes in the species' geographic range as well as changes in migration patterns and timings [10]. Many, but not all species are experiencing a poleward shift in distribution [6,10,11]. Predictions suggest suitable habitat for cold-water species will reduce in availability whereas species reliant on warmer waters may experience an expansion in suitable habitat [5,9,12]. For example, in the northern hemisphere, as SSTs increase, some species may move northwards as new areas warm to habitable temperature ranges [6,10]. Furthermore, marine mammal distribution is influenced by changing prey distributions, which can be indirectly impacted by CC through rising SSTs, changing ocean currents, and ocean acidification [5,12,13]. In the last decade (2016–2026) there have been two instances of record-breaking global average SSTs, where SSTs in 2023 and 2024 were 0.25 higher than the previous 2016 record [14].

In addition to changes in distribution, marine mammals are being increasingly found in areas unusual for that species, commonly referred to as 'out of habitat' (OOH) [8]. The term OOH can have slightly varying definitions, and as this project is building on the work of Nunny et al. (2025), their definition will be used; "an individual outside of their natural range or an individual within their natural range in habitat that is not optimal for their health or survival due to a lack of suitable conditions and/or because of potential conflict with humans" [8] (p. 2). Alternative terms have also been used to describe similar scenarios, such as 'pioneer' and 'vagrant' [8]. These terms are not strict alternatives for the term OOH, but terms that may be used as replacements occasionally or may be used to describe similar scenarios.

Increasing OOH events can be linked to several climate-change-related stressors, such as habitat degradation, and changes in prey abundance and distribution [8,15]. These increasing environmental pressures may drive marine mammals into new and unknown locations in search of prey or more suitable habitat [15,16]. For example, six individual walruses (*Odobenus rosmarus*) were sighted in temperate areas of Europe between the years 2013 and 2022 [16]. Their natural geographic range (NGR) is limited to arctic and subarctic regions; therefore, sightings in lower latitudes would fall under the term OOH [16–18]. These OOH individuals may face situations that compromise their welfare by travelling into locations unsuitable for their survival [8]. In addition, these OOH individuals may pose a safety risk to humans and may increase the risk of human–animal conflict [8].

1.1. Aims

The aims of this study were as follows:

To gain quantifiable insights into the scale and location of 'out of habitat' (OOH) marine mammals by consulting with experts around the world, including wildlife rescue organisations who may be responsible for responding to these animals. These insights include:

- Location of OOH animals;
- Whether there is a consensus on trends;
- Whether there is a consensus on possible causes;
- Preparedness of local authorities and rescue networks in responding to OOH marine mammals.

1.2. Hypotheses

1. Marine mammal experts are witnessing an increase in the number of OOH events in recent years.
2. This phenomenon is global.
3. Local authorities and rescue centres are not adequately prepared to successfully respond to OOH individuals.

2. Materials and Methods

2.1. Questionnaire Distribution

This study used a process of adaptive expert opinion assessment. Data collection was conducted through an online questionnaire targeted at experts within the marine mammal field. The questionnaire was hosted on the Joint Information Systems Committee (JISC) Online Survey platform. The draft version was reviewed by a panel of 15 experts, including several authors of the Nunny et al. (2025) paper [8]. Feedback from them was used to refine the final version.

The final questionnaire consisted of 58 questions in six sections covering personal information, location, knowledge of the term OOH, OOH events, responses to OOH species, and changes in native species. The questionnaire body comprised multiple choice, ranking, and yes or no questions with the opportunity to provide further information. The questionnaire was approved by the University of Bristol Faculty of Health Science Research Ethics Committee. A copy of the questionnaire can be viewed at: https://app.onlinesurveys.jisc.ac.uk/s/svs/msc-research-project-climate-change-and-marine-mammals-duplic-6 (accessed on 26 April 2026).

The questionnaire hyperlink and participant information sheet were distributed via email directly addressing the participant or organisation. However, where an email address was not available, the organisation was contacted via the message submission point on their website.

The final version was sent to marine mammal rescue organisations around the world, using details provided by the organisation OceanCare. A mid-study review of the responses identified a low response rate (around 16%) from these rescue organisations. The questionnaire was then distributed to whale watching organisations (identified through further research), and the questionnaire hyperlink was also posted to the MARMAM and ECS-Talk email lists.

The initial cutoff date for the questionnaire responses was the 1 August 2025; however, this was extended to the 12th August to ensure those contacted late in July had sufficient time to respond. As the questionnaire cutoff date approached, reminders were sent to 68 individuals. A continuation of the study in late 2025 resulted in a further nine participants. In total, 235 individuals and organisations were contacted via email. Overall, 65 people participated: 63 through the survey and two provided comments via email. The number of responses to each question varied as only some questions were mandatory.

2.2. Questionnaire Analysis

Data collected through the questionnaire was collated via a Microsoft Excel spreadsheet, analysed, and summarised using tables and pie charts generated in Microsoft Excel.

Eight participants were sent a follow up email asking to confirm or expand upon information they had provided, and from this, five responded. QGIS 3.40.4 was used to create a map displaying the locations of all the questionnaire respondents [19]. Reported locations of each species were compared with the International Union for Conservation of Nature (IUCN) Red List assessments (IUCN Maps). From this, animals reported outside of the IUCN NGR Map for that species, were judged to be OOH. The estimated distance travelled outside of the species NGR was estimated using the Google Earth (online version) measuring tool and displayed in Table A1.

2.3. Case Studies One and Two

Following a review of the questionnaire responses, two case studies were identified for further investigation based on availability of data and agreement from the people/organisations concerned. Data sharing agreements were completed with both organisations. Case Study one data was provided by the British Divers Marine Life Rescue (BDMLR) and included the date, region, location, and species of OOH marine mammals sighted within the UK between 2019 and 2025. These records were reported to the BDMLR hotline and consisted of sightings and live strandings. The BDMLR hotline is a 24 h phone line where members of the public can report sightings and strandings of marine mammals that might require intervention. Case Study two data was provided by the Organisation for Research and Conservation of Aquatic Animals (ORCA) and consisted of OOH pinniped stranding records between 2000 and 2025 in Peru, including the location, date, season, cause of stranding or death, age, gender, species, and body condition of the animal. Structured online interviews were held with the primary contacts of both organisations.

The data set for Case Study one consisted of named locations of the OOH reports. These named locations were entered into Google Maps and the coordinates gained from this were used to create maps using QGIS. In Case Study 2's map, the species' NGR according to the IUCN Red List assessments were included for comparison. Using Microsoft Excel, Pearsons Correlation Coefficient was conducted for both case studies to determine whether OOH animal reports were increasing over time.

3. Results

3.1. Questionnaire

3.1.1. Response Locations and the Term 'OOH'

Questionnaire responses were received from six different continents: Africa, North America, South America, Europe, Asia, and Australia (Oceania) (Figure 1). The continents of Europe and North America have the most responses at 20 and 16 respectively.

Prior to receiving the questionnaire, 70% (n = 44) had heard of the term OOH and 30% (n = 19) had not. Of these respondents, 35 had heard only of the term OOH; however, across the remaining respondents, 14 alternative terminologies were recorded. The alternative terminologies and the number of times each was recorded are: vagrant (n = 7), extralimital (n = 4), out of range (n = 2), out of its environment (n = 1), displaced (n = 1), lost (n = 1), misadventure (n = 1), pioneer (n = 1), out of its distribution areas (n = 1), wandering (n = 1), exploring (n = 1), exotic (n = 1), alien/invasive (n = 1), and non-native (n = 1).

3.1.2. Who Is Witnessing OOH Species

Across the 63 questionnaire respondents, seven main categories of company/organisation were identified. Research and conservation non-governmental organisation (NGO) was the most common occupation type with 40% (n = 25) of all respondents falling within this category. The six other categories are as follows: academic staff member (n = 11), stranding

network including veterinarians and rehabilitation centres (n = 8), government organisation (n = 7), boat tour company (n = 6), museum (n = 4), and consultancy (n = 2).

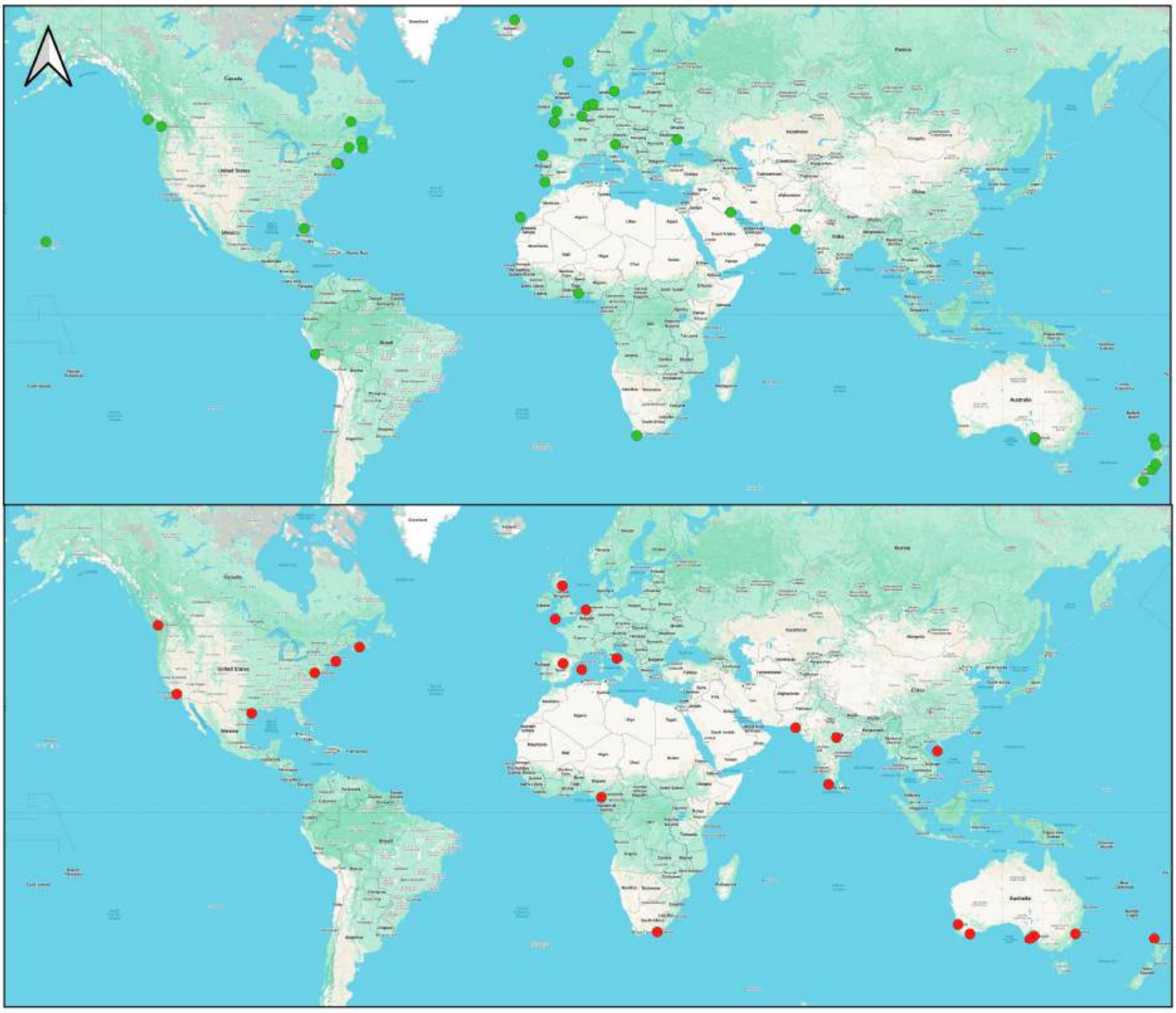

Figure 1. The locations of questionnaire respondents, and if they are seeing new/unusual species in their location. ● = Responses that replies 'Yes' to seeing new/unusual species in their location. ● = Responses that replied 'No' to seeing new/unusual species in their location.

When participants were asked if they were seeing new or unusual species in their region, 60% (n = 38) responded 'Yes' and 40% (n = 25) 'No'. Locations of these answers are shown in Figure 1, which demonstrates both answers have a similar geographic spread. Additionally, responses from participants mostly showed no clear trend between occupation and if they believe new species have been recorded in their location. However, 68% (n = 17) of participants belonging to a research and conservation NGO responded 'Yes' to seeing new species in their region.

From the participants that responded 'Yes', 32% (n = 12) strongly agreed and 45% (n = 17) agreed instances of rare species are increasing in recent years (Figure 2). Furthermore, 29% (n = 11) strongly agreed and 26% (n = 10) agreed that these instances of rare species in their region are evidence of distributional change (Figure 2). Only one person disagreed with the latter. From these same participants, 65% (n = 24) believe the term OOH

adequately describes what they are witnessing; however, 35% (n = 13) disagreed, with three suggesting what they are witnessing may be more akin to a distribution shift.

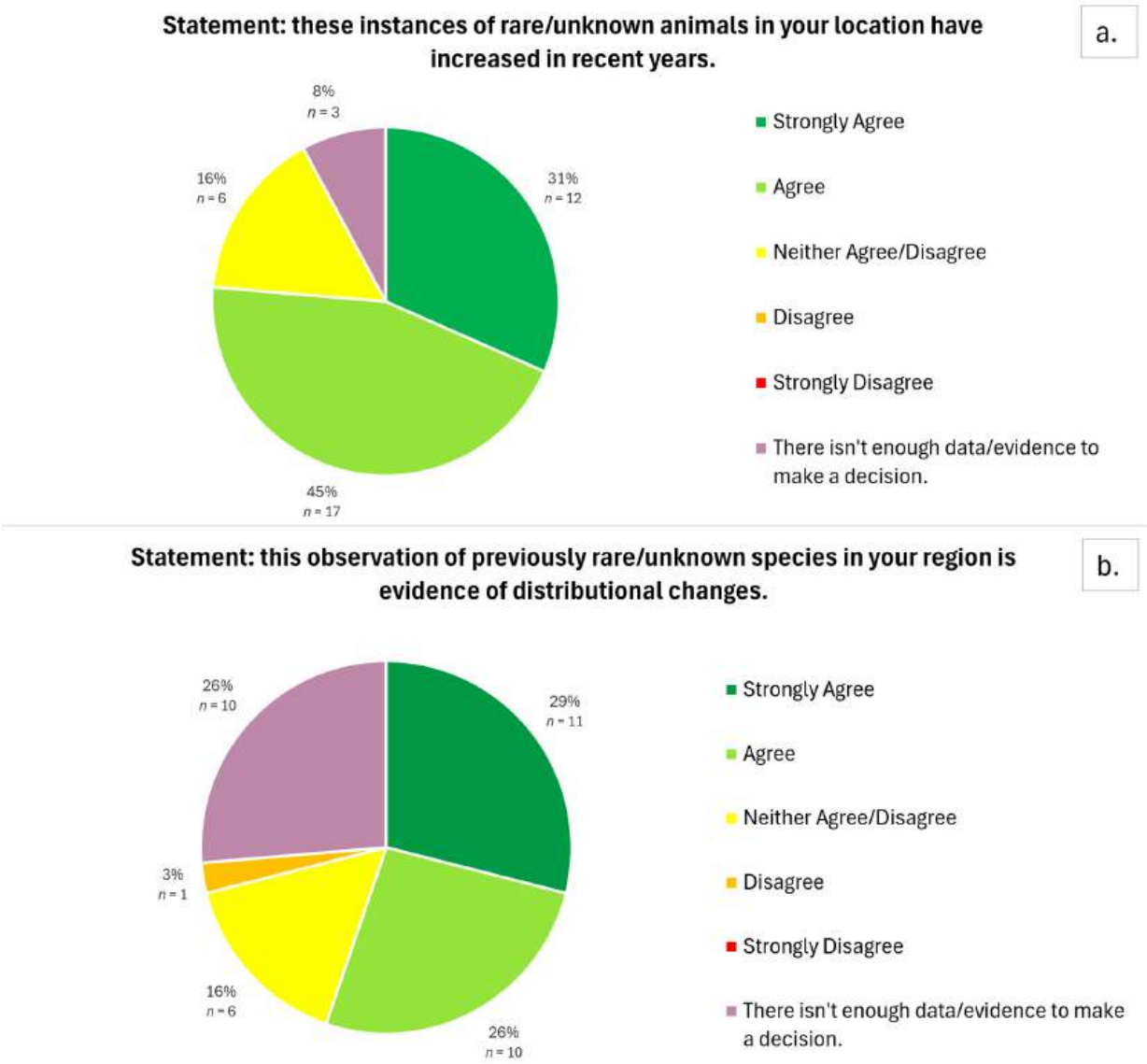

Figure 2. To what degree participants agreed with two statements: (**a**) instances of rare/unknown animals in your location have increased in recent years, (**b**) this observation of previously rare/unknown species in your region is evidence of distributional changes.

3.1.3. Reported OOH Species

A summary of the OOH events reported within the questionnaire is displayed in Table A1. Thirty-five different species were reported: 24 cetaceans and 11 pinnipeds. Of the 35 species, 22 are considered OOH when compared to the IUCN maps, 12 are not, and one had instances of both. Each species reported in Table A1 follows the same movement direction away from their NGR. On a scale of 1–10, 65% (n = 21) of participants reported the OOH animals they encountered were in good health to some degree (>5 on the scale), similarly, 60% (n = 20) reported good body condition (>5 on the scale). Health and body condition were reported to be assessed through visual assessments and post-mortem examinations. Four of the species reported are classed as endangered or critically endangered. Of these four species, three are classified as endangered: Australian Sea Lion (*Neophoca cinerea*), Galápagos fur seal (*Arctocephalus galapagoensis*), Hooded Seal (*Cystophora*

cristata) global population assessment. The remaining species, the North Atlantic Right whale (*Eubalaena glacialis*), is classified as critically endangered (Table A1).

3.1.4. Factors Driving OOH Events

Which factors participants believe may be causing these OOH events and how many times each factor was mentioned can be seen in Figure 3. Responses were summarised into 12 main factors, and the two most mentioned were changes in ocean water temperatures and changes in prey distribution/abundance. These two factors were mentioned a total of 51 times (60% of all factors), at 25 and 26 respectively. Additionally, outside of the question directly addressing factors, through other open-ended questions, multiple participants suggested the population of some species are currently increasing.

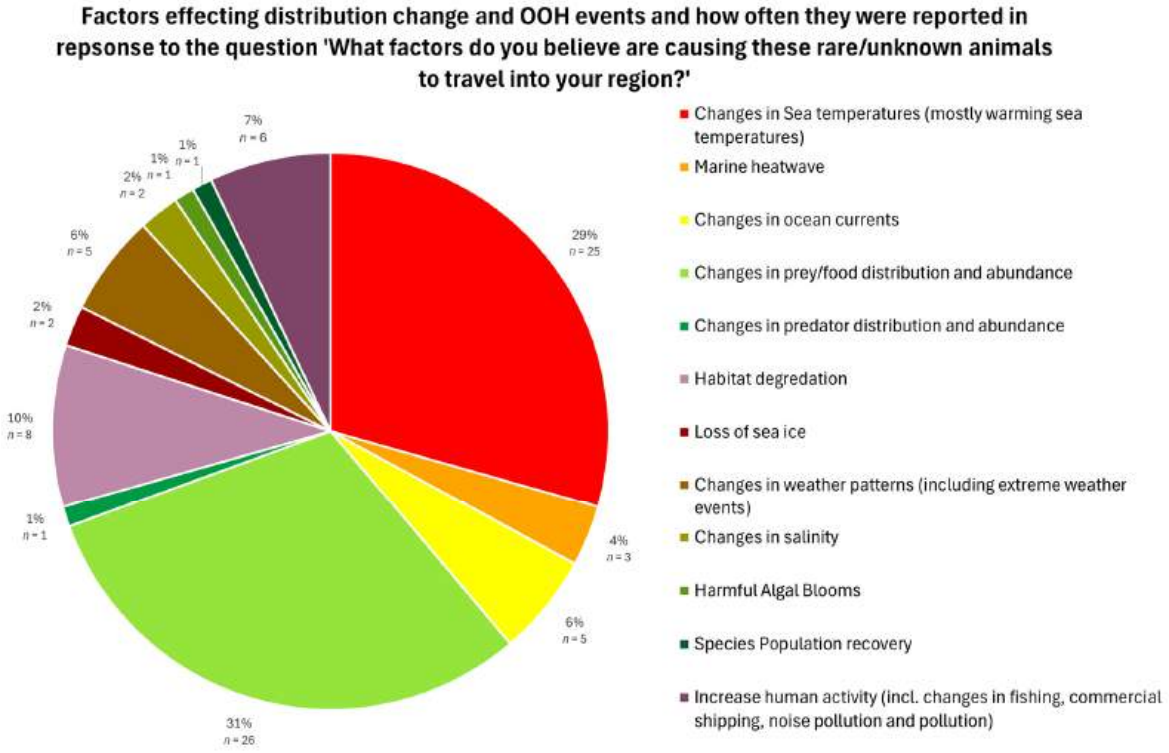

Figure 3. Which factors participants believe are affecting OOH events and how often each factor was reported.

3.1.5. Preparedness to Respond to OOH Marine Mammals

Out of the 65 participants, 54% (n = 34) had previously been involved in responding to an OOH animal, and out of this, 69% (n = 22) believed their response was successful and 31% (n = 10) did not. In total, 40% (n = 25) believed their local authorities and rescue centres are prepared to some degree to adequately respond to OOH marine mammals, 46% (n = 29) believed they are unprepared, and 14% (n = 9) had a neutral opinion (Figure 4). The main factors affecting this preparedness level can be seen in Table 1.

Table 1. What participants believe affects the preparedness of OOH responses.

Key Reasons for Being Unprepared	Number of Times Mentioned
Lack of rescue and rehab facilities.	11
Rescue/stranding teams have little to no support from local authorities and government.	7
Trying to train/prepare but there is poor funding for rescue teams.	6
Emergency networks have no clear plan, or ethical response, on how to respond.	5
There is a struggle responding to larger cetaceans and rare cases.	5

Table 1. *Cont.*

Key Reasons for Being Unprepared	Number of Times Mentioned
Focus is on native species and not on OOH species (OOH not given protection/priority).	4
There are no protection measures in place (e.g., nothing in place to reduce boat strikes).	3
Bureaucracy, rules and regulations slow down response to marine mammals.	1
Lack of data available/large data gap in species distributions.	1
The presence/distribution shift in these OOH/rare species was not predicted.	1
Key Reasons for Being Prepared	**Number of Times Mentioned**
Good experience dealing with OOH animals.	8
Strong collaboration between local law enforcement, lifeguards, rescue teams, and government.	8
Large stranding and response network across the region.	5
Good collaboration/reports from public (public are aware and educated).	4
Good funding/good resources.	3
Clear plan with how to deal with OOH animals and how to deal with public.	1

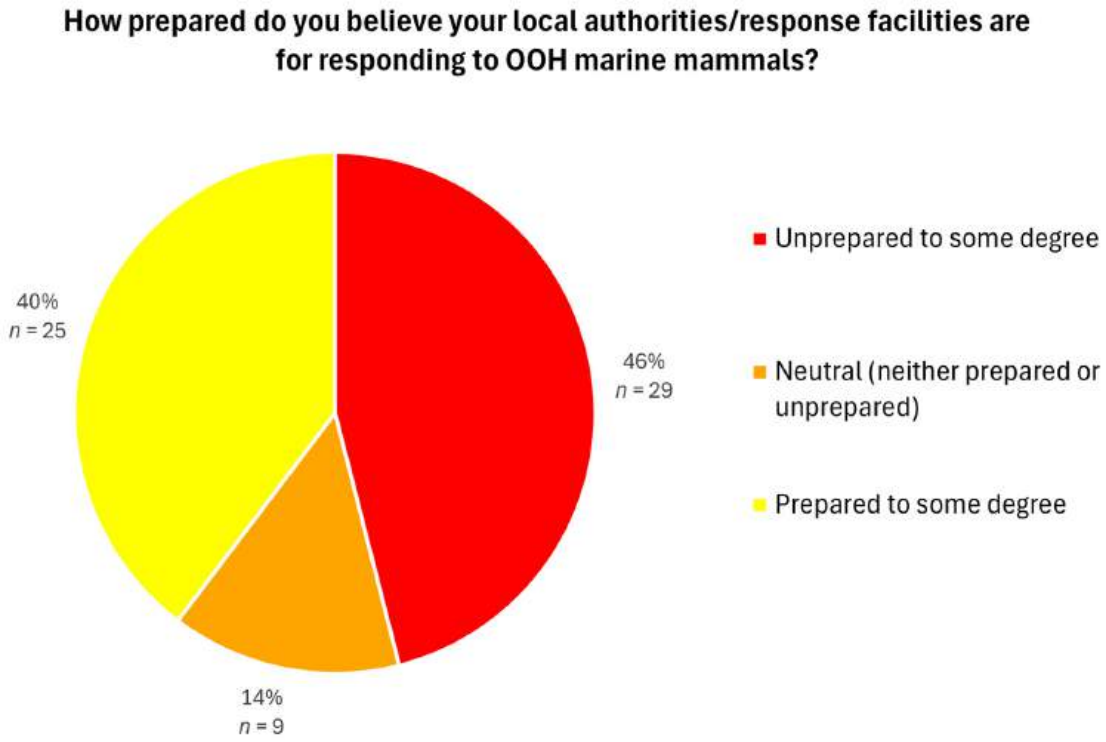

Figure 4. How prepared participants believe their local authorities and rescue centres are to responding to OOH animals.

3.2. Case Study 1

3.2.1. BDMLR UK OOH Marine Mammal Records 2019–2025

Of the 18 species reported in the BDMLR data, four species are geographically OOH and the other 14 species are OOH due to the unsuitable location they were recorded in (Figure 5). Of these 18 species, 15 are cetaceans and three are pinnipeds. The River Thames, Forth, and Severn, as well as their estuaries, are key locations where native species have been recorded as OOH (Figure 5). In 2021, a minke whale (*Balaenoptera acutorostrata*) was recorded in Teddington Lock, London, and is the furthest inland record from BDMLR.

A Pearsons Correlation Coefficient test strongly suggests there is a statistically significant strong positive correlation between the number of OOH marine mammal instances and the year, with an r value of 0.936 and p value of 0.00188 (below the significance level of 0.05).

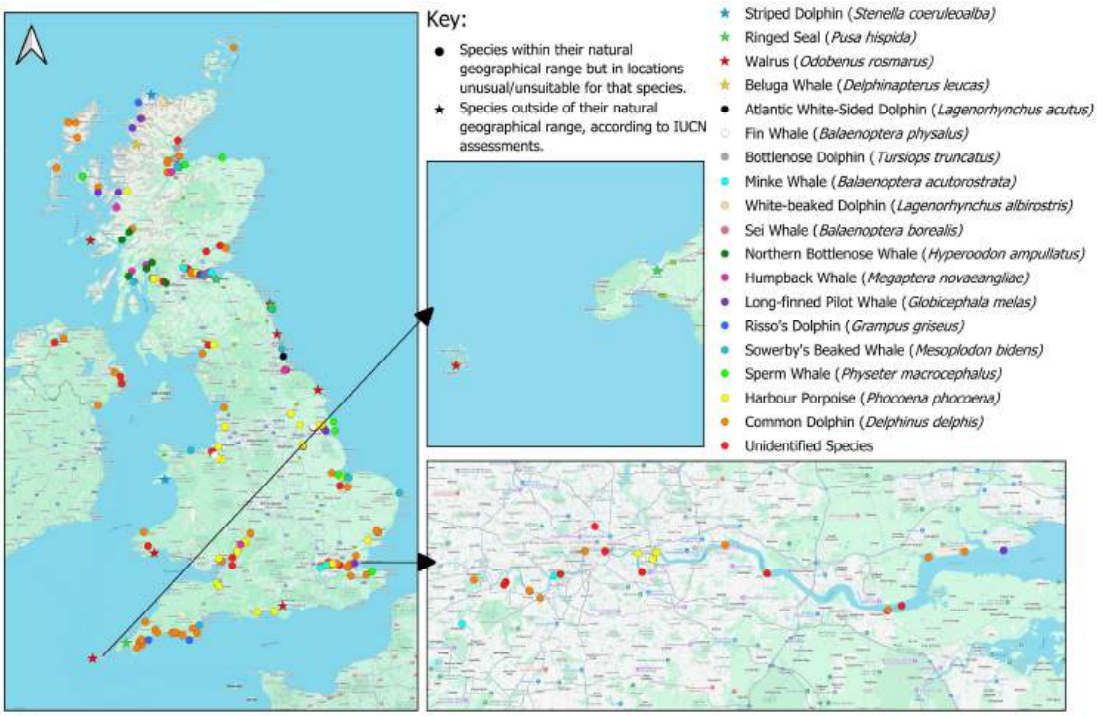

Figure 5. Case study one data containing the locations of all OOH cetaceans and pinnipeds within the UK reported to the BDMLR hotline between the years 2019 and 2025 [17,18,20–37].

3.2.2. Meeting Summary

The following points were gleaned from the semi-structured discussion with BDMLR:

- Instances of OOH marine mammals may be increasing in their area.
- Driving factors include habitat loss and loss of prey availability. Additionally, the populations of some species are increasing, such as humpback whales (*Megaptera novaeangliae*).
- Non-native species clearly fit into the term OOH, e.g., ringed seals (*Pusa hispida*). However, the definition extends to native species, e.g., common dolphin (*Delphinus delphis*), which are OOH when in unsuitable environments (e.g., estuaries and rivers) that can cause health complications.
- OOH responses are inconsistent, and responding to larger species, e.g., walrus (*Odobenus rosmarus*), can be challenging to maintain the safety of the animal and the public.

3.3. Case Study Two

3.3.1. ORCA Peru Pinniped OOH Records

Figure six displays records of three OOH pinniped species along the Peruvian coastline in relation to their NGR. Between 2000 and 2025, 25 Galápagos fur seals (*Arctocephalus galapagoensis*), six Southern elephant seals (*Mirounga leonina*), and two Antarctic fur seals (*Arctocephalus gazella*) were recorded in Peru, outside of their NGR. One species, the Juan Fernández fur seal (*Arctocephalus philippii*), was not included within Figure 6 as their NGR covers the south of Peru, and only one of the two recorded sightings would be considered OOH according to the IUCN [38]. The OOH report from this species was sighted approximately 300 km north of its NGR while the non-OOH report was located the same 300 km inside the species' NGR. Of the 35 records across the four species, 19 stranded/died due to human causes and 16 of these were due to human actions. The majority of these actions concerned fisherman protecting their catch.

The Pearsons Correlation Coefficient test suggests a weak positive correlation between the sightings of OOH Galápagos fur seals and the years of the study ($r = 0.115$ and $p = 0.575$). This is not significant as the p value is above 0.05.

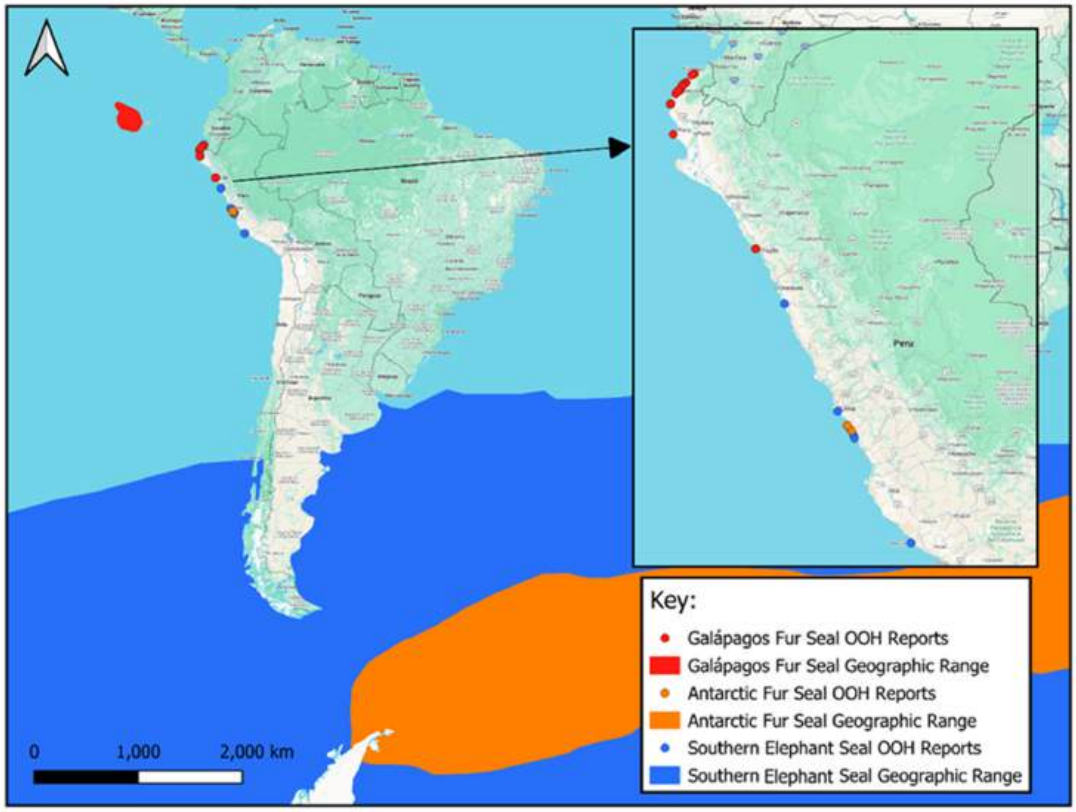

Figure 6. Case study two data displaying OOH reports of Galápagos fur seals, Antarctic fur seals, and Southern elephant seals in Peru compared to their natural geographic range according to the IUCN Red List assessments [39–41].

3.3.2. Meeting Summary

The following points were gleaned from the semi-structured discussion with ORCA:

- Elephant seals and Antarctic fur seals are travelling north of their NGR to Peru and ultimately stranding or are unable to find food.
- OOH events appear to be strongly linked to changes in prey distribution and ocean temperatures.
- OOH Galápagos fur seals are probably establishing residency on a Peruvian Island with similar environmental conditions to the Galápagos Islands, due to a warm water 'bridge' created during El Niño events.
- Galápagos fur seals (an endangered species) have begun to breed on a Peruvian island and are now thought to be on their 3rd generation.
- Southward movement of the Galápagos fur seals is dependent on warming ocean temperatures, and in cold water events the new residents move back north temporarily.
- Suggestions that the new resident colony could be an isolated population of the South American fur seal (*Arctocephalus australis*) have been disproved. Samples from the new colony, including fur, blood and skin samples, as well as behavioural assessments have confirmed the new colony to be Galápagos fur seals.

4. Discussion

4.1. Questionnaire

4.1.1. OOH Terminology and Response Locations

The term OOH was reported as the prevailing terminology, despite being relatively new, suggesting the term is quickly being adopted by experts. However, terms such as 'vagrant' are still favoured by some and will have a larger presence in older published

literature. Most participants are witnessing new species in their region (Figure 1), and most of these participants believe 'OOH' correctly describes what they are witnessing. This demonstrates that OOH marine mammals are a widespread global phenomenon. This further supports the notion that CC is causing widespread change to marine environments, and OOH marine mammals may be a result of this [42]. Similarly, more than half of participants witnessing new species believe these OOH events have increased in recent years and may be evidence of distributional change. These increasing OOH events may represent the beginning of distribution shifts as an adaptation to CC [43].

4.1.2. Reported OOH Species

Responses to the questionnaire and data provided through both case studies identified a total of 44 different species reported to be affected by this phenomenon (35 via the questionnaire and nine additional species via the BDMLR case study). It was identified that 32 of the 94 known cetacean species, and 12 of the 37 known pinniped [44] species have been recorded as OOH in recent years. This confirms that at least 34% of all cetacean and pinniped species are currently affected by this phenomenon, demonstrating that this is affecting a wide range of species.

Most participants reported good health and body condition in the OOH species they encountered, suggesting health complications are not a leading cause of OOH events. Multiple OOH events reported in the questionnaire were the first sightings of that species in that region (Table A1). Despite this, some are within their NGR according to the IUCN. For example, the first recorded sighting of a Cuvier's beaked whale (*Ziphius cavirostris*) in Lakolk, Denmark, was recorded in 2020 (Table A1). Contrasting to the IUCN assessment, local experts are reporting this species as OOH suggesting that there is some disagreement about the NGR of this species and that local experts are not being consulted during range assessments [8,45]. To support this, Chen et al. (2023) comments the IUCN often overestimates NGR, especially at the limits of the range [46]. In addition to overestimation, multiple of the IUCN red list assessments used within this study are over 10 years old, suggesting that there is a need for these databases to be updated and reassessments to be conducted.

An Australian sea lion (*Neophoca cinerea*) was reported as OOH in Adelaide, Australia, in 2025 (Table A1). This species is within its natural range in this location, but this individual unusually travelled inland to a motorway [47,48]. No intervention was made due to the high human and animal safety risk, and unfortunately, the individual was later struck and killed by a car [47]. This is an example of an OOH individual experiencing poor welfare as well as compromising human safety [8].

Each individual from the same species travelled outside of their NGR in the same direction, e.g., each reported OOH Bryde's whale (*Balaenoptera edeni*) was north of its NGR (Table A1), suggesting each individual experienced the same environmental pressures. However, while this information provides important insights into possible trends, further research must be undertaken [16].

One participant reported an increase in OOH Southern elephant seals (*Mirounga leonina*) in New Zealand, alongside a decline in the sub-Antarctic breeding population, and suggested this population change may be related to warming SSTs and a change in prey availability (Table A1) [49]. If SSTs continue to warm, the New Zealand sub-Antarctic breeding population may continue to decrease and eventually cease [49]. It was also noted by the participant that this population decline echoes the population trend in rockhopper penguins (*Eudyptes chrysocome*) [49].

One participant reported the North Atlantic right whales (*Eubalaena glacialis*) in the Gulf of St. Lawrence, Canada, were once considered OOH but have now shifted their

distribution to this area. The participant reports that since the first sighting in 1994, sightings have been increasing and this species is now considered to be resident within the area, despite being considered as non-residents just over 30 years ago. The North Atlantic right whale is classified as critically endangered and has a decreasing population trend [50]. The population size, life-expectancy, and reproductive success of this species have all decreased due to human pressures, such as vessel strikes [4]. Additionally, North Atlantic right whales are amongst the marine species most vulnerable to CC [4]. Therefore, this observed distribution change may pose further challenges to the species' survival and should be factored into conservation actions.

Notably, the findings of this study centre heavily around pinnipeds and cetaceans and little information was received about other groups. No information was received about polar bears (*Ursus maritimus*), and limited information was received about manatees and otters. One participant reported a possible increase in West Indian manatee (*Trichechus manatus*) sightings within the Gulf of Mexico, USA, which may be due to increased public engagement with reporting these sightings. The participant further explains that this species is well within their NGR, but individuals occasionally become OOH and require intervention when they fail to move to warmer waters in the winter months. The second participant reported more sightings of manatees closer to high human and boat activity, as well as more manatee entanglements, leading to concerns about the wellbeing of the individuals and the sea grass meadows they rely on.

4.1.3. Factors Driving OOH Events

Of the 12 reported factors, 10 are directly related to climate change, suggesting that CC is considered the leading driver of OOH events (Figure 3). Of these, changing SST and prey distributions were the two leading factors. These two factors often coexist and influence marine mammal distributions [5]. As SST increases, prey distributions change and marine mammals move into new locations to follow their prey, suggesting these OOH movements may be evidence of adaptation to CC [5,8,9]

Increased human activity was also highlighted as a potential factor, and while this is not directly caused by CC, changes such as decreased sea ice allow increased human activities to occur in arctic regions, such as shipping, tourism and resource extraction [51–53]. This increases the risk of ship strike and entanglement as well as degrading habitat [8,51].

One participant, located in New Zealand, reported increased humpback whale strandings in their region and suggests this might be related to the increasing population in East Australian waters. The South Pacific humpback whale (*Megaptera novaeangliae*) population has been steadily recovering since the moratorium on commercial whaling was implemented by the International Whaling Commission [54]. This increase in population helps explain the increased sightings of this species inside and outside of its NGR [8].

4.1.4. Preparedness to Respond to OOH Events

There was no clear consensus as to how prepared participants believe their local authorities and rescue centres are regarding OOH responses (Figure 4). Participants reported a range of variables contributing to the level of preparedness (Table 1). The amount of funding allocated to wildlife rescue organisations was identified as a key variable as it directly impacts the availability of rescue facilities and training opportunities [55]. There is a strong link between the regional public perceptions of marine mammals and available funding [56]. This highlights the importance of boosting public awareness and education surrounding OOH marine mammals.

Furthermore, increased research will deepen the understanding of possible movement patterns, which can be used to advise conservation plans [57]. A study by Chandelier and

Kiszka (2026) highlights the role climate projections and distribution models may have in predicting these range expansions and shifts. These predictions can be used to help keep management plans up to date, as well as adapt a more 'dynamic' approach where conservation plans adjust with species range shifts [58].

4.2. Case Study One

The Pearson's Correlation Coefficient results suggest that over time the number of OOH marine mammals around the UK is increasing. Between the years 2019–2025, 10 instances of OOH arctic pinnipeds were recorded in the UK (Figure 5). Recorded instances of arctic pinnipeds in the UK date back to the early 1900s, with one of the earliest recordings being an OOH harp seal (Pagophilus groenlandicus) sighted in Teignmouth, Devon, in 1902 [59]. However, recordings have increased substantially over the years, with 50% of recorded sightings in the southwest of England, since 1900, occurring in the last 10 years [59]. While it is unclear precisely what causes these OOH pinnipeds, habitat degradation and environmental changes are a likely cause [9]. Figure 7 displays two instances of OOH pinnipeds in the southwest UK. These findings again support the link between OOH events and CC.

Figure 7. (**a**) A walrus sighted in the Isles of Scilly, UK (Photographed by Dan Jarvis BDMLR). (**b**) A juvenile hooded seal rescued in St. Ives, UK (Photographed by Dan Jarvis BDMLR).

Many marine species native to the UK were recorded in locations unsuitable for their survival, e.g., within freshwater environments (Figure 5). For example, eight common dolphins were recorded within the Thames River and Estuary. As discussed in the BDMLR meeting, dolphin species often experience poor welfare and health complications in freshwater environments and often require intervention from rescue teams [60]. Health complications can arise from low salinity conditions, and an increased risk of ship strikes [8,60]. A juvenile minke whale sighted in the Thames River in 2021 (Figure 5) also experienced health complications. This individual travelled as far inland as Teddington Lock, where it ultimately became distressed and was euthanised by local veterinarians as its health declined [61].

4.3. Case Study Two

Dueñas et al. (2021) suggests marine mammals in the Galápagos islands are negatively impacted by the increasing frequency of El Niño-Southern Oscillations [62]. Additionally, Páez-Rosas et al. (2017) predicts increasing SST and warm water events will cause an increase in OOH Galápagos fur seals, and possibly an expansion of their range [63]. Both studies support the findings of this case study and provide further evidence that increasing SSTs and El Niño events are causing the OOH Galápagos fur seal events and the new resident colony in Peru [64]. As the Galápagos fur seal is classified as endangered, this distribution change should be considered within conservation plans for the species [39].

The six OOH Southern elephant seals recorded far north of their NGR may be driven by environmental pressures caused by CC, and by the possibly increasing Atlantic population [65]. Environmental factors such as El Niño events and increased SST may be causing these OOH movements by changing the distribution of the elephant seals' prey [65]. In addition to frequent El Niño events, there is evidence of a relationship between La Niña events and increased occurrence of stranded OOH pinnipeds in Peru [64]. These La Nina events may create a cold water 'bridge' allowing OOH species, such as the Southern elephant seal and Antarctic fur seal, to travel northwards of their natural range [64].

The high level of deaths caused by humans, specifically human aggression, shows there is a high risk of human–wildlife conflict within this region. It was identified during a structured interview with ORCA that a large portion of this conflict is the result of a misunderstanding amongst fisherman who initially mistook the Galápagos fur seals for sea lions. Fishermen in Peru often feel that sea lions pose a threat to their livelihood through the competition for fish populations. A study by Davis et al. (2021) discovered that 69% of South American fisherman state that sea lions are often killed in order to defend a catch [66]. However, through increased education around the Galápagos fur seals' presence in Peru, human-caused deaths of this species have begun a downwards trend. Additionally, human-related deaths may also be caused by boat collisions and entanglements. This identifies a need for human–wildlife conflict mitigation training within rescue teams as well as public education on OOH marine mammals, to further reduce the risk of harm to the animal and the public [8]. This also highlights the need for a standardised and potentially international protocol for responding to OOH marine mammals [64].

4.4. Limitations

While this study provides valuable insight into the perceived relationships between CC and marine mammal distributions, the limitations of this study must be acknowledged. Participants were informed the study completion time was approximately 30–45 min and additional time may be needed to gather information. It is possible that this was an intimidating length of time and may have reduced the overall number of responses received. Another limitation of the study is that the term 'recent years' was not clearly

defined and resulted in a variation in what participants considered 'recent'. Additionally, the experience level of participants was not formally assessed.

Lastly, using the IUCN red list assessments as a primary source of species NGR is an imperfect method. While the IUCN red list assessments provided an accessible and standardised method to compare the NGR of multiple species on a global scale, it must be noted that numerous assessments were more than a decade old and may contain outdated information.

5. Conclusions

The majority of respondents, located across the world, indicated they are seeing an increase in OOH species. Forty-four different species were reported as OOH, equating to 34% of all known cetacean and pinniped species. This supports the notion that this phenomenon is affecting a wide range of species on a global scale. There is strong evidence that these OOH events are increasing and may be indicators of distribution shifts, supported by multiple OOH species establishing residency in new locations. Each OOH individual from the same species travelled outside of their NGR in the same direction (e.g., North or South), suggesting possible patterns in OOH movements.

Multiple instances of OOH individuals experiencing poor welfare were identified, often due to unsuitable environments, especially marine species travelling far inland in freshwater environments. CC was identified as the likely leading driver for this phenomenon mainly mediated via sea water temperature and prey distribution changes. Additionally, four of the reported OOH species are classified as either endangered or critically endangered. The Galápagos fur seal (endangered) and the North Atlantic right whale (critically endangered) have made a range shift. This information should be used to advise conservation plans.

Responses to OOH marine mammals were reported to be inconsistent and highly dependent on available funding, facilities and training opportunities. Hence, human–wildlife conflict mitigation training should be provided to all response teams. It was also determined that respondents did not always agree with the IUCN NGR maps which suggests some marine mammal ranges are not fully understood, and this therefore requires further investigation. This also suggests that local experts are not being consulted during these assessments and this should be considered in future assessments. Additionally, further research should also be conducted on possible movement trends exhibited by OOH marine mammals, which can further be used to predict where OOH individuals are likely to occur.

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Data Availability Statement: The raw data supporting the conclusions of this article will be made available by the authors on request.

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Abbreviations

The following abbreviations are used in this manuscript:

CC	Climate change
SST	Sea surface temperatures
BDMLR	British Divers Marine Life Rescue
ORCA	Organization for Research and Conservation of Aquatic Animals
OOH	Out of habitat
IUCN	International Union for Conservation of Nature
NGR	Natural geographic range
NGO	Non-governmental organisation

Appendix A

Table A1. OOH records reported in the questionnaire, evaluated against the IUCN Red List Assessments (Yes = OOH according to IUCN, No = not OOH according to IUCN, NT = near threatened, DD = data deficient, LC = least concern, VU = vulnerable, EN = endangered, CR = critically endangered).

OOH Marine Mammal Events Reported through the Questionnaire				*Data from IUCN Red List Assessments and other Relevant Sources Substantiating or Negating Questionnaire Responses*			*Information from the Questionnaire and Additional Sources*
Species, IUCN Status, and Relevant Citations	**Date of Sighting (s) and Record Type**	**Number of Individuals Sighted**	**Recorded Sighting Location**	**OOH or not According to IUCN Assessment Data**	**Closest Natural Geographical Range (IUCN Assessment Data)**	**Sighting Location in Relation to NGR and the Estimated Distance Outside This (km)**	**Additional Notes**
Cetaceans							
Beluga Whale (*Delphinapterus leucas*) LC-Global VU-Europe [22,67]	2010 Sighting	2	Sept-Iles and Havre St-Pierre, Canada, North America	Yes	River of St Lawrence, Canada, North America	South-East (250 km)	Far South from main natural range, but only just east of separate recorded habitat.
	2022 and 2023 Sighting	4	Indian Harbour, Nova Scotia, Canada, North America	Yes	River of St Lawrence, Canada, North America	South (600 km)	One individual sighted in 2022 then same individual in 2023 with 3 others.
	2025	1	Ullapool, UK, Europe	Yes	Svalbard	South (2000 km)	
	2018	1	River Thames, UK, Europe	Yes	Svalbard	South (2500 km)	
Bowhead Whale (*Balaena mysticetus*) LC [68]	2017 Sighting	1	Belgium, Europe	Yes	North Coast of Iceland, Greenland Sea	South (2000 km)	
	2015 Sighting	1	Isles of Scilly, Cornwall, UK, Europe	Yes	North Coast of Iceland, Greenland Sea	South (1900 km)	
	2016 Sighting	1	Mounts Bay, Penzance, Cornwall, UK, Europe	Yes	North Coast of Iceland, Greenland Sea	South (1900 km)	Juvenile individual.

Table A1. *Cont.*

OOH Marine Mammal Events Reported through the Questionnaire				*Data from IUCN Red List Assessments and other Relevant Sources Substantiating or Negating Questionnaire Responses*			*Information from the Questionnaire and Additional Sources*
Species, IUCN Status, and Relevant Citations	**Date of Sighting (s) and Record Type**	**Number of Individuals Sighted**	**Recorded Sighting Location**	**OOH or not According to IUCN Assessment Data**	**Closest Natural Geographical Range (IUCN Assessment Data)**	**Sighting Location in Relation to NGR and the Estimated Distance Outside This (km)**	**Additional Notes**
Bryde's Whale (*Balaenoptera edeni*) LC-Global VU-Europe [69–71]	2020 Sighting	1 (at least)	Coast of Mainland Portugal, Europe	Yes	Waters around Madeira	North (750 km)	First sighting ever was in 2020, but have been sightings every year since.
	2000 Sighting and Death	1	Isefjord Inlet, Denmark, Europe	Yes	Waters around Madeira	North (3000 km)	A few sightings of the individual acting erratic, then later died. First record ever in this region
	2025 Stranding and Death	1	Port McNeil, British Columbia, Canada, North America	Yes	Waters around California	North (1700 km)	First ever sighting. Deceased.
Common Dolphin (*Delphinus delphis*) LC [37]	2025		Tofino, Canada, North America	No			Not technically OOH but on the upper limit of their range.
Cuvier's (Goose) Beaked Whale (*Ziphius cavirostris*) LC [45,72]	2020 Deceased Stranding	1	Lakolk, Rømø, Denmark, Europe	No			First ever recording in this location, according to the participant.
Dwarf Sperm Whale (*Kogia sima*) LC-Global DD-Europe [73,74]	2012	1	Cornwall, UK, Europe	Yes	Portugal, Europe	North (1000 km)	
	2011 and 2014 Stranding and Sighting	2	Mounts Bay, Penzance, Cornwall, UK, Europe	Yes	Portugal, Europe	North (1000 km)	2011 individual stranded and was successfully refloated.

Table A1. *Cont.*

OOH Marine Mammal Events Reported through the Questionnaire				*Data from IUCN Red List Assessments and other Relevant Sources Substantiating or Negating Questionnaire Responses*			*Information from the Questionnaire and Additional Sources*
Species, IUCN Status, and Relevant Citations	**Date of Sighting (s) and Record Type**	**Number of Individuals Sighted**	**Recorded Sighting Location**	**OOH or not According to IUCN Assessment Data**	**Closest Natural Geographical Range (IUCN Assessment Data)**	**Sighting Location in Relation to NGR and the Estimated Distance Outside This (km)**	**Additional Notes**
Fin Whale (*Balaenoptera physalus*) VU-Global LC-Europe [24,25]	Last 10 Years Sighting	1	Wales, UK, Europe	No			
Gray Whale (*Eschrichtius robustus*) LC [75]	2023–2024	5	East of Vancouver Island, British Columbia, Canada, North America	No	West side of Vancouver Island, British Colombia, Canada, North America		Very rare to be the east side of the Island, not within migration route. Two sightings in Tsibass Lagoon.
Hourglass dolphin (*Lagenorhynchus cruciger*) LC [76]	Sightings	Multiple	Auckland, New Zealand, Oceania	Yes	South New Zealand, Oceania	North (900 km)	Increased sightings.
Indo-Pacific Beaked Whale (*Indopacetus pacificus*) LC [77]	2015 and 2017	2	Northern Arabian Sea	No			
Killer Whale (Orca) (*Orcinus orca*)			Kailua, Hawaii, USA	No			Almost global distribution.
DD [78]	2025 Sightings	Pod (multiple)	Florida Keys, USA, North America	No			Almost global distribution.

Table A1. *Cont.*

OOH Marine Mammal Events Reported through the Questionnaire				*Data from IUCN Red List Assessments and other Relevant Sources Substantiating or Negating Questionnaire Responses*			*Information from the Questionnaire and Additional Sources*
Species, IUCN Status, and Relevant Citations	**Date of Sighting (s) and Record Type**	**Number of Individuals Sighted**	**Recorded Sighting Location**	**OOH or not According to IUCN Assessment Data**	**Closest Natural Geographical Range (IUCN Assessment Data)**	**Sighting Location in Relation to NGR and the Estimated Distance Outside This (km)**	**Additional Notes**
Long-finned pilot whale (*Globicephala melas*) LC [32]	Sighting and Death	1	Mono Reserve, Benin, West Africa	Yes	Separate populations in the North and South Hemisphere	South (2600 km) or North (2400 km)	First ever record. Died a few days after discovery.
Melon headed whale (*Peponocephala electra*) LC [79]	Stranding	Multiple	New Zealand, Oceania	Yes	Fiji Water, Oceania	South (2000 km)	
Minke Whale (common) (*Balaenoptera acutorostrata*) LC [27]		Multiple	Wales, UK, Europe	No			Almost global distribution.
Narwhal (*Monodon monoceros*) LC-Global VU-Europe [80,81]	2016 Sighting and Stranding	1	Belgium, Europe	Yes	Greenland Sea	South (2200 km)	Spotted live in a river. Stranded later on.
North Atlantic Right whale (*Eubalaena glacialis*) CR [50]	1994	1	Gulf of St Lawrence, Canada, North America	No			First sighting, since then sightings have been increasing. Northwards movement.

Table A1. *Cont.*

OOH Marine Mammal Events Reported through the Questionnaire				*Data from IUCN Red List Assessments and other Relevant Sources Substantiating or Negating Questionnaire Responses*			*Information from the Questionnaire and Additional Sources*
Species, IUCN Status, and Relevant Citations	**Date of Sighting (s) and Record Type**	**Number of Individuals Sighted**	**Recorded Sighting Location**	**OOH or not According to IUCN Assessment Data**	**Closest Natural Geographical Range (IUCN Assessment Data)**	**Sighting Location in Relation to NGR and the Estimated Distance Outside This (km)**	**Additional Notes**
Pygmy Killer whale (*Feresa attenuata*) LC [82]	2010 and 2018 Strandings	1 (2010) Multiple (2018	North New Zealand, Oceania	Yes	Waters south of Fiji	South (2000 km)	Single individual stranded in 2010 (first sighting in NZ). Mass stranding in 2018.
Risso's Dolphin (*Grampus griseus*) LC [33]	2007 Deceased	1	Denmark, Europe	No			First sighting in 2007 since 1938.
Rough-toothed Dolphin (*Steno bredanensis*) LC [83]		Multiple	New Zealand, Oceania	Yes	Waters south of Fiji	South (2000 km)	Increasing sightings.
Sowerby's Beaked Whale (*Mesoplodon bidens*) LC [34]	Last 10 Years	1	Wales, UK, Europe	No			
Spectacled Porpoise (*Phocoena dioptrica*) LC [84]	2011	1	Coromandel, New Zealand, Oceania	Yes	South of New Zealand, Oceania	North (1500 km)	
Sperm Whale (*Physeter macrocephalus*) VU [35]	Least 10 years	Multiple	Multiple locations including Wales and North-East UK, Europe	No			
	2016	1	Cornwall, UK, Europe	No			Female.

Table A1. *Cont.*

OOH Marine Mammal Events Reported through the Questionnaire				*Data from IUCN Red List Assessments and other Relevant Sources Substantiating or Negating Questionnaire Responses*			*Information from the Questionnaire and Additional Sources*
Species, IUCN Status, and Relevant Citations	**Date of Sighting (s) and Record Type**	**Number of Individuals Sighted**	**Recorded Sighting Location**	**OOH or not According to IUCN Assessment Data**	**Closest Natural Geographical Range (IUCN Assessment Data)**	**Sighting Location in Relation to NGR and the Estimated Distance Outside This (km)**	**Additional Notes**
True's Beaked Whale (*Mesoplodon mirus*) LC [85]	2023 Stranding	1	Sept-Iles area (west Gulf of Saint Lawrence), Canada	Yes	South Gulf of Saint Lawrence	North (230 km)	
Pinnipeds							
Antarctic fur seal (*Arctocephalus gazella*) LC [40]	2019 Stranding	1	Galápagos Islands, Ecuador, South America	Yes	Southern Atlantic Ocean	North (7200 km)	
	2019 Stranding	1	San Antonio Beach, Peru, South America	Yes	Southern Atlantic Ocean	North (5800 km)	
	Sighting	Multiple	Coast of South Africa	Yes	Southern Atlantic Ocean	North (2300 km)	
Australian Sea Lion (*Neophoca cinerea*) EN [47,48]	2025 Sighting and Death	1	Near the North–South Motorway, Adelaide, Australia	Within Geographical range but too far inland for this species	Gulf St. Vincent, Adelaide	Too far inland	No response/rescue was given. Later died.
Elephant Seal (Southern) (*Mirounga leonina*) LC [41]	Sighting	Multiple	Coast of South Africa	Yes	Sub-Antarctic Region	North (700 km)	
	Sighting	Multiple	New Zealand, Oceania	Yes	Sub-Antarctic Region	North (600 km)	Decline in Sub-Antarctic breeding population and increase in OOH individuals in New Zealand.
	2021 and 2023 Stranding	6	Peru, South America	Yes	Sub-Antarctic Region	North (3500 km)	

Table A1. *Cont.*

OOH Marine Mammal Events Reported through the Questionnaire				*Data from IUCN Red List Assessments and other Relevant Sources Substantiating or Negating Questionnaire Responses*			*Information from the Questionnaire and Additional Sources*
Species, IUCN Status, and Relevant Citations	**Date of Sighting (s) and Record Type**	**Number of Individuals Sighted**	**Recorded Sighting Location**	**OOH or not According to IUCN Assessment Data**	**Closest Natural Geographical Range (IUCN Assessment Data)**	**Sighting Location in Relation to NGR and the Estimated Distance Outside This (km)**	**Additional Notes**
Galápagos fur seal (*Arctocephalus galapagoensis*) EN [39]	2006–2025 Strandings and Deaths	25	Peru, South America	Yes	Galápagos Islands, Ecuador	South-East (1800 km)	
Harp Seal (*Pagophilus groenlandicus*) NT [86]		Multiple	Netherlands, Europe	Yes	North Coast of Norway, Europe	South (1800 km)	
Hooded Seal (*Cystophora cristata*) EN-Global VU-Europe [87,88]		Multiple	Netherlands, Europe	Yes	West Coast of Norway, Europe	South (800 km)	
	2024	1	Cornwall, UK, Europe	Yes	Orkney, Scotland, UK, Europe	South (1100 km)	
Juan Fernández fur seal (*Arctocephalus philippii*) LC [38]	2018–2019 Stranding	2	Peru, South America	Yes for one, No for the other	South Peru	North (300 km)	
Leopard Seal (*Hydrurga leptonyx*) LC [89]		Multiple	New Zealand, Oceania	Yes	Sub-Antarctic Region	North (2300 km)	Increased sightings.
Ringed Seal (*Pusa hispida*) LC-Global VU-Europe [21,90]		Multiple	Netherlands, Europe	Yes	Gulf of Bothnia, Sweden and Finland, Europe	South (1300 km)	

Table A1. *Cont.*

OOH Marine Mammal Events Reported through the Questionnaire				*Data from IUCN Red List Assessments and other Relevant Sources Substantiating or Negating Questionnaire Responses*			*Information from the Questionnaire and Additional Sources*
Species, IUCN Status, and Relevant Citations	**Date of Sighting (s) and Record Type**	**Number of Individuals Sighted**	**Recorded Sighting Location**	**OOH or not According to IUCN Assessment Data**	**Closest Natural Geographical Range (IUCN Assessment Data)**	**Sighting Location in Relation to NGR and the Estimated Distance Outside This (km)**	**Additional Notes**
Ringed Seal (*Pusa hispida*) LC-Global VU-Europe [21,90]	2016–2025	Multiple (at least 3)	Devon, Cornwall, Shetland, Firth of Forth and Northumberland, UK, Europe	Yes	Gulf of Bothnia, Sweden and Finland, Europe	South (2000 km)	
Subantarctic fur seal (*Arctocephalus tropicalis*) LC [91]	2024	1	Glenelg, Australia, Oceania	Yes	Sub-Antarctic Region	North (1800 km)	
Walrus (*Odobenus rosmarus*) VU-Global NT-Europe [17,18]	2021 and 2022 Sighting	2	2021 in Den Helder and 2022 in Petten, Netherlands, Europe	Yes	East Greenland	South (2200 km)	Previously 1 Walrus is seen every 25–30 years but 2 were recorded in a short period, (participant suggests it could be the beginning of a trend, but could also be coincidence).
	2021–2023 Sighting	3	(2021) South Wales, Cornwall and Isles of Scilly; (2022) Northumberland and Shetland; (2023) Hampshire, Yorkshire and Northumberland and west Scotland, UK, Europe	Yes	East Greenland	South (2300 km)	

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