frontiers | Frontiers in Conservation Science

TYPE Original Research
PUBLISHED 02 April 2024
DOI 10.3389/fcosc.2024.1366064

OPEN ACCESS

EDITED BY
Jean Hugé,
Open University of the Netherlands,
Netherlands

REVIEWED BY
Timothy C. Haas,
University of Wisconsin–Milwaukee,
United States
Susan B. McRae,
East Carolina University, United States

*CORRESPONDENCE
Alice E. M. Walters
alice.walters@whales.org

RECEIVED 05 January 2024
ACCEPTED 11 March 2024
PUBLISHED 02 April 2024

CITATION
Hodgins NK, Steel EM, Dyke K, Walters AEM, Dolman SJ, Hall K, Neave-Webb E, Evans PGH, Bird C, Robinson KP, Marwood EM, Foubister R, Harrop H, Knight A and Munro K (2024) Using citizen science to better understand Risso's dolphin (*Grampus griseus*) presence in northeast Scotland and the Northern Isles.
Front. Conserv. Sci. 5:1366064.
doi: 10.3389/fcosc.2024.1366064

Using citizen science to better understand Risso's dolphin (*Grampus griseus*) presence in northeast Scotland and the Northern Isles

Nicola K. Hodgins[1,2], Emma M. Steel[1], Katie Dyke[1], Alice E. M. Walters[1]*, Sarah J. Dolman[3,4], Karen Hall[5], Emma Neave-Webb[6], Peter G. H. Evans[7], Colin Bird[7], Kevin P. Robinson[2,8], Eleanor M. Marwood[8], Robert Foubister[1], Hugh Harrop[9], Andy Knight[1] and Karen Munro[1]

[1]Whale and Dolphin Conservation, Fochabers, United Kingdom, [2]Centre for Ecology and Conservation, School of Biosciences, University of Exeter, Exeter, United Kingdom, [3]Environmental Investigation Agency, London, United Kingdom, [4]College of Medical, Veterinary and Life Sciences, University of Glasgow, Glasgow, United Kingdom, [5]NatureScot, Lerwick, United Kingdom, [6]Orkney Marine Mammal Research Initiative, The Old School, Evie, United Kingdom, [7]Sea Watch Foundation, Amlwch, United Kingdom, [8]Cetacean Rescue and Research Unit, Banff, United Kingdom, [9]Shetland Wildlife, Shetland, United Kingdom

There is no current population estimate for Risso's dolphin (*Grampus griseus*) in Scottish waters and their distribution in the northeast of Scotland and the Northern Isles is poorly documented. Using a combination of citizen science and historical sightings data, photographs of Risso's dolphins from northeast Scotland and the Northern Isles were gathered to gain an indication of the presence of the species in this region. A review of all available sighting records from as early as 1933 (n = 1,904 records), showed a historical presence of Risso's dolphins in the study locations, with a notable increase in sightings reports over time and with higher numbers of sightings reported from July-September. Collation of photographs (n = 1,884) taken by members of the public and researchers facilitated the establishment of two photo-identification catalogues for Northeast Scotland and Orkney (n = 112 individuals) and for Shetland (n = 47 individuals) respectively. Mother/calf pairs were recorded between April and November. Repeated recaptures of identifiable animals throughout the study area provided the first evidence of inter/intra-annual site fidelity. The combined datasets demonstrate the potential importance of inshore coastal waters in northeast Scotland, Orkney, and Shetland as critical habitat for Risso's dolphins. Recommendations are made for ongoing monitoring studies to inform the protection of Risso's dolphins in Scottish waters.

KEYWORDS

Risso's dolphin, Scotland, Shetland, Orkney, photo-identification, citizen science, conservation, critical habitat

Introduction

The use of citizen science to advance scientific understanding and enhance public participation is increasingly recognised (Evans, 1976, 1980; Evans et al., 2003; Silvertown, 2009; Merenlender et al., 2016; Gutiérrez-Muñoz et al., 2021) and valued by governments, policy makers and the scientific community (Hecker et al., 2018). Local volunteers and wildlife enthusiasts can contribute valuable data to improve the understanding of spatial and temporal patterns in local cetacean populations. This is particularly true where sightings can be made close to the shore by well-trained individuals using suitable, standardised equipment (Scullion et al., 2021; Beck et al., 2014). Increasingly, high quality professional digital cameras are widely available to the general public and citizen scientists, facilitating the collection of and contribution to photo-identification catalogues relevant to research projects. Social media platforms are also expanding in their popularity and the number of people posting their photographs of cetaceans (and other wildlife) to various marine-focused interest groups is growing.

Field research typically focuses on common or frequently seen species, such as harbour porpoise (*Phocoena phocoena*) or bottlenose dolphins (*Tursiops truncatus*). There are far fewer studies on less frequently observed species, such as Risso's dolphin (*Grampus griseus*). However, Risso's dolphins are highly distinctive, displaying a tall, well-marked dorsal fin and individual differences that make them good subjects for mark recapture studies. Natural markings include distinctive nicks and notches in the dorsal fin, body scarring from intra-specific interactions, and injuries from fishing gears and vessels which do not re-pigment as readily as in other delphinids (Hartmann, 2018). Photo-identification is therefore appropriate for use as a research tool for Risso's dolphins (Atkinson et al., 1997; Hartmann et al., 2008; de Boer et al., 2013; Maglietta et al., 2018; Weir et al., 2019) to better understand the ecology of the species and identify potential threats (Hartmann et al., 2008; Urian et al., 2015; Weir et al., 2019).

Risso's dolphins (*Grampus griseus*) typically inhabit deep, offshore waters (from 200 to 1,000 metres in depth) concentrated along the upper continental slope or around steep shelf-edge areas (Hartmann, 2018). However, research has shown that Risso's dolphins can sometimes occur in shallower waters, namely those less than 200m in depth, around the northeast Atlantic shelf (Jefferson et al., 2013; Bloch et al., 2012) and mainly over slopes of 50 to 100 metres along the European continental shelf, although in several areas of the British Isles they regularly inhabit coastal waters of between 20 and 30 metres depth (Evans et al., 2003). Around the west coast of Scotland, the Northern Isles of Orkney and Shetland, and the northern Scottish mainland, Risso's dolphins have frequently been encountered in shallow waters less than 20 metres deep and in close proximity to the shore (Robinson et al., 2007; Evans et al., 2011; Weir et al., 2019; Orkney Marine Mammal Research Initiative (OMMRI), 2021; OMMRI, unpublished data[1]; OWIARC, unpublished data[2]; SWF, unpublished data[3]; WDC Shorewatch, unpublished data[4]).

Large-scale cetacean abundance surveys were carried out in European Atlantic waters during the summers of 1994, 2005, 2016 and 2022 (SCANS I, II, III & IV; Hammond et al., 2021; Gilles et al., 2023). There were insufficient Risso's dolphin sightings in 1994 and 2005 to allow for abundance estimates. In 2016 however, the survey estimated an abundance of 13,584 individuals in European shelf waters and 8,687 in UK waters (Hammond et al., 2021; IAMMWG, 2021) with the 2022 survey generating an abundance estimate of 13,854 animals for European shelf waters but no estimate for UK waters (Gilles et al., 2023). Whilst the species is considered widely distributed within Scottish waters, there is currently a lack of data to determine sub-populations and no separate regional abundance estimates have been made. Subsequently, in UK waters, all Risso's dolphins are encompassed within a single Management Unit (MU) (IAMMWG, 2023).

Although there is limited understanding of the population structure of Risso's dolphins in the northeast Atlantic, previous research indicates genetic differentiation between UK (N=18; of which 16 were Scottish samples) and Mediterranean populations (Gaspari et al., 2007). In addition, whilst Risso's dolphins are believed to be fragmented in their distribution within Scotland, there is some evidence for site fidelity by known individuals (Weir et al., 2019).

To date, detailed research into the presence and distribution of the species in Scotland has focused primarily on the west coast, specifically around the Outer Hebrides (Atkinson et al., 1999; Hodgins et al., 2014; Weir et al., 2019) and subsequently, documented sightings of Risso's dolphins are most common in northwest Scotland (Evans et al., 2003; WDC Shorewatch, unpublished data[4]) and the Outer Hebrides, specifically around the Isle of Lewis (Paxton et al., 2014; Weir et al., 2019) with the majority of sightings recorded during the summer and autumn months (Evans et al., 2003; Paxton et al., 2014; Hall et al., 2019; Weir et al., 2019). Seasonal dedicated boat-based surveys for Risso's dolphins have been undertaken off northeast Lewis since 2010 (Hodgins et al., 2014; Weir et al., 2019) and the area has hosted a dedicated WDC Shorewatch site since 2011, facilitating the land-based collection of data year-round. Through long-term data collection, Weir et al. (2019) have demonstrated the year-round occurrence of Risso's dolphins off Tiumpan Head in northeast Lewis. Risso's dolphins have been recorded in the North Sea (central & northern) for many decades both from strandings (Natural History Museum, 2018) and sightings (Evans, 1976, 1980; Evans et al., 2003; Paxton et al., 2014) but sightings nevertheless are generally uncommon except around Caithness,

1 Sightings data from: Orkney Marine Mammal Research Initiative. Supplied August 2022. https://ommri.org/. hello@ommri.org.

2 Sightings data from: Orkney Wildlife Information and Records Centre. Supplied August 2022. https://owiarc.orkneylibrary.org.uk/.

3 Sightings data from: Seawatch Foundation. Supplied August 2022. https://www.seawatchfoundation.org.uk/.

4 Sightings data from: Whale and Dolphin Conservation (WDC) Shorewatch Dataset. Supplied August 2022. https://whales.org/Shorewatch Shorewatch.data@whales.org.

Orkney (Orkney Marine Mammal Research Initiative (OMMRI), 2021; OMMRI, unpublished data[1]; OWIARC, unpublished data[2]; SWF, unpublished data[3]; WDC Shorewatch, unpublished data[4]) and Shetland (Hall et al., 2019; SWF, unpublished data[2]). In recent years, more frequent records from further south (central North Sea) have been recorded (Evans and Waggitt, 2020a). This increase in the number of sightings recorded may reflect a change in the way that dolphins are using some coastal areas but also may result from an increase in observer presence, effort and species identification confidence.

The northeast coastline of Scotland comprises the coasts of Sutherland, Caithness, Morayshire and north Aberdeenshire. Orkney is an archipelago of 68 islands and smaller skerries in the Northern Isles of Scotland, situated approximately 6.2 miles off the northeast tip of mainland Scotland (Porter et al., 2020). The bathymetry of these waters' ranges from depths of 10 to 50 m close inshore, with increasing depths (of up to 90 m) within the peripheral offshore areas. It comprises the deepwater channel of the Pentland Firth, Scapa Flow, the Atlantic Ocean and North Sea around the Orkney North Isles and Sula Skerry (Orkney Islands Council, 2020).

Shetland is a subarctic archipelago in the North Atlantic. The southern tip of mainland Shetland lies approximately 160 km from the northeast coast of mainland Scotland and approximately 135 km from mainland Orkney. As with Orkney, the islands separate the North Sea to the east, from the Atlantic Ocean to the west. Around Shetland, the bottom topography shelves steeply close inshore, with deep shelf edges of 150 to 250 m depth. Fair Isle is the southernmost island and lies 38 km south of mainland Shetland and 44 km from North Ronaldsay, Orkney's most northerly isle (Figure 1).

By undertaking two distinct analyses – (1) historical and current sightings data of Risso's dolphins were gathered from northeast Scotland and the Northern Isles of Orkney and Shetland to examine the presence of this species in the region; and (2) all suitable photographs of Risso's dolphin sighted in the region were collated to help create two regionally specific photo-ID catalogues – this paper seeks to demonstrate the power of collaborative citizen science to contribute to our understanding of Risso's dolphin in Scottish waters. In recognising the limitations of simply analysing reported sightings and *ad hoc* photographs taken by citizen scientists, targeted ongoing research is recommended to enable data gaps to be filled leading to our further understanding of the presence and habitat use of individual Risso's dolphins in Scottish waters.

FIGURE 1
Map of Scotland, showing the location of Orkney, Shetland, Sutherland, Caithness, Morayshire and Aberdeenshire.

Materials and methods

Combined sightings data

Sightings recorded by local researchers and organisations [Whale and Dolphin Conservation (WDC) Shorewatch, Sea Watch Foundation (SWF), Karen Hall (NatureScot), ORCA, Orkney Marine Mammal Research Initiative (OMMRI) and the Cetacean Research & Rescue Unit (CRRU)], members of the public, and trained citizen scientists were collated to provide an indication of the presence of Risso's dolphin in northeast Scotland. Most sightings were made from land, during both dedicated effort-based watches and casual records. Additionally, sightings made from platforms of opportunity (e.g., tour boats, ferries, fishing vessels and postal boats) and some sightings from photo-ID encounters were sent in by citizen scientists. In all cases, data used in this study were collated and verified by an experienced local data custodian prior to inclusion in the analysis.

To ensure there were no duplicates in the dataset, sightings with the same location, date, time, species and count details were removed (n=550). Sighting reports of dead animals were also removed (n=2). Each sighting was subsequently assessed for the presence or absence of calves and to confirm count data for adults and calves respectively. Sighting reports and count data were combined for both study locations to assess annual and monthly trends in the species presence across northeast Scotland, Orkney, and Shetland (final number of sightings used in this combined sightings data analysis n=1867).

Once cleaned and processed the combined sightings were catalogued in Microsoft Excel. Temporal analysis was applied to the sightings data of both adults and calves and location details analysed to document their presence within the study area. A frequency analysis was applied to sightings of adults and the proportion of sightings with calves calculated.

Photo-identification

Members of the public, local researchers and photographers have been sending images of Risso's dolphins to WDC since 2010 and Sea Watch has collected images opportunistically from around the same time. To complement these contributions, active engagement was undertaken with researchers, wildlife enthusiasts and photographers to acquire any historical and/or recent photographs of Risso's dolphin from the Moray Firth,

Pentland Firth, Orkney and Shetland. Callouts were further made through social media platforms (Twitter and Facebook) and through existing WDC science and Shorewatch networks. These long-established citizen science networks rely on, and benefit from, local involvement. The authors are sensitive to local community feelings and are determined to maintain and encourage local participation. Therefore, to provide a form of "ownership" to islanders and due to geographic distances, the region was separated into two different field sites with two resulting complementary and comparable photo-ID catalogues: (1) Northeast Scotland and Orkney, and (2) Shetland. However, for the purpose of this analysis, these data were combined, and specific regional results were only assessed where required.

Through this process, images dating from 2001 from a variety of cameras (from mobile phones to DSLR cameras) were received. Screenshots taken from UAV (unmanned aerial vehicle) footage was also received from Shetland.

Each photographic image submitted to this study was initially assessed for quality and clarity by one of the first three authors, in accordance with recognised protocols (Würsig and Jefferson, 1990; Urian et al., 2015). Poor quality photographs were omitted from the analyses. Images with no distinguishable markings were also excluded but were retained for potential matching opportunities in the future within both these and other Risso's dolphin photo-ID catalogues. Thereafter, all quality images were analysed by two separate assessors (as before, one of the first three authors) for natural markings such as nicks, scarring and dorsal fin shape. Body scars and wounds were also noted, including the presence of lesions or disease and potential anthropogenic injuries. Each individual displaying uniquely identifiable features was assigned a number and added to the relevant photo-ID catalogue based on the location of the sighting. Identification of individual dolphins and all recaptures were then verified by at least three of the co-authors.

Dolphins were categorised as mother-calf pairs if the calf was photographed swimming either in the echelon position or in close proximity to the same adult's mid-lateral flank and displayed foetal folds or was less than 50% of the size of the mother. Numbers of calves were verified if photographed at the surface together at the same time (minimum count) or associated with different mother pairings.

Each identifiable dolphin was added to the geographically relevant catalogue and given a unique identifier. Individuals first sighted in northeast Scotland and Orkney were given the acronym "NEO" followed by their number in the catalogue, e.g. NEO019, whilst individuals in Shetland were given the acronym "SH" followed by their number in the catalogue, e.g. SH016. The two catalogues were subsequently compared for matches/duplicates and an analysis undertaken.

Once processed, the photo-ID data were catalogued in Microsoft Excel, then tabulated by year and by month to produce two frequency distributions. The proportion of calves recorded was calculated. Location details were mapped. The data were subsequently analysed for frequency and distribution of recaptures, marking when the same individual was recorded/resighted again at a different time, date or in a different location. Recapture data were further analysed for individual associations, identifying individuals recaptured together on more than one occasion.

Results

Combined sightings data

Reports of Risso's dolphins from northeast Scotland, Orkney, and Shetland between 1933 and 2021 were collated. Each report of an individual or a group of Risso's dolphins was considered a "sighting"; a total of 1867 sightings were included in the analysis with 90% of these sightings (n=1,680) reported from 2001 onwards. There was inter-annual variation in the number of sightings

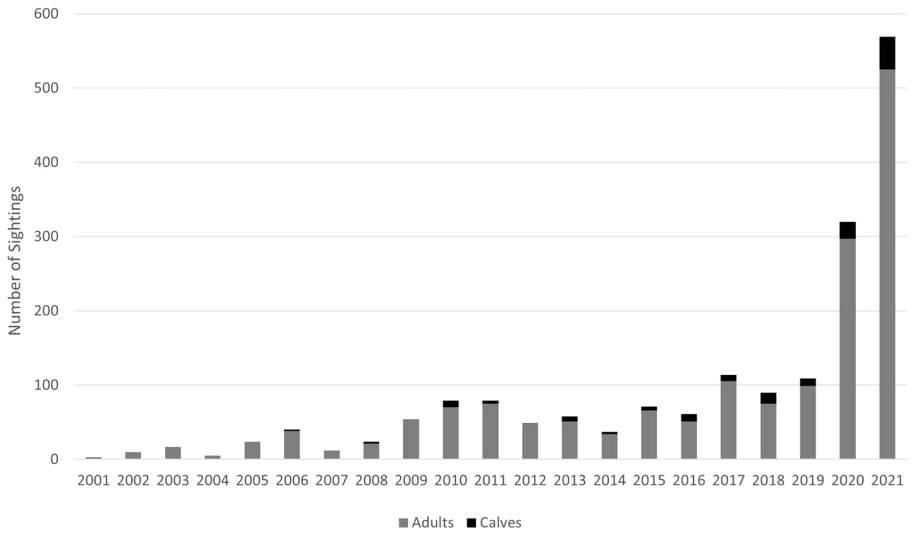

FIGURE 2
Annual sighting reports of Risso's dolphin throughout northeast Scotland, Orkney, and Shetland between 2001 and 2021 (n=1,680).

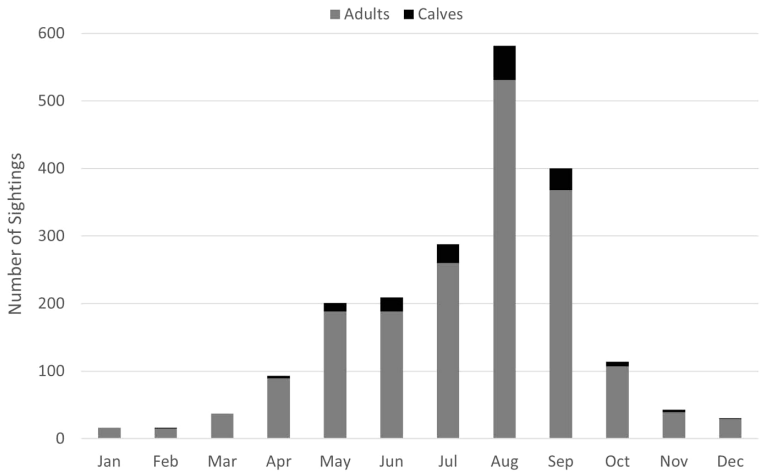

FIGURE 3
Monthly occurrence of Risso's dolphins throughout northeast Scotland, Orkney and Shetland between 1933 and 2021 (n=1,867).

reported but a clear increase over time (Figure 2). This upward trend in records started in 2009 with a rapid increase in 2020 and 2021.

Sightings data indicated the presence of Risso's dolphin in every month of the year, with the highest number of sightings in August (28%) and with 82% of all annual sightings occurring between May and September (Figure 3). Calves were recorded in 162 (9%) sightings overall. Calves were recorded in all months excluding January and March, with over 20 encounters with calves each month from June to September.

Combined sightings data suggests a year-round coastal presence of Risso's dolphins around northeast Scotland (the Pentland Firth and Caithness coastline), Orkney and Shetland. Fewer sightings were recorded along the south Caithness and Moray coasts, with only a limited number of sightings recorded along the Aberdeenshire coast and the southern Moray Firth (Figure 4).

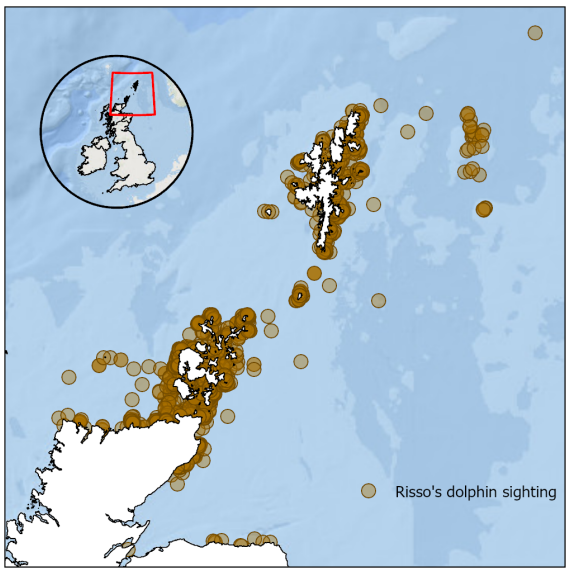

FIGURE 4
Map showing historical sightings of Risso's dolphin around northeast Scotland, Orkney and Shetland from 1933 to 2021 (n=1,867).

Photo-identification

A total of 1,884 images from 134 separate sightings between 2001 and August 2022, were received from 49 photographers. All images were assessed and collated into the forementioned two Photo ID catalogues: (1) The Northeast Scotland and Orkney Risso's Dolphin Photo ID Catalogue and the (2) Shetland Risso's Dolphin Photo ID catalogue (Whale and Dolphin Conservation (WDC), 2022).

Across the study locations, 156 individual dolphins displayed unique markings and were subsequently included in the photo-ID catalogues: 112 in northeast Scotland and Orkney and 47 in Shetland. Three individuals were initially captured in both catalogues. Catalogued individuals from northeast Scotland and Orkney were encountered in all months except January and February. Encounters were highest in May (n=27), June (n=29), with a significant peak in August (n=64), although dropping in July (n=6). Shetland catalogued individuals were sighted from March to October with peaks in April (n=10), July (n=11), August (n=13), and September (n=11). Data from northeast Scotland and Orkney were available between 2001 and 2021 with the highest number of images collected in 2021, accounting for 61 separate encounters of catalogued individuals. Of these encounters, 41 were individual dolphins that had not previously been catalogued, accounting for 37% of Risso's dolphins in the northeast Scotland and Orkney catalogue. Data from Shetland were available between 2006 and 2021, however, encounters were sporadic with most catalogued individuals photographed in 2019 and 2020.

Photographs of catalogued individuals are spread across the study area although higher numbers of high-quality images were contributed at locations near to where regularly contributing photographers lived and could access the coastal waters where sightings are made close to shore (Figure 5).

10.3389/fcosc.2024.1366064

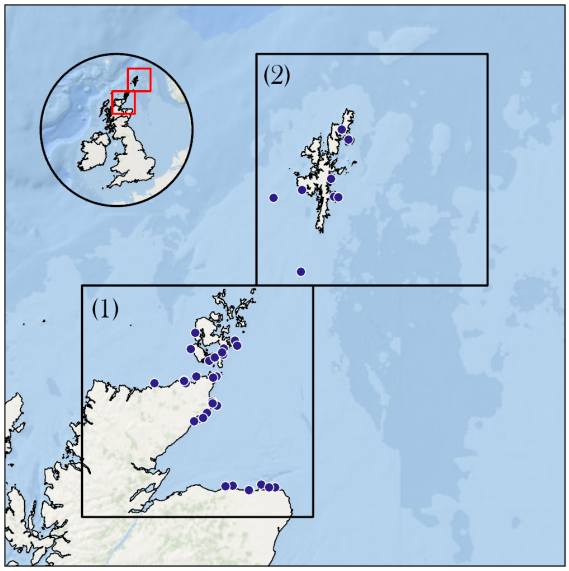

FIGURE 5
Map showing the geographical position of images used in this study and the location of field sites from which photo ID datasets were collated into catalogues: (1) Northeast Scotland and Orkney and (2) Shetland.

Calves were recorded within 32 photo-ID encounters: 24 within the northeast Scotland and Orkney region, and eight within the Shetland region. On 12 occasions, multiple calves were identified within a single sighting. From photo-ID encounters, calves were documented between April and December with no sightings in November and a peak in August. Mother/calf pairs were recorded from 21 locations: Holborn Head, Scrabster, Latheronwheel, Navidale, Swinney Hill, Thurso, Brough Bay, Strathy Point (Caithness and Sutherland), Fraserburgh, Findlater Castle, Rosemarkie (Moray Firth), Hoxa Head, Echnaloch Bay, Ness Point, Cantick Head (Orkney) and Noss, Fetlar, Sumburgh Head, Busta Voe, Mousa, Wester Sound, and Fair Isle (Shetland). The northeast Scotland and Orkney catalogue includes 12 mothers, and the Shetland catalogue includes 13 mothers. Two of these individuals were recorded in both catalogues (long distance recaptures), therefore 23 mothers are catalogued in total (14.7% of catalogued individuals). Calves were not included within the photo-ID catalogue due to the high degree of uncertainty around their recapture.

Individual recaptures

Out of all catalogued individuals (n=156), 42 (27%) were photographed on multiple occasions (recapture) from either a different location or different date/time.

A total of 13 individuals catalogued from northeast Scotland and Orkney were resighted in locations further than 100 km away from previous photo-ID encounters. Matches show distance travelled from the Aberdeenshire coast to Caithness and Sutherland (approx. 120 km), Aberdeenshire coast to Fair Isle (approx. 210 km), and Caithness to Shetland (approx. 200 km). This latter resighting involved two mothers, first photographed in a mother calf pod in Caithness in 2010 and again in 2014 off Sumburgh Head Lighthouse, Shetland. Individual NEO019 was recaptured five times between 2014 and 2020 along the Caithness coast (at Strathy Point, Holborn Head, Lybster and John O Groats), with both left and right sides of the dorsal fin photographed. NEO019 has very distinctive scarring allowing for easy re-identification, even from poorer quality pictures (Figure 6).

Individual NEO022 was recaptured four times between 2016 and 2020 along the Caithness coast at Strathy Point, Holborn Head, Lybster, Brough Bay and John O Groats (Figure 7).

Although a full analysis of association patterns was beyond the scope of this paper, repeated associations between individuals were noted, a selection of which are represented in Figure 8.

Over 90% of images used to document and finalise both catalogues were taken from land, thus any possible negative welfare impacts, or disturbance of individual dolphins, associated with vessel or drone presence, were minimised.

Discussion

Historical sightings data indicates the long-term presence of Risso's dolphins in coastal waters throughout the northeast of Scotland, Orkney and Shetland, with records analysed in this study dating back to 1933 (OWIARC, unpublished data[2]), and descriptions from Orkney and Shetland of the hunting of Risso's dolphins in the 1880s (Evans and Scanlan, 1988). Although there was a gap between the earliest reported sightings in the 1930s and more regular sightings reported from 1970 onwards, this is most likely a reflection of the lack of targeted effort to capture these data rather than an absence of the species.

Risso's dolphins were found to be present in the region year-round, with a higher number of reported sightings in August, consistent with similar previous studies in the area (Evans et al., 2010), and with annual and seasonal trends seen in other regions such as the Outer Hebrides (Weir et al., 2019), Moray Firth (WDC Shorewatch, unpublished data[4]) and East Grampian coastline (Evans et al., 2003; Genesis Oil and Gas Consultants, 2011; Anderwald and Evans, 2020; Gutiérrez-Muñoz et al., 2021). Although with considerable spatiotemporal variation, initial photo-ID and reported sightings data suggests that Risso's dolphins are consistently recorded inshore at specific locations within the study area. These projections will be somewhat biased as this study has utilised reported sightings rather than effort corrected monitoring and data collection has been impacted by observer behaviour, weather, and seasonal limitations. However, this observation does mirror spatial and temporal patterns seen in Risso's dolphins in other regions, which could be a response to increased prey abundance and changing sea temperature (van der Kooij et al., 2016).

The results of this study suggest the following areas as potentially important habitat for Risso's dolphins: Noss Sound, Sumburgh Head, Fetlar and Bluemull Sound (Shetland), the Churchill Barriers and Hoxa Head (Orkney), Lybster,

10.3389/fcosc.2024.1366064

FIGURE 6
Risso's dolphin NEO019 photographed by citizen scientists in 2014, 2018 and 2020.

FIGURE 7
Risso's dolphin NEO022 photographed by citizen scientists in 2018.

10.3389/fcosc.2024.1366064

Association	Sighting 1	Sighting 2	Sighting 3	Sighting 4
NEO019 / NEO022	21/04/2018 Strathy Point, Sutherland	27/05/2018 John o' Groats, Caithness	28/05/2020 Holburn Head, Caithness	19/08/2020 Lybster, Caithness
NEO019 / NEO022 / NEO027	21/04/2018 Strathy Point, Sutherland	27/05/2018 John o' Groats, Caithness	28/05/2020 Holburn Head, Caithness	
NEO080 / NEO081 / NEO082	17/05/2019 Churchill Barriers, Orkney	18/05/2019 Churchill Barriers, Orkney		
SH016 / SH017 / SH018	07/09/2014 Noss, Shetland	15/09/2017 Noss, Shetland	20/07/2021 Foula, Shetland	

FIGURE 8
Associations of individual Risso's dolphin from both NEO and SH catalogues, as a result of multiple re-sightings.

Latheronwheel (Caithness), and Strathy Point (Sutherland). The majority of sightings data used in this analysis were collected opportunistically so sighting "hotspots" may be influenced by the locations of towns, popular lookout points, or regional data initiatives. Due to utilising only reported sightings, this study confirms Risso's presence in the areas where reports have been submitted and does not indicate presence or absence in areas where there are less or no sightings reports. Nonetheless, in spite of the lack of effort data and the gaps in coverage, Risso's dolphins have been regularly recorded throughout the study area. Individual Risso's dolphins were found to demonstrate some level of site fidelity, with a third of catalogued Risso's dolphins resighted over multiple years. A higher proportion were resighted within the northeast Scotland and Orkney catalogue than within the Shetland region. However, this may be due to the greater number of images received from northeast Scotland and Orkney, the variability of observer behaviour, and access to coastal vantage points within the two regions.

Across both regions, several individuals were resighted together multiple times between 2010 and 2021. This is consistent with Risso's dolphin photo-ID studies in northeast Lewis (Weir et al., 2019; WDC Shorewatch, unpublished data[4]) and elsewhere in the world (Hartmann et al., 2008), where individuals are shown to return to the same habitat over multiple years and are often associating with the same individuals. Further research is required to assess habitat use at a finer scale and to increase our current knowledge of the movements and ecology of the species. However, given the apparent preference for some areas by Risso's dolphins over multiple years, these may be considered important habitat and may be appropriate candidates for further research to inform future site protection. Given the documented long term and year-round presence of Risso's dolphins in these waters, it is recommended that future developments in the northeast of Scotland, Orkney and Shetland, particularly by both the noise-producing (military, fossil fuel and renewable energy) sectors and wave and tidal power developments, consider robust mitigation for the species, employing the precautionary principle at all times.

In addition to finding that Risso's dolphins show some level of site-fidelity, photo-ID data analysis showed that several individual dolphins also travelled long distances of over 100km, and occasionally over 200km. These individuals were not sufficiently recaptured to be able to conclude if this is a one-way or returning movement. Such long-distance movements should not preclude the potential for multiple Management Units (MUs) for Risso's dolphins as exist for other species and similar delineation of protected areas and site-specific MUs for Risso's dolphin are suggested to ensure management is at an appropriate scale. In Scotland, Risso's dolphins are afforded some protection through the MPA designation in northeast Lewis and out with the MPA, through European Protected Species legislation. This study has the potential to help focus attention on important habitats for Risso's dolphin in northeast Scotland and highlight the requirement for more detailed surveys to provide further evidence of habitat-use and determine appropriate additional spatial protection measures.

Data collected by citizen scientists have proven to be invaluable to marine conservation in providing supplementary evidence for policymakers. For example, where there had previously been a winter data gap, the WDC Shorewatch programme provided evidence of the year-round presence of Risso's dolphins in the Outer Hebrides which was used to inform the 2020 designation of the North-east Lewis Marine Protected Area (Weir et al., 2019).

The collection of historical sightings originated from several different citizen science sources (Sea Watch Foundation, Orkney Wildlife Information & Records Centre (OWIARC), and members of the public). While accepting variation in the robustness of data verification between organisations, we still expect some error and/or bias due to observer variability, knowledge on cetacean identification and motivation for reporting sightings. A higher number of records over the summer months is likely to be a result of greater observer effort, better weather conditions and

longer daylight hours. Additionally, at-sea dedicated research is predominantly undertaken in the summer months resulting in a gap in data collection at other times of the year. Analysis of the collated data, however, indicates a clear trend of Risso's presence over time and throughout the year in the coastal waters around northeast Scotland, Orkney and Shetland. In 2020 and 2021, harbour porpoise and Risso's dolphins were the two most commonly sighted cetacean species in Orkney waters (Orkney Marine Mammal Research Initiative (OMMRI), 2021; OMMRI, unpublished data[1]; WDC Shorewatch, unpublished data[4]). Citizen scientists may be able to fill gaps over the winter as they can take advantage of weather windows and are less restricted compared to other traditional effort-based research methods. Supporting citizen scientists to maintain effort over the winter, through initiatives such as WDC Shorewatch's Winter Watch Challenge each year promotes effort during the winter months.

The analysis further indicated an increase in reported sightings of this species in both regions from 2010. This could be because of increased Risso's dolphin presence in the region, a result of increased effort and reporting through citizen science and social media networks, or, most likely, a combination of both. Between 2020-2021 alone, OMMRI launched in Orkney and saw sightings reports rise by at least three-fold in two years (OMMRI, unpublished data[1]), WDC Shorewatch expanded into the Northern Isles, training 100 new volunteers in cetacean identification, and the "COVID-19 effect" influenced an increase in the overall number of citizen science observers. However, there is also previous evidence suggesting an upward trend in the occurrence of Risso's dolphin around Scotland from effort-corrected monitoring (Gutiérrez-Muñoz et al., 2021). Changes in prey distribution due to climate change could also play a part (Hall et al., 2019; Evans and Waggitt, 2020b) and is worthy of further consideration, given the implications for future spatial protection. For example, the distribution and biomass of squid, a favoured prey species of Risso's dolphins, have increased across the North Sea over a 35-year period as associated changes in sea temperature (van der Kooij et al., 2016).

Through citizen science, it is possible to inspire conservation-minded behaviour and encourage stewardship of the marine environment and species within (Merenlender et al., 2016). This is particularly relevant when the focus is a species or population that can be studied from land, as the opportunity to take photographs does not rely on access to a boat and is therefore open to more potential contributors. Collaborating with wildlife photographers and the public can result in the contribution of quality images. Nevertheless, one constraint with this approach can be the consistency and quality of data received (Newman et al., 2003; Embling et al., 2015; Gutiérrez-Muñoz et al., 2021). However, keeping volunteers engaged and providing guidance as to what is required for a valid photo-ID image can help to improve both of the above. An additional constraint to using photographs of Risso's dolphins which have been taken "opportunistically" or "off-effort" is that this information provides a "snapshot" of their lives and habitat use. Nonetheless, as this study has shown, even opportunistic photo-ID data can be further analysed to improve understanding of social structure, behaviour and importantly, habitat use, which could support the identification of areas of critical importance for Risso's dolphins.

Conclusion

This research demonstrates that Risso's dolphins are regularly and repeatedly utilising coastal and inshore waters around northeast mainland Scotland and the Northern Isles. Further, regular sightings of mothers and their dependent calves indicate that areas of sheltered, shallow coastal waters (<200 m) are being used as nursery grounds. Understanding the habitat use of Risso's dolphins on a broad spatial scale is expensive, time-consuming, and labour intensive. Although not a substitute for systematic, effort-based surveys and accepting the use of citizen science data has clear limitations, increased uptake and facilitation of citizen science, productive collaboration between organisations, and growing community awareness of Risso's dolphins, have the potential to fill data gaps and contribute to understanding the presence of this species around the coast in northeast Scotland, Orkney and Shetland. The methods demonstrated in this study can be replicated for other areas (a similar study is currently underway on Risso's in south-west England) and/or other cetacean species observed in coastal waters.

Ongoing consistent and effort related data collection, alongside the development and expansion of photo-ID catalogues will be vital in filling the gaps in understanding of Risso's dolphin distribution and behaviour within Scottish waters, with the potential to support efforts to inform important processes such as defining population management units and future MPA designations to support the conservation of Risso's dolphins and other species.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

Ethical approval was not required for the study involving animals in accordance with the local legislation and institutional requirements because the study used sighting and photographic data only (predominantly taken from land) with no close contact between humans and animals.

Author contributions

NH: Conceptualization, Methodology, Validation, Visualization, Writing – original draft. ES: Formal analysis, Investigation, Validation, Writing – original draft. KD: Formal analysis, Investigation, Validation, Writing – original draft. AW: Data curation, Formal analysis, Writing – review & editing. SD:

Writing – review & editing. KH: Data curation, Writing – review & editing. EN-W: Data curation, Writing – review & editing. PE: Data curation, Writing – review & editing. CB: Writing – review & editing. KR: Data curation, Writing – review & editing. EM: Writing – review & editing. RF: Writing – review & editing. HH: Writing – review & editing. AK: Writing – review & editing. KM: Writing – review & editing.

Funding

The author(s) declare that no financial support was received for the research, authorship, and/or publication of this article.

Acknowledgments

The authors are grateful to everyone who submitted images to this project; Alan McGee, Alan Mackinnon, Alex Penn, Alex Styles, Andy Denton, Andy Edgar, Anita Cook, Barbara Cheney, Becky Austin, Ben Fiddian, Chevonne Angus, Chloe Bunch, Chris Booth, Claire Boardman, Chloe Robinson, Christie Smilie, Craig Nisbet, Christina Worth, Daniel Gornall, David Joicey, Drew Kennedy, Fair Isle Bird Observatory, Gary Bell, Geoff Atherton, Helen Perry, Jane Wallace, Jenni Kakkonen, Lorna Jappy, Marijke de Boer, Margaret Fox, Mary Russel, Monika Carrie, Maurice Henderson, Neil Macpherson, Nick McCaffrey, Paul Harvey, Paul Macklam, Richard Bailey, Robert Warren, Robbie Brookes, Ryan Leith, Susie Gold, Tim Marshall, Tommy Kirkpatrick, Walter Innes, Will Scott, Zoe Doran. We are also grateful to the individuals who contributed sightings data and to those who undertook verification and storage of the data over the years. We also thank our funders NatureScot, the National Lottery Heritage Fund and the RS Macdonald Charitable Trust.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

References

Anderwald, P., and Evans, P. G. H. (2020). *Cetaceans of the East Grampian Region* (Report of Seawatch Foundation).

Atkinson, T., Gill, A., and Evans, P. G. H. (1997). Notes on the natural markings on Risso's Dolphins (*Grampus griseus*) photographed in the coastal waters around the Eye Peninsula, Isle of Lewis, Scotland. *Eur. Res. Cetaceans* 11, 209.

Atkinson, T., Gill, A., and Evans, P. G. H. (1999). A photo-identification study of Risso's dolphins in the Outer Hebrides, Northwest Scotland. *Eur. Res. Cetaceans* 12, 102.

Bloch, D., Desportes, G., Harvey, P., Lockyer, C., and Mikkelsen, B. (2012). Life history of Risso's dolphin (*Grampus griseus*) (G. Cuvier 1812) in the Faroe Islands. *Aquat. Mammals* 38, 3.

Beck, S., Foote, A. D., Kötter, S., Harries, O., Mandleberg, L., Stevick, P. T., et al. (2014). Using opportunistic photo-identifications to detect a population decline of killer whales (*Orcinus orca*) in British and Irish waters. *J. Mar. Biol. Assoc. United Kingdom* 94, 1327–1333. doi: 10.1017/S0025315413001124

de Boer, M. N., Clark, J., Leopold, M. F., Simmonds, M. P., and Reijnders, P. J. H. (2013). Photo-identification methods reveal seasonal and long-term site-fidelity of Risso's dolphins (*Grampus griseus*) in shallow waters (Cardigan Bay, Wales). *Open J. Mar. Sci.* 03, 66–75. doi: 10.4236/OJMS.2013.32A007

Embling, C. B., Walters, A. E. M., and Dolman, S. J. (2015). How much effort is enough? The power of citizen science to monitor trends in coastal cetacean species. *Global Ecol. Conserv.* 3, 867–877. doi: 10.1016/j.gecco.2015.04.003

Evans, P. G. H. (1976). An analysis of sightings of Cetacea in British Waters. *Mammal Rev.* 6, 5–14. doi: 10.1111/j.1365-2907.1976.tb00196.x

Evans, P. G. H. (1980). Cetaceans in British waters. *Mammal Rev.* 10, 1–52. doi: 10.1111/j.1365-2907.1980.tb00232.x

Evans, P. G. H., Anderwald, P., and Baines, M. E. (2003). UK Cetacean Status Review. *Report to English Nature and the Countryside Council for Wales*. Sea Watch Foundation: Oxford. 160. Available at: https://www.seawatchfoundation.org.uk/wp-content/uploads/2012/08/28.-UK-cetacean-status-review-2003.pdf. Accessed: 20 March 2024.

Evans, P., Baines, M., and Coppock, J. (2011). *Abundance and Behaviour of Cetaceans and Basking Sharks in the Pentland Firth and Orkney Waters (Report No. 419)*. Report by Hebog Environmental Ltd. Report for Scottish Natural Heritage.

Evans, P. G. H., Baines, M. E., and Coppock, J. (2010). *Abundance and behaviour of cetaceans & Basking sharks in the Pentland Firth and Orkney waters*. Report by Hebog Environmental Ltd & Sea Watch Foundation. *Scottish natural heritage commissioned report no.418 (iBids and projects ID 1052)*. 44, Figure 22.

Evans, P. G. H., and Scanlan, G. (1988). *Historical analysis of cetaceans in British waters. Report to Greenpeace UK*. 105.

Evans, P. G. H., and Waggitt, J. J. (2020a). "Cetaceans," in *Atlas of the mammals of Great Britain and Northern Ireland. Published for the Mammal Society by Pelagic Publishing, Exeter*. Eds. D. Crawley, F. Coomber, L. Kubasiewicz, C. Harrower, P. Evans, J. Waggitt, B. Smith and F. Mathews, 134–184, 205pp.

Evans, P. G. H., and Waggitt, J. J. (2020b). Impacts of climate change on marine mammals, relevant to the coastal and marine environment around the UK. *MCCIP Sci. Rev.* 2020, 421–455. doi: 10.14465/2020.arc19.mmm

Gaspari, S., Airoldi, S., and Hoelzel, A. R. (2007). Risso's dolphins (*Grampus griseus*) in UK waters are differentiated from a population in the Mediterranean Sea and genetically less diverse. *Conserv. Genet.* 8, 727–732. doi: 10.1007/s10592-006-9205-y

Genesis Oil and Gas Consultants. (2011). *European Offshore Wind Deployment Centre*. EIA Technical Report Marine Mammals. Genesis Job Number J-71666/A. https://marine.gov.scot/sites/default/files/appendix_12.2_marine_mammals_eia.pdf. Accessed: 14/03/2024.

Gilles, A., Authier, M., Ramirez-Martinez, N. C., Araujo, H., Blanchard, A., Carlstrom, J., et al. (2023). *Estimates of cetacean abundance in European Atlantic waters in summer 2022 from the SCANS-IV aerial and shipboard surveys*. 64 pp. https://tinyurl.com/3ynt6swa. Accessed: 14/03/2024.

Gutiérrez-Muñoz, P., Walters, A. E. M., Dolman, S. J., and Pierce, G. J. (2021). Patterns and trends in cetacean occurrence revealed by Shorewatch, a land-based citizen science program in Scotland (United Kingdom). *Front. Mar. Sci.* 8. doi: 10.3389/fmars.2021.642386

Hall, K., Harrop, H. R., Harvey, P. V., Evans, P. G. H., and Bertulli, C. G. (2019). "How social media is changing the way we learn about cetaceans in remote locations: bringing 60°N sightings to the masses," in *World Marine Mammal Conference*, Barcelona, Spain, 9th–12th December 2019. Book of Abstracts, pg. 181. https://www.wmmconference.org/wp-content/uploads/2020/02/WMMC-Book-of-Abstracts.pdf Accessed: 14/03/2024.

Hammond, P. S., Lacey, C., Gilles, A., Viquerat, S., Börjesson, P., Herr, H., et al. (2021) Estimates of cetacean abundance in European Atlantic waters in summer 2016 from the SCANS-III aerial and shipboard surveys. Available online at: https://scans3.wp.st-andrews.ac.uk/files/2021/06/SCANS-III_design-based_estimates_final_report_revised_June_2021.pdf.

Hartmann, K. L. (2018). Risso's dolphin: *Grampus griseus*. In *Encyclopaedia of marine mammals*, *3rd ed*. Eds. B. Wursig, J. G. M. Thewissen and K. M. Kovacs (Academic Press), 824–827. doi: 10.1016/B978-0-12-804327-1.00219-3

Hartmann, K. L., Visser, F., and Hendriks, A. J. (2008). Social structure of Risso's dolphins (*Grampus griseus*) at the Azores: a stratified community based on highly associated social units. *Can. J. Zoology* 86, 294–306. doi: 10.1139/Z07-138

Hecker, S., Haklay, M. E., Bowser, A., Makuch, Z., Vogel, J., and Bonn, A. (Eds.) (2018). *Citizen science* (London, UK: UCL Press). doi: 10.2307/j.ctv550cf2

Hodgins, N. K., Dolman, S. J., and Weir, C. R. (2014). Potential hybridism between free-ranging Risso's dolphins (*Grampus griseus*) and bottlenose dolphins (*Tursiops truncatus*) off north-east Lewis (Hebrides, UK). *Mar. Biodiversity Records* 7, e97. doi: 10.1017/S175526721400089X

IAMMWG. (2021). *Updated abundance estimates for cetacean Management Units in UK waters. JNCC Report No. 680* (JNCC Peterborough). https://data.jncc.gov.uk/data/3a401204-aa46-43c8-85b8-5ae42cdd7ff3/jncc-report-680-revised-202203.pdf. Accessed: 14/03/2024.

IAMMWG. (2023). *Review of Management Unit boundaries for cetaceans in UK waters,(2023). JNCC report 734* (JNCC, Peterborough). https://hub.jncc.gov.uk/assets/b48b8332-349f-4358-b080-b4506384f4f7. Accessed: 14/03/2024.

Jefferson, T. A., Weir, C. R., Anderson, R. C., Ballance, L. T., Kenney, R. D., and Kiszka, J. J. (2013). Global distribution of Risso's dolphin *Grampus griseus*: a review and critical evaluation. *Mammal Rev.* 44, 56–68. doi: 10.1111/mam.12008

Maglietta, R., Renò, V., Cipriano, G., Fanizza, C., Milella, A., Stella, E., et al. (2018). DolFin: an innovative digital platform for studying Risso's dolphins in the Northern Ionian Sea (Northeastern Central Mediterranean). *Sci. Rep.* 8, 1. doi: 10.1038/s41598-018-35492-3

Merenlender, A. M., Crall, A. W., Drill, S., Prysby, M., and Ballard, H. (2016). Evaluating environmental education, citizen science, and stewardship through naturalist programs. *Conserv. Biol.* 30, 1255–1265. doi: 10.1111/cobi.12737

Natural History Museum (2018). *Historical UK cetacean strandings dataset (1913-1989)* (Natural History Museum). doi: 10.5519/0028204

Newman, C., Buesching, C. D., and Macdonald, D. W. (2003). Validating mammal monitoring methods and assessing the performance of volunteers in wildlife conservation - "Sed quis custodiet ipsos custodies?" *Biol. Conserv. 113 no.* 2, 189–197.

Orkney Islands Council (2020). Orkney islands marine region: state of the environment assessment. *A baseline assessment of the Orkney Islands Marine Region*. Pg. 21. https://www.orkney.gov.uk/Files/Planning/Development-and-Marine-Planning/20210107-OIC-Report-V9-screen%20v2.pdf Accessed: 14/03/2024.

Orkney Marine Mammal Research Initiative (OMMRI) (2021). *Sightings atlas 2020* (Orkney, UK).

Paxton, C. G. M., Scott-Hayward, L. A. S., and Rexstad, E. (2014). *Statistical approaches to aid the identification of Marine Protected Areas for minke whale, Risso's dolphin, white-beaked dolphin and basking shark, Scottish Natural Heritage Commissioned Report No. 594*. https://www.nature.scot/doc/naturescot-commissioned-report-594-statistical-approaches-aid-identification-marine-protected-areas. Accessed: 14/03/2024.

Porter, J., Austin, W., Burrows, M., Clarke, D., Davies, G., Kamenos, N., et al. (2020). *Blue carbon audit of Orkney waters. Scottish Marine and Freshwater Science Reports, no. 3*. Vol. 11 (Marine Scotland. Scottish Government). doi: 10.7489/12262-1

Robinson, K. P., Baumgartner, N., Eisfeld, S. M., Clark, N. M., Culloch, R. M., Haskins,, et al. (2007). The summer distribution and occurrence of cetaceans in the coastal waters of the outer southern Moray Firth in northeast Scotland (UK). *Lutra* 50, 19–30.

Scullion, A., Harrop, H., Munro, K., Truluck, S., and Foote, A. (2021) Scottish killer whale photo identification catalogue. Available online at: https://drive.google.com/file/d/17tlazLV6uQVG-rlboQm9-SfwEZBODlZy/view (Accessed 20 09 2023).

Silvertown, J. (2009). A new dawn for citizen science. *Trends Ecol. Evol.* 24, 467–471. doi: 10.1016/j.tree.2009.03.017

Urian, K., Gorgone, A., Read, A., Balmer, B., Wells, R. S., Berggren, P., et al. (2015). Recommendations for photo-identification methods used in capture-recapture models with cetaceans. *Mar. Mammal Sci.* 31, 298–321. doi: 10.1111/mms.12141

van der Kooij, J., Engelhard, G. H., and Righton, D. A. (2016). Climate change and squid range expansion in the North Sea. *J. Biogeography* 43, 2285–2298. doi: 10.1111/jbi.12847

Weir, C. R., Hodgins, N. K., Dolman, S. J., and Walters, A. E. M. (2019). Risso's dolphins (*Grampus griseus*) in a proposed Marine Protected Area off east Lewis (Scotland, UK), 2010–2017. *J. Mar. Biol. Assoc. United Kingdom* 99, 703–714. doi: 10.1017/S0025315418000516

Whale and Dolphin Conservation (WDC) (2022) (1) The Orkney and Northeast Scotland Risso's dolphin photo ID catalogue and the (2) Shetland Risso's dolphin photo ID. Available online at: https://drive.google.com/drive/folders/1gorXgefaysTQOyGxN5RGel0zh4MvYnk6?usp=drive_link.

Würsig, B., and Jefferson, T. A. (1990). Methods of photo-identification for small cetaceans. In: P.S. Hammond, S.A. Mizroch and G.P. Donovan Eds., *Individual Recognition of Cetaceans: Use of Photo-Identification and Other Techniques to Estimate Population Parameters, Reports of the International Whaling Commission*, Special Issue 12, Cambridge, 43-52.