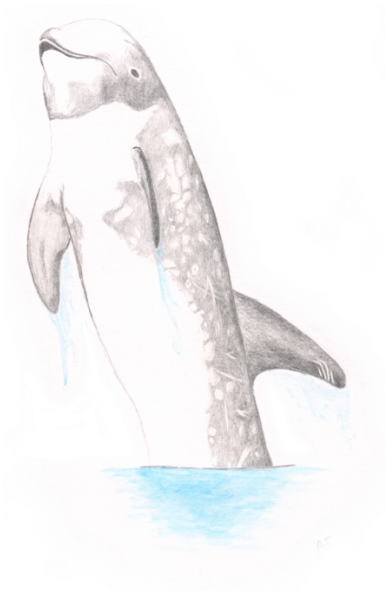
LMU LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN

BACHELOR THESIS

First description and Photo ID catalogue of the Risso's dolphin *Grampus griseus* (G. Cuvier, 1812) population off Northern Norway



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Picture on cover page drawn with pencil and details added with aquarelle by author

Zusammenfassung

Der Rundkopfdelfin *Grampus griseus* (G. Cuvier, 1812) ist eine Delfinart, die bis 45° nördlicher Breite sehr verbreitet ist und auch in manchen Gebieten bis zu 64° N bekannt ist. Noch weiter nördlich wurde die Art bisher nur selten gesehen. Dementsprechend ist es durchaus außergewöhnlich, dass diese Art seit 2017 jedes Jahr im Sommer mehrfach in der Gegend des Bleik Canyons im Norden Norwegens bei einer nördlichen Breite von über 69° gesichtet wurde. Die beiden dort ansässigen Whale-Watching-Unternehmen Whale2Sea und Whalesafari Andenes wollten dem Thema unter der Leitung der Forschungsorganisation Norwegian Orca Survey auf den Grund gehen und haben von den ersten Sichtungen an wissenschaftlich auswertbare Daten gesammelt, die im Rahmen dieser Bachelorarbeit ausgewertet werden. Da Rundkopfdelfine nicht die Kernkompetenz der Forschungsorganisation sind und diese genug mit der Forschung rund um die Killerwale (*Orcinus orca*) zu tun haben, wurden mir die Daten zur Auswertung übergeben. Ziel der Bachelorarbeit ist es, sich einen Überblick über Rundkopfdelfine im Nordostatlantik zu verschaffen, einen Photo ID Katalog aus den vorhandenen Fotos zu erstellen, daraus eine grobe Schätzung vorzunehmen, wie viele verschiedene Individuen bereits dokumentiert wurden und einen ersten Eindruck der Gruppenzusammensetzungen zu gewinnen.

Das Untersuchungsgebiet befindet sich im Norden Norwegens am Bleik Canyon und den darum liegenden Gewässern. Der Studienzeitraum startet mit dem Beginn der regelmäßigen Sichtungen im Sommer 2017 und endet mit der letzten Sichtung im Sommer 2023. Zur Datenerfassung dienten vor allem Whale Watching und Forschungs-, aber auch private Boote. Dabei wurden Informationen wie Ort, Datum und Uhrzeit der Sichtung aufgezeichnet. Fotos der Tiere dienen der Identifizierung einzelner Individuen. Identifizierte Individuen wurden in drei Gruppen unterteilt, d.h. Jungtiere und Kälber, die sich optisch noch sehr stark verändern, temporäre IDs, von denen keine Bilder mit ausreichender Qualität vorhanden sind, und Katalog IDs, die mit einer hohen Wahrscheinlichkeit auf einem Bild mit ähnlicher Qualität wiedererkannt werden können. Aus der letzten Gruppe wurde der Photo-ID-Katalog erstellt (siehe Appendix). Die Geschlechtsbestimmung erfolgte entweder über sichtbare primäre Sexualorgane oder über das Vorhandensein eines Kalbes an der Seite eines ausgewachsenen Tieres.
Zusätzlich wurde eine Literaturrecherche über Rundkopfdelfine im Nordostatlantik durchgeführt.

Begegnungen mit Rundkopfdelfinen fanden ausschließlich im Sommer meist direkt über dem Bleik Canyon statt. Des weiteren nimmt die Zahl der Sichtungen immer mehr zu, vor allem 2022 und 2023 weisen deutlich mehr Sichtungen auf als die Jahre zuvor. Der Aufwand, gemessen anhand der Ausfahrten von Whalesafari Andenes, zeigt auch die Höchstwerte jedes Jahr im Sommer mit etwas geringeren Werten in den Jahren, die von den Einschränkungen durch COVID-19 beeinträchtigt waren.
Insgesamt wurden 11.335 Fotos gesammelt und zur Identifizierung der Individuen verwendet. Die Mindestanzahl an identifizierten Individuen, die im Katalog erfasst sind, ist 114, die Maximalanzahl ist 145. Bei den temporären IDs liegt die Zahl zwischen 65 und 117 Individuen und bei den Jungtieren und Kälbern zwischen 30 und 54 Individuen. Bereits 20 IDs aus dem Katalog wurden in mindestens zwei verschiedenen Jahren in dem Studiengebiet gesichtet.
Insgesamt handelt es sich bei 57 der im Katalog beschriebenen Individuen um Weibchen. Bei den anderen 88 Individuen ist das Geschlecht bisher nicht bekannt. Von den temporären IDs sind 26 Individuen weiblich und von den 91 restlichen ist das Geschlecht noch unbekannt.

Die Recherche bezüglich vorangegangener Rundkopfdelfin-Sichtungen im Nordostatlantik ergab, dass diese in unregelmäßigen Abständen auch in anderen Teilen von diesem gesichtet wurden, jedoch nirgends so häufig und so regelmäßig wie in der Gegend um den Bleik Canyon. Die Art ist in den älteren Aufzeichnungen der Wale, die es bei den Faröer Inseln gibt, nicht vertreten. Seit 2009 werden sie auch dort immer wieder gesehen, aber deutlich seltener als in dem Studiengebiet. Im Süden Norwegen gibt es ebenfalls vereinzelte Sichtungen, die sich aber oft auf gestrandete oder einzelne Tiere beziehen.

Die Datenerfassung ist aufgrund der Zusammenarbeit mit Whale-Watching-Unternehmen Schwankungen unterworfen. Die Rundkopfdelfine müssen die Aufmerksamkeit der Boote mit anderen Walarten teilen, Wind und Wetter haben Einfluss darauf, wann Touren stattfinden können, und die Nachfrage der Touristen ist im Sommer deutlich höher als im Rest des Jahres. Nichtsdestotrotz bietet diese Zusammenarbeit auch einen großen Vorteil. So können mit geringem finanziellem Aufwand große Mengen an Daten gewonnen werden.
Der Bleik Canyon bietet mit seinen Kontinentalabhängen einen geeigneten Lebensraum für Rundkopfdelfine, die jeden Sommer wiederkehren. Dass diese auch den Winter über dort bleiben, kann nicht ausgeschlossen werden, ist aber eher unwahrscheinlich, da sich die Meeresoberflächentemperatur im Sommer schon nur leicht über der Wohlfühltemperatur dieser Art (ca. 12 °C) befindet.
Photo ID hat sich als großartige Methode erwiesen, um die Rundkopfdelfine in Nordnorwegen zu studieren. Es konnten ähnliche soziale Strukturen erkannt werden, wie sie bereits von den Azoren beschrieben wurden. Um eine aussagekräftige Einschätzung treffen zu können, sind jedoch weitere Daten notwendig.
Basierend auf aktueller Datenlage und heutigem Stand des Wissens wird eine Erweiterung des artenkundigen Verbreitungsgebietes der Rundkopfdelfine empfohlen. Die neue nördliche Verbreitungsgrenze sollte das Studiengebiet mit einschließen, die westliche Grenze sollte etwa bei den Faröer Inseln liegen.

Diese Arbeit stellt die erste Beschreibung der Rundkopfdelfine mitsamt Photo-ID-Katalogs im Norden Norwegens dar. Fragestellungen, die noch bestehen oder neu aufgeworfen wurden, kann mit verschiedenen Methoden wie der Fortsetzung der Photo-ID-Arbeit, DNA-Proben, akustischen Aufnahmen, GPS-Tags und Capture-Recapture-Verfahren auf den Grund gegangen werden.

Table of Content

1. Introduction

Whales are divided into two different groups, the baleen whales (Mysticeti) and the toothed whales (Odontoceti). Within the toothed whales we find the family Delphinidae, the oceanic dolphins. The Risso's dolphin *Grampus griseus* (G. Cuvier, 1812) is a member of this group. The species was first described by Cuvier (1812) based on the studies of the French naturalist Antoine Risso to whom they owe their name (Figure 1).

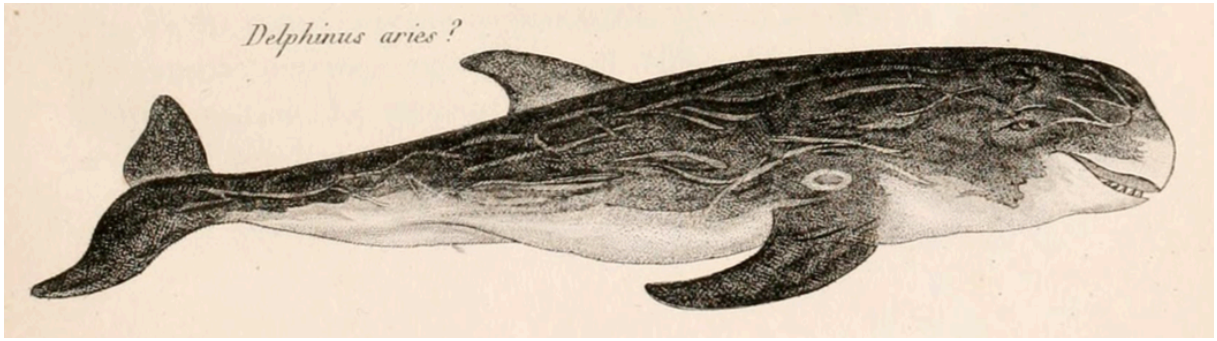

Figure 1: Drawing of the Risso's dolphin in the original description by Cuvier (1812).

Risso's dolphins can be found in tropical, subtropical, and temperate waters, in latitudes from 50 °S to 64 °N. Their most common distribution range lies between 30 °S and 45 °N according to the 'International Union for Conservation of Nature' (IUCN) (Jefferson et al., 2014; Kiszka, 2018). The species IUCN distribution range in comparison to the sighting records documented by the 'Ocean Biodiversity Information System' (OBIS) is demonstrated in Figure 2.

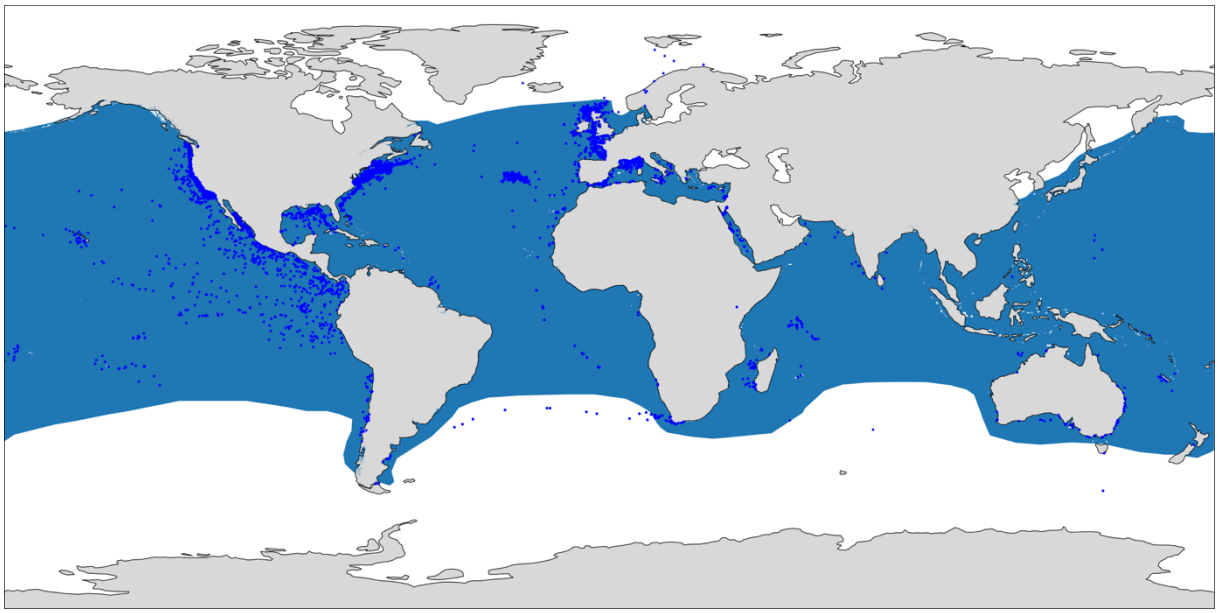

Figure 2: Distribution of Risso's dolphins worldwide. The blue area indicates the distribution of the species suggested by IUCN Red List (Kiszka, 2018), the blue dots show the locations of sightings registered in OBIS (OBIS, 2023).

Risso's dolphins prefer habitats along the continental slopes (Azzellino et al., 2008; Jefferson et al., 2014). On those slopes they go on deep dives to forage for their preferred prey (Rone et al., 2022; Visser et al., 2021).
The species feeds on small cephalopods (Blanco et al., 2006; Bloch et al., 2012; Cockcroft et al., 1993; Evacitas et al., 2017; Luna et al., 2022; Oztürk et al., 2007;

Pauly et al., 1998; Plön et al., 2020; Würtz et al., 1992), which they suck into their mouths. Therefore, they do not need cutting teeth. Instead their teeth have evolved to serve a different purpose. They have lost the teeth in the upper jaw and the ones left in the lower jaw can leave the for this species typical scars on the body of their likes in social interactions (MacLeod, 1998). Research in the Azores has shown that their social structure is organised in social stratified groups (Hartman et al., 2008; Hartman et al., 2023). This means that they form groups based on their age and sex. Individuals in those groups are typically not closely related to each other. The different group types are bachelor groups consisting of sub-adults of both sexes, nursery pods consisting of mother-calf pairs, and adult male groups.
The Bleik Canyon is located in Northern Norway between 69.3 and 69.5 °N and 15.6 and 15.9 °E and therefore far outside the known distribution range of the Risso's dolphin. It is a canyon which starts at around 200 metres and drops off to more than 1,000 metres in its centre (Laberg et al., 2007). In Norway this is the closest point from the shoreline to the edge of the continental slope. Although the Bleik Canyon offers favourable conditions for Risso's dolphins (Chicote et al., 2023), the species was not regularly seen before 2017. This has changed since then and now they are observed in summer every year.
The two whale watching companies Whale2Sea and Whalesafari Andenes decided to study the phenomenon under the coordination of the non-governmental organisation Norwegian Orca Survey.
Eve Jourdain (Norwegian Orca Survey) handed the data which had been collected over to me because the Risso's dolphin is not the species with the primary interest to the organisation. In the time between 15/07/2023 and 26/08/2023 I was able to personally contribute to the data collection during my stay in Andenes and employment as a whale watching guide for Whale2Sea. Now the project of evaluating the collected data has become my bachelor thesis.

The aims of my bachelor thesis are first to get an overview about the collected data, second to create an ID catalogue, third to estimate the number of individuals frequenting the area, fourth to identify individuals returning to the area, and fifth to get an idea of the group composition of the encountered Risso's dolphins. All those factors can give a first indication about the ecology and social structure of the encountered animals.

2. Material and Methods

2.1 Study Area and Period

The collection of data for this study started in August 2017. Since then Risso's dolphins encounters have occurred in the summer months every year. Therefore, the data includes all recorded sightings from the summers between 2017 and 2023. The study area is located in the Northeast Atlantic near Andenes in Northern Norway (Figure 3 A). In the vicinity of Andenes lies Bleik Canyon, which starts approximately 8 nautical miles from the closest point onshore (Figure 3 B).

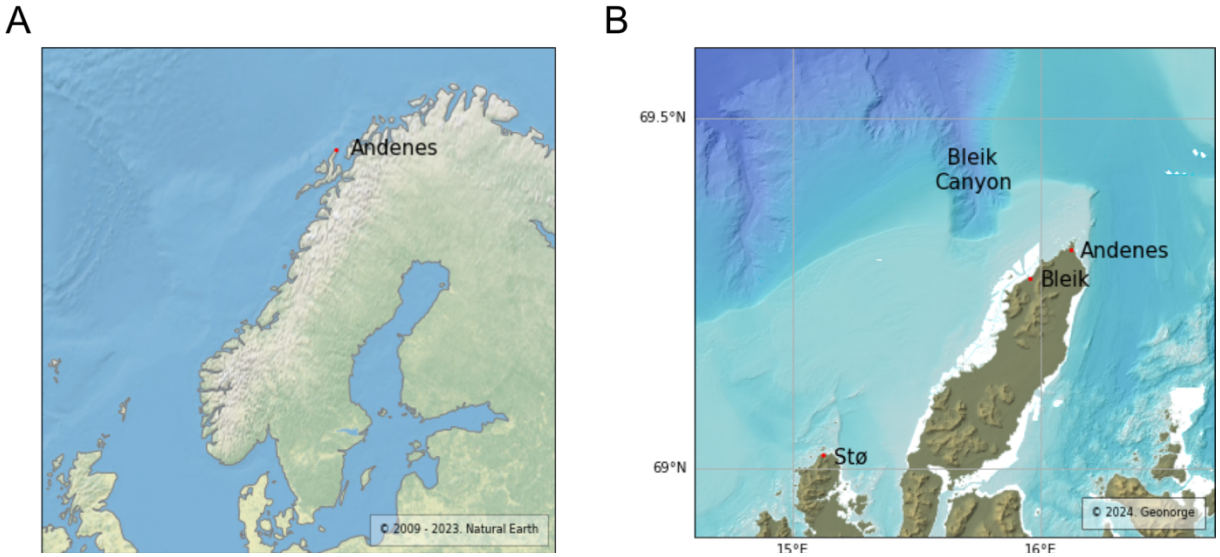

Figure 3: Study area. A. Location of the study area in the Northeast Atlantic. B. Detailed view of the study area showing from where boats have been operated in the process of data collection.

2.2 Data Collection and Contributors

In charge of the documentation of the Risso's dolphins observations were the two whale watching companies Whale2Sea and Whalesafari Andenes as well as the research organisation Norwegian Orca Survey (all three of them based in Andenes), which dedicates its work to study the Norwegian killer whales (*Orcinus orca*). From 2017 to 2022 the data was exclusively provided by these three parties. Since summer 2023 the data collection has increased. The whale watching companies Arctic Whale Tours and Green Gold of Norway have started contributing to the project also. Arctic Whale Tour runs their trips from Stø, which is located about 20 nm south-south-west of the Bleik Canyon, Green Gold of Norway from Bleik, southwest along the coast from Andenes.

For Green Gold of Norway 2023 was the first year they operated their business in this area at this time of the year. So, they have decided to help gaining further knowledge about these animals right from when they started their tours in the area. Additionally, guests onboard the Whale2Sea vessels contributed their pictures on several occasions and Espen Bergersen collected data from his private vessel. All contributors to the project are listed in Table 1.

The effort in the collection of data was measured by the number of whale watching trips Whalesafari Andenes had been running in every month from January 2017 to December 2023. Unfortunately, these numbers were not available for the tours Whale2Sea had been running.

Table 1: Platforms for data contributors

Platform	Type of organisation	Operating from	Type of vessel(s)	Data contribution
Norwegian Orca Survey	Non-governmental organisation	Andenes	9 m mono hull	Since 2021
Whale2Sea	Whale watching	Andenes	Multiple RIBs*	Since 2017
Whalesafari Andenes	Whale watching	Andenes	30 m mono hull 23 m mono hull	Since 2017
Arctic Whale Tours	Whale watching	Stø	22 m catamaran	Since 2023
Green Gold of Norway	Whale watching	Bleik	1 RIB*	Since 2023
Espen Bergersen	private	Andenes	1 RIB*	Since 2023

*RIB – rigid inflatable boat

2.3 Encounter Information

The recorded data includes the date and time, the GPS location, the platform on which the information was documented, how many photos were taken, and the photographer (Table 2). If not otherwise stated in the explanations of the abbreviations below the table, the photographer was part of the relevant platform at that time. Whalesafari Andenes employees usually collected the photos in the name of the company, the person who took the pictures is not mentioned in those cases. Complete data sets are often not available, especially photos are not available for numerous encounters.

Table 2: Information about Risso's dolphins encounters.

Date	Time (UTC)	Latitude	Longitude	Platform	Number of Photos	Photographer
10/08/17				W2S	123	MB
08/09/17				WSA	22 *	
30/09/17				WSA	-	
19/07/18		69.405 N	15.760 E	WSA	-	
25/07/18				W2S	281	MB
27/07/18				WSA	19 *	
09/09/18		69.416 N	15.823 E	WSA	-	
14/09/18				WSA	-	
18/07/19				WSA	-	
19/07/19		69.393 N	15.785 E	WSA	-	
26/07/19		69.396 N	15.721 E	WSA	-	
26/07/19		69.380 N	15.800 E	WSA	-	
26/07/19				W2S	167	PvdB
26/08/19		69.386 N	15.695 E	WSA	-	
18/07/20		69.473 N	15.470 E	WSA	-	
25/07/20				W2S	-	
06/08/20		69.420 N	15.826 E	WSA	10 *	
20/08/20		69.407 N	15.835 E	WSA	2 *	
20/08/20	12:28	69.524 N	15.640 E	W2S	-	
21/08/20		69.410 N	15.659 E	WSA	-	
30/07/21				WSA	3 *	
31/07/21				WSA	4 *	
06/08/21				NOS	445	EJ
07/08/21		69.383 N	15.859 E	W2S	77	TS
07/08/21	09:30	69.478 N	15.987 E	W2S	-	
07/08/21				WSA	19 *	
08/08/21				WSA	9 *	
17/09/21	10:54			W2S	-	
28/09/21	10:05			W2S	-	
04/07/22				NOS	130	EJ
04/07/22	13:51	69.390 N	15,862 E	W2S	20	ZM
05/07/22		69.487 N	15.706 E	WSA	-	
19/07/22		69.417 N	15.835 E	WSA	-	

19/07/22		69.417 N	15.830 E	WSA	-	
19/07/22				NOS	1119	EJ
19/07/22				NOS	15:31 min drone video	RK
19/07/22				W2S	115	SOC
19/07/22	17:25	69.443 N	15.884 E	W2S	-	
19/07/22	21:15			W2S	-	
24/07/22	09:45	69.438 N	15.823 E	W2S	-	
25/07/22		69.393 N	15.628 E	WSA	-	
29/07/22		69.487 N	15.779 E	WSA	-	
29/07/22		69.433 N	15.773 E	WSA	-	
29/07/22		69.388 N	15.830 E	WSA	-	
29/07/22	13:44	69.466 N	15.797 E	W2S	-	
02/08/22				WSA	4 *	
04/08/22		69.434 N	15.665 E	WSA	-	
04/08/22		69.417 N	15.680 E	WSA	-	
04/08/22		69.406 N	15.719 E	WSA	-	
04/08/22	14:40	69.410 N	15.758 E	W2S	-	
28/09/22		69.398 N	15.827 E	WSA	-	
28/09/22	14:23			W2S		
2022				W2S	187 **	LD
18/06/23				WSA	38	
06/07/23	08:49	69.375 N	15.759 E	W2S		
06/07/23	10:00			W2S	36	TH
06/07/23	10:00			W2S	65	RR
06/07/23	12:00			W2S	35	SA
06/07/23	12:00			W2S	10	CRA
06/07/23				WSA	9	
15/07/23	09:30	69.405 N	15.484 E	W2S	-	
15/07/23	10:20	69.369 N	15.951 E	W2S	20	KM
15/07/23	09:30	69.386 N	15.848 E	W2S	130	AE
18/07/23	09:39	69.400 N	15.849 E	W2S	183	ZM
18/07/23	10:00	69.392 N	15.858 E	W2S	174	AE
23/07/23	12:00			WSA	636	JH
23/07/23				WSA	27	
23/07/23				WSA	4	
23/07/23	13:14	69.457 N	15.759 E	W2S	-	
23/07/23	15:23	69.477 N	15.653 E	W2S	127	ZM
23/07/23	13:40	69.476 N	15.692 E	W2S	-	
23/07/23				AWT	5	HV
23/07/23				GGN	89	KB
24/07/23				WSA	93	
24/07/23				W2S	602	EJ
24/07/23	13:20	69.394 N	15.843 E	W2S	191	AE
24/07/23	16:03	69.349 N	15.801 E	NOS	24	EJ
26/07/23				WSA	10	
26/07/23	14:35	69.376 N	15.827 E	W2S	17	AE
26/07/23	13:30	69.404 N	15.809 E	W2S	-	
26/07/23				W2S	112	EJ
01/08/23				AWT	52	HV
02/08/23	09:30	69.406 N	15.799 E	W2S	107	ZM
02/08/23	13:37	69.404 N	15.809 E	W2S	17	ZM
02/08/23	13:52	69.416 N	15.765 E	W2S	150	ZM
02/08/23				W2S	494	EJ
02/08/23				W2S	223	MH
02/08/23				P	166 ***	EB
02/08/23				P	68 photos + 07:51 min drone video	EB
02/08/23				GGN	473	KB
04/08/23	13:20	69.448 N	15.931 E	W2S	-	

06/08/23	11:20	69.417 N	15.733 E	W2S	4	AE
06/08/23	13:30	69.392 N	15.863 E	W2S	2	AE
06/08/23	13:25	69.394 N	15.858 E	W2S	-	
06/08/23	21:46	69.402 N	15.712 E	W2S	-	
06/08/23				WSA	91	
06/08/23				W2S	5	FW
06/08/23				W2S	105	EJ
07/08/23	11:20	69.378 N	15.668 E	W2S	18	AE
07/08/23	11:42	69.375 N	15.683 E	W2S	-	
07/08/23				W2S	18	EJ
10/08/23				AWT	740	HV
11/08/23				WSA	18	
12/08/23				WSA	131	
12/08/23	19:52	69.371 N	15.838 E	W2S	-	
13/08/23	13:40	69.425 N	15.775 E	W2S	24	AE
13/08/23	14:05	69.441 N	15.668 E	W2S	503	AE
13/08/23	10:40	69.406 N	15.640 E	W2S	255	MB
13/08/23				GGN	922	KB
13/08/23	14:19	69.387 N	15.890 E	W2S	-	
14/08/23	09:44			W2S	7	MB
14/08/23	09:42	69.416 N	15.745 E	W2S	-	
14/08/23				WSA	5	
19/08/23	09:47	69.399 N	15.645 E	W2S	-	
22/08/23	11:28	69.387 N	15.989 E	W2S	-	
22/08/23	13:35	69.445 N	15.878 E	W2S	-	
26/08/23	16:16	69.381 N	15.854 E	W2S	212	AE
26/08/23	16:15	69.386 N	15.865 E	W2S	154	ZM
26/08/23				W2S	29	LK, TH
30/08/23				AWT	557	HV
02/09/23	18:24			W2S	-	
15/09/23	09:31			W2S	105	ZM
27/09/23	13:33	69.348 N	15.720 E	W2S	-	
27/09/23	14:57	69.355 N	15.657 E	W2S	-	
2023				W2S	62	LD

Abbreviations: Platform: AWT – Arctic Whale Tours, GGN – Green Gold of Norway, NOS – Norwegian Orca Survey, P – private, W2S – Whale2Sea, WSA – Whalesafari Andenes; Photographer: AE – Alexander Eckerle, CRA – Christoph Reuß-Arzt (Whale2Sea guest), EJ – Eve Jourdain, FW – Frauke Wetzel, HV - Hannaleena Väisänen, JH – Jan Hendrych, KB – Krisztina Balotay, KM – Kelly Mulder (Whale2Sea guest), LD – Luís Dias, LK, TH – Lena Küchenberg & Tobias Hübenthal (Whale2Sea guests), MB – Marten Bril, MH – Maartje Houben, PvdB – Piet van den Bemd, RK – Richard Karoliussen, RR – Rasmus Rudnäs (Whale2Sea guest), SA – Shari Arzt (Whale2Sea guest), SOC – Seán O'Callaghan, TH – Theresa Hülk (Whale2Sea guest), TS – Tiu Similä, ZM – Zoë Morange;
* photos already selected and individuals identified by Femke de Ruiter;
** photos preselected and partially edited by the photographer, without the exact date
*** photos preselected and partially edited by the photographer

On some days several groups of Risso's dolphins were encountered in different locations. The number of observed individuals in an encountered group ranged from only a few to several dozens. The number of photos taken of a specific group is not necessarily an indication of how many different individuals this group consisted of as the motivation to take pictures and technique varies widely across different photographers.

2.4 Camera Equipment

As there has not been a standardised way of collecting data, the equipment and the approach varies across different contributors. A list of the camera equipment is given in Table 3.

Table 3: Camera equipment of all contributors to the photo collection.

Dates	Camera equipment	Maximum focal length (mm)	Photographer
06/07/23	Cellphone: Huawei P30 Pro	5.56 *	Arzt Shari
23/07/23, 02/08/23, 13/08/23	Nikon D850	135	Balotay Krisztina
26/07/23	Canon EOS-1D X	400	van den Bemd Piet
02/08/23	Canon EOS R5	300	Bergersen Espen
02/08/23	Drone: DJI Air 2S	8.38 **	Bergersen Espen
10/08/17	Nikon D500	200	Bril Marten
25/07/18	Nikon D5	400	Bril Marten
13/08/23	Sony Alpha 1	200	Bril Marten
2022	Nikon D500	200	Dias Luís
2023	Nikon D850	500	Dias Luís
15/07/23, 18/07/23, 24/07/23, 07/08/23, 13/08/23, 26/08/23	Canon EOS 100D	250	Eckerle Alexander
23/07/23	Canon EOS 5D Mark III	600	Hendrych Jan
02/08/23	Canon EOS 1300D	75	Houben Maartje
06/07/23	Sony Alpha 37	300	Hülk Theresa
06/08/21, 04/07/22, 19/07/23, 24/07/23, 26/07/23, 02/08/23, 06/08/23, 07/08/23	Canon EOS 5D Mark III	200	Jourdain Eve
19/07/23	Drone: DJI Phantom Pro 4 +	8.6 **	Karoliussen Richard
26/08/23	Canon EOS 80D	300	Küchenberg Lena, Hübenthal Tobias
04/07/22, 18/07/23, 23/07/23, 02/08/23, 26/08/23	Nikon D500	200	Morange Zoë
15/07/23	Canon EOS 2000D	250	Mulder Kelly
19/07/23	Canon EOS 90D	200	O'Callaghan Seán
06/07/23	Canon EOS 550D	250	Reuß-Arzt Christoph
06/07/23	Canon EOS R6	400	Rudnäs Rasmus
07/08/21	Canon EOS 7D	200	Similä Tiu
01/08/23	Nikon Z6II	200	Väisänen Hannaleena
10/08/2023, 30/08/23	Nikon Z8	250	Väisänen Hannaleena
06/08/23	Canon PowerShot G7 X Mark II	36.8 ***	Wetzel Frauke

* exploiting digital zoom: equivalent up to fl = 1350 mm of a 35 mm format camera
** equivalent to fl = 22 mm of a 35 mm format camera
*** equivalent to fl = 100 mm of a 35 mm format camera

2.5 Photo Identification

Photo identification is a method which has been used to study cetacean populations worldwide for a long time (Hammond et al., 1990; Würsig & Jefferson, 1974). It uses visual characteristics to distinguish different individuals from each other (Figure 4).

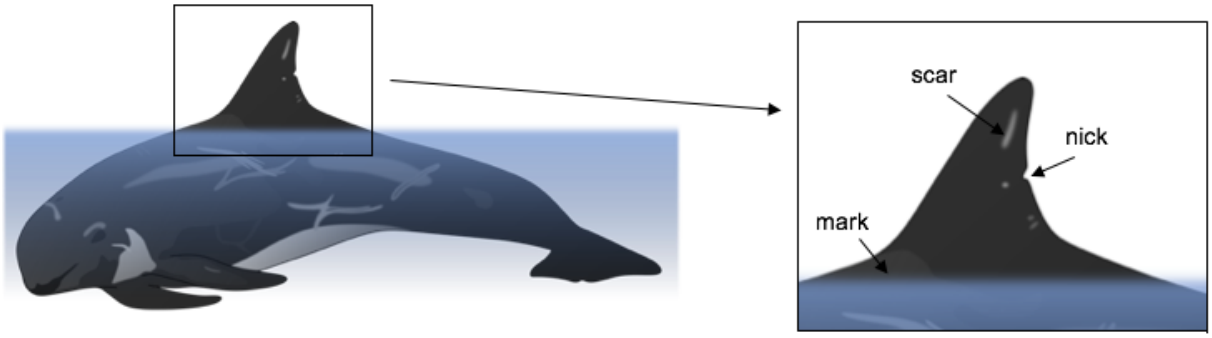

Figure 4: Illustration of a Risso's dolphin (left) and a photo ID picture (right). Among others, features to recognise a specific individual can include the shape of its dorsal fin, nicks in the trailing edge of the dorsal fin, scars, and marks.

2.5.1 Identification of Individuals in an Encounter

The collected pictures of each encounter were thoroughly studied visually to find individuals which could be identified based on the shape of their dorsal fin, marks and scars. Thereby pictures of both body sides were used.
Matching both sides of their body was either done by comparing the outline of the dorsal fin, when they were very characteristic on a particular animal, or by comparing drone images with pictures taken from both sides of the animals. Single frames were cut out of the drone videos for top-views, when the dolphins took a breath, usually just after the blow had vanished into the air and the biggest part of their body was at the surface during this movement.
As a final step of studying an encounter all identified individuals were compared with the individuals identified on earlier encounters. By this the individuals were distinguished between new entries, which were seen on the photos for the first time, and re-sightings, which had been documented before. All of this information was registered in a table in Excel for further statistical analyses.

2.5.2 Classification of Individuals into Different ID Groups

The individuals seen on the photos were divided into three groups. The first group consists of those individuals which might possibly be identified again on a picture with similar quality. But more likely it needs a picture of better quality to identify this animal on a different encounter. These individuals were given a temporary ID.
The same problem exists for juveniles and calves which make up the second group. Because their appearance still changes a lot over time, in particular the shape and size of their dorsal fin, and they still have less unique marks and scars, it is hard to identify them in two consecutive years. Juveniles were identified as such according to Hartman et al. (2013, 2014, 2016). The third group are those individuals which are likely to be re-identified on a picture of similar quality. Therefore, they are the ones generating the most reliable data. For the ID-catalogue only this group was considered and selected. The animals of the other two groups were also registered and held back for more specific questions or studies in the future.

2.5.3 Photo ID Catalogue

The ID-catalogue consists of two elementary parts. In the beginning an overview of all individuals is given. Later on, the individuals are shown in more detail.
In the overview, the dorsal fins of twenty individuals are depicted on one page, first from the left and then from the right. This shall give the reader a fast comparison of the different dorsal fins. When there was no picture available of a specific dolphin from one side, it is stated by “N/A”.
The detailed description shows one individual per page with at least one of the following elements: one selected picture of the dorsal fin from each side and a frame cut out of the drone videos showing the dolphin from the top. Missing data was again marked with “N/A”.
The pictures were selected from any of the available to demonstrate which characteristics make this animal visually particularly unique. Quite often this shows a picture of one of the latest encounters, because of scars which had been added on the dolphin’s skin after earlier documented encounters.

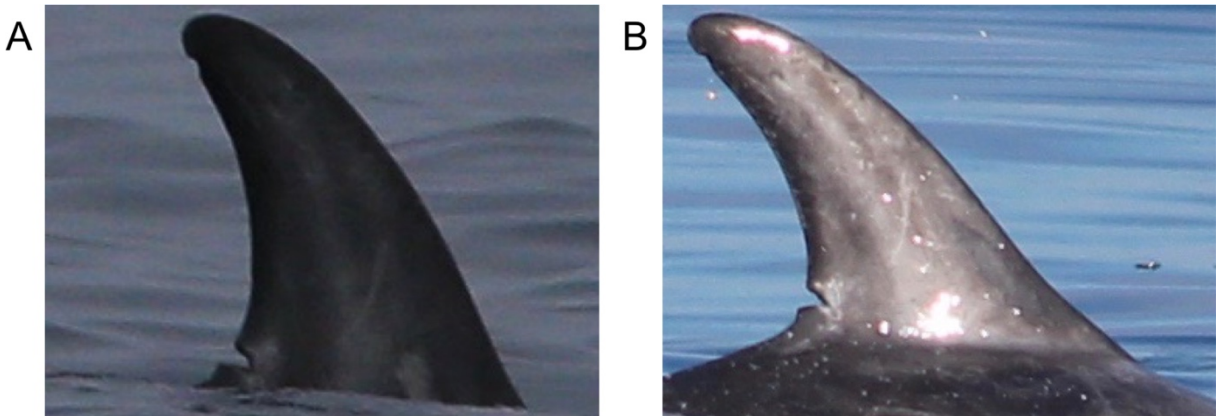

Figure 5: Comparison of the dorsal fin of GG016 on a picture taken in 2019 (A) and 2023 (B). Some additional scars which the individual obtained in the four years between these two photos were taken can be seen in B like the one underneath the little nick in the trailing edge.
Photographer and copy right owner: A: Piet van den Bemd, B: Alexander Eckerle

In the detailed ID descriptions either the same pictures as in the overview were chosen or different ones, if a closer perspective on the dorsal fin and a wider picture showing more details on the individual’s body was found helpful for its identification.

2.6 Sex Determination

If there were pictures available of a breaching individual which showed its primary sexual organs, this was also used to determine its sex. For the determination of the sex of the rest of the individuals two different groups were defined. Juveniles which were still too young to reproduce were taken out of this study, because it is very hard to determine their sex. According to Hartman et al. (2008, 2015), females were described as such if they were seen with calves on their side on at least one of the encounters. As the sexual size dimorphism in Risso’s dolphins is very low (Perrin & Reilly, 1984), males were not described in an own group. Instead the second group was made up of those adult individuals which have never been seen with a calf on their side. This group was named ‘adult, unknown sex’.

2.7 Literature Review on Risso’s Dolphins in the Northeast Atlantic

To find out more about the Risso’s dolphins in the Northeast Atlantic existing literature was reviewed. All possible sources were thereby considered. First, scientific primary

literature was searched on Google Scholar. Then the species was looked up on the global online databases ‘World Register of Marine Species’ (WoRMS, 2023) and OBIS (OBIS, 2023). OBIS collects the information from different sources, like surveys of national research institutes, and publishes the accumulated information. Scientist working on other Risso’s dolphin populations shared their catalogues and additional catalogues were found online. ‘Whale and Dolphin Conservation’ (WDC) is responsible for the Scottish population (WDC, 2022a, b), Oihana Olhasque shared her catalogue from the north of France (Oihana Olhasque, Association Al Lark, personal communication), and the Irish catalogue was found online (Felce, 2012). Additionally, a colleague shared his knowledge about a Norwegian citizen science databank, posts in a social media group, posts of a whale watching company in the Faroe Islands, and an unofficial, unpublished but more up to date Photo ID catalogue from Ireland than the one mentioned earlier (Seán O’Callaghan, PhD Student at Atlantic Technological University, personal communication).

2.8 Software

All software used in this study is open available and free.
The maps in this work were plotted with Python using the package Cartopy (Met Office, 2010 - 2015). Map backgrounds were downloaded from Natural Earth (Natural Earth, 2009 - 2023) (Figure 3 A, 10) or from Geonorge (Statens Kartverk, 2024), the national Norwegian map data server (Figure 3, 6). For these the Mercator projection was used. The maps of the world (Figure 2) and of the Atlantic Ocean (Figure 13) were printed with the Plate Carrée projection.
Graphs were created with the statistic software R and illustrations with the vector programme Inkscape.
I did not use any artificial intelligence tools in order to write this thesis.

3. Results

3.1 Encounter Information

The encounters happened in the months between June and September. A complete illustration of all documented encounters in the study period can be found in Figure 6 A. It is visible that the number of days on which encounters were recorded has increased during the study period. Especially 2022 and 2023 show significantly higher number of sighting days.
The effort, symbolised by the number of whale watching trips Whalesafari Andenes ran in the years of this study, is depicted next to the encounter days in Figure 6 B. In summer the number of whale watching trips is by far the highest over the year. While the number of trips is higher in summer than in winter, they have not increased with the years. The years 2020 and 2021, affected by COVID-19 and restricted tourism, even show a decline in the number of trips in the summer compared to the years before.

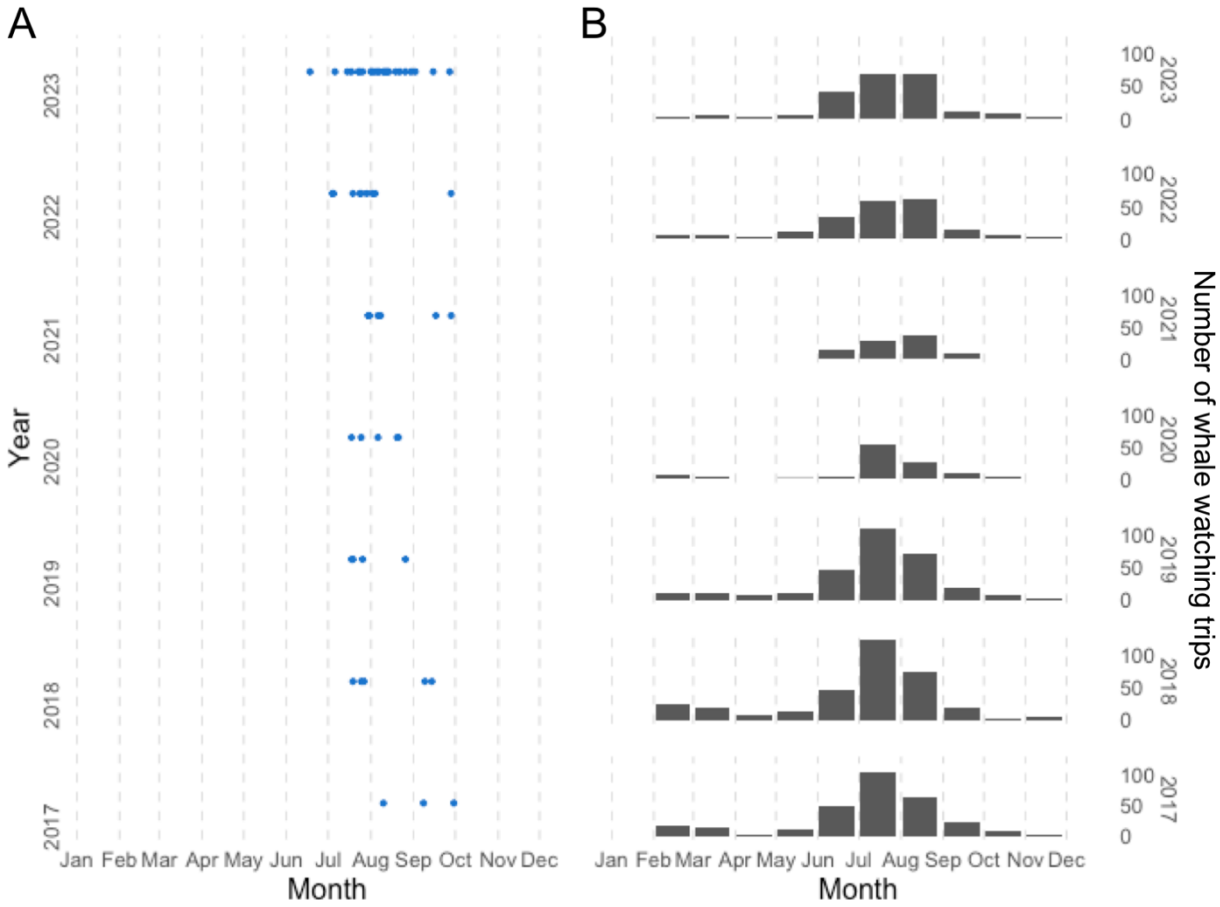

Figure 6: Risso's dolphins encounter days (A) and data collection effort (B) A. The days when Risso's dolphins were seen are displayed with blue dots for each year. B. The effort to collect data is demonstrated by the number of whale watching trips Whalesafari Andenes ran in every month between January 2017 and December 2023 (grey bars).

3.2 Encounter Locations

The encounter locations are mainly found in the Bleik Canyon starting where it drops down into the deep. At the edge of the canyon the water depth is around 200 metres and in its centre around 1,200 metres. A map with the encounters in the different years is shown in Figure 7. In 2017 the location was not recorded on any of the encounters. Therefore, data points for that year are not available.

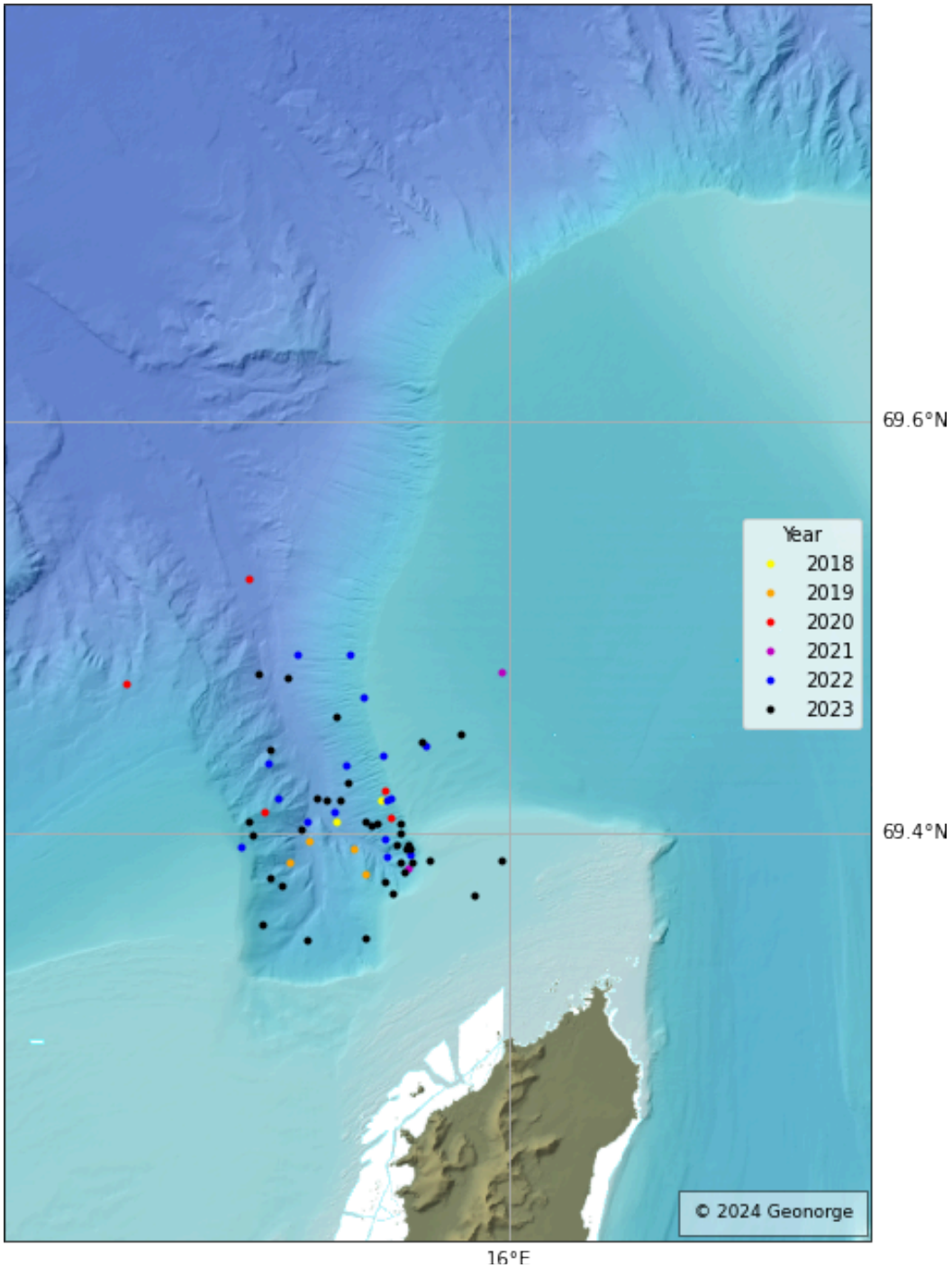

Figure 7: Locations of Risso's dolphins encounters in the area surrounding the Bleik Canyon. The locations, for the encounters with documented positions, are colour-coded for the different years.

3.3 Photo ID

The resulting Photo ID catalogue features 145 different IDs and can be found in the appendix. Exemplary pages of the overview of the dorsal fins and the detailed descriptions of the different individuals can be seen in Figure 8 and Figure 9, respectively. This Photo ID catalogue serves as basis for further investigations. It was compared to the Photo ID catalogues from Scotland (WDC, 2022a, b), Ireland (Felce, 2012; Seán O'Callaghan, personal communication) and France (Oihana Olhasque, personal communication), but no matches were found between this Norwegian and any of the other catalogues.

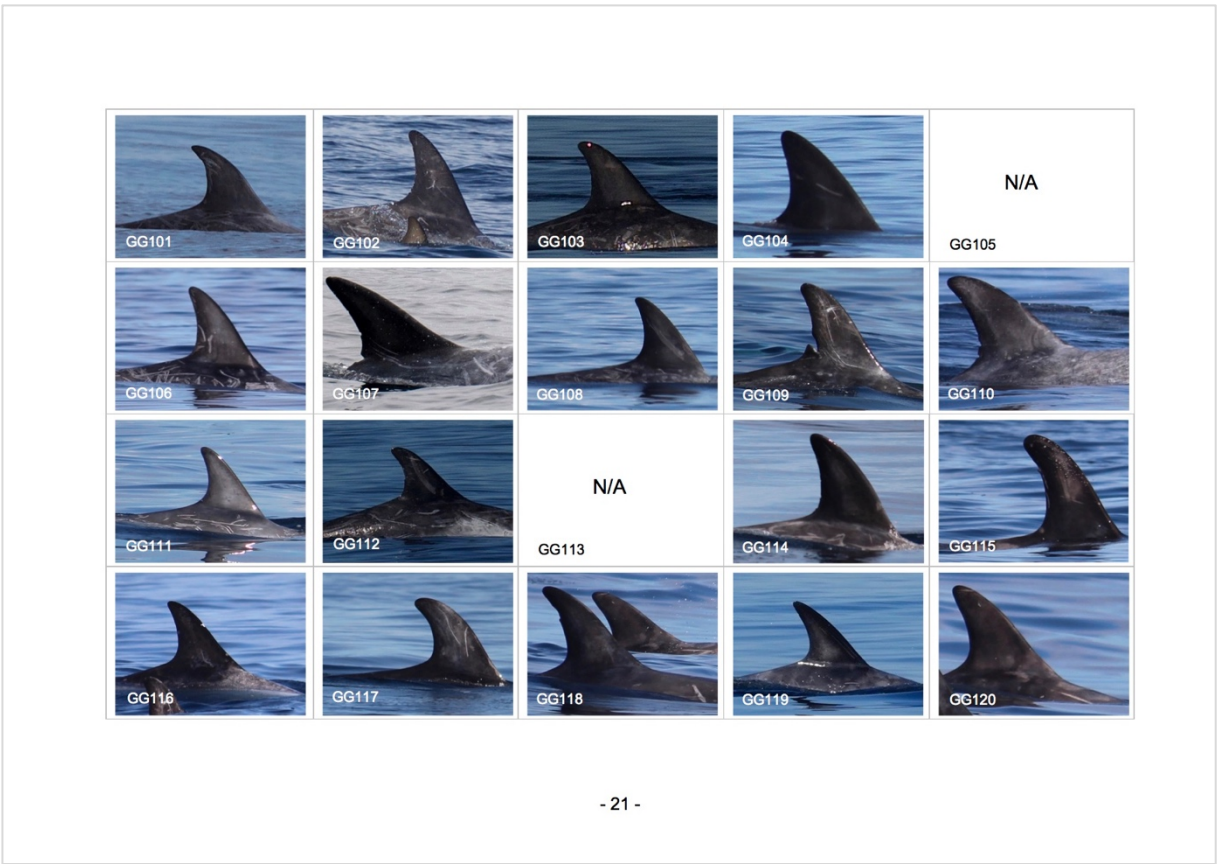

Figure 8: Example page of the overview in the photo ID catalogue. In principle, the dorsal fins of 20 different individuals are shown on one page in the overview, here IDs GG101 to GG120 from the right. If there is no picture available of an individual from one side the spot is kept empty and marked with "N/A".

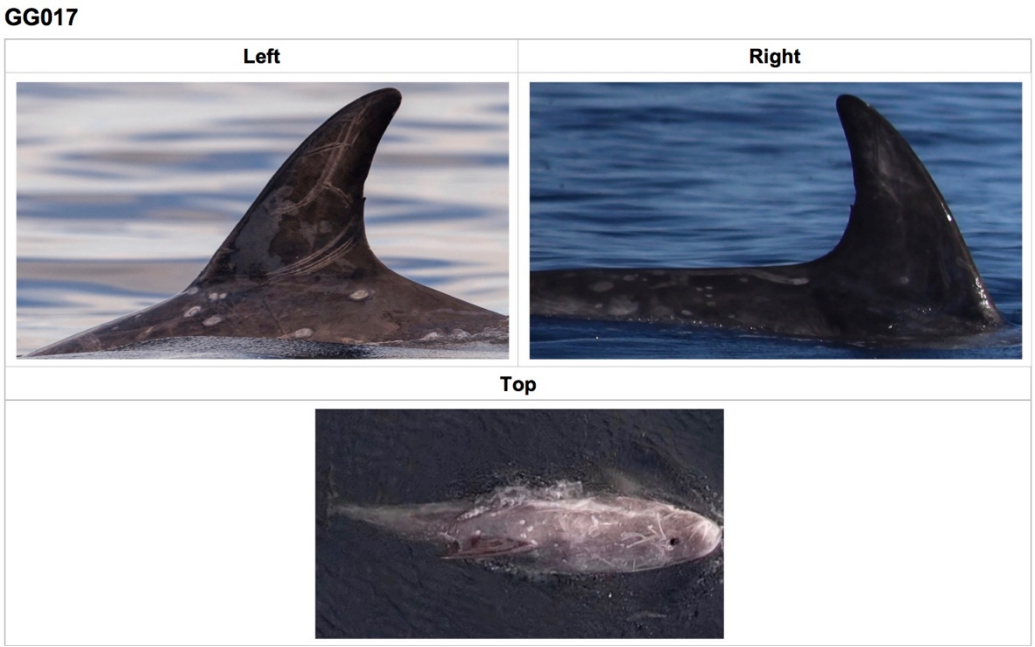

Figure 9: Example of a detailed description of an individual. The ID of the individual (here GG017) is given on the top left. If available, one photo from each side of the dorsal fin and a screenshot of the cropped frame from a drone video gives a clear visual description of the individual.

The number of individuals identified from either or both body sides is shown in Table 4 depending on the different identification groups.

Table 4: The number of identified individuals in the identification groups.

Identification group	Both sides	Left side only	Right side only	Minimum	Maximum
Temporary IDs	5	60	52	65	117
Juveniles/ calves	5	25	24	30	54
Catalogue IDs	67	47	31	114	145

The total number of how many different individuals were actually identified is not exactly clear, because images of both sides of the animals were used and neither are images of both sides available for every ID, nor are all available images of the body sides assigned to each other for all individuals in the catalogue yet. This means that there are most likely some individuals in the catalogue with different IDs for their left and their right body side.
To describe the minimum number of identified individuals the number of matched sides can be left aside for the moment. The number of different individuals in the catalogue is at least the number of the side of which more individuals were identified. In Table 4 the number for individuals identified from a particular side is the sum of the numbers in ‘both sides’ and ‘left/right side only’. For example in the identification group ‘Catalogue IDs’ the number of individuals identified from the left is 114 (the sum of 67 IDs from both sides and 47 IDs from the left side only) and 98 from the right (the sum of 67 IDs from both sides and 31 IDs from the right side). Therefore, the minimum of identified individuals in the catalogue is 114.

When describing the maximum number of identified individuals, the number of individuals of which the body sides have been matched must be taken into account. The maximum number is the sum of individuals identified from both sides, individuals identified from the right body side only, and individuals identified from the left body side only, under the condition that no individual was registered double from one side. This adds up to a maximum of 145 different individuals representing the number of IDs in the catalogue.
To find out how the number of identified individuals has developed over time, a cumulative discovery curve was plotted (Figure 10) including only individuals from the third group, which are the catalogue IDs. Individuals were only taken out of the data for the opposite side if they were identified from one body side. However, if an animal has been described from both sides in any of the years of the study period, but in one year photos of this individual were only taken of its right side, it will still be registered in the left body side data of Figure 10 B and vice-versa.

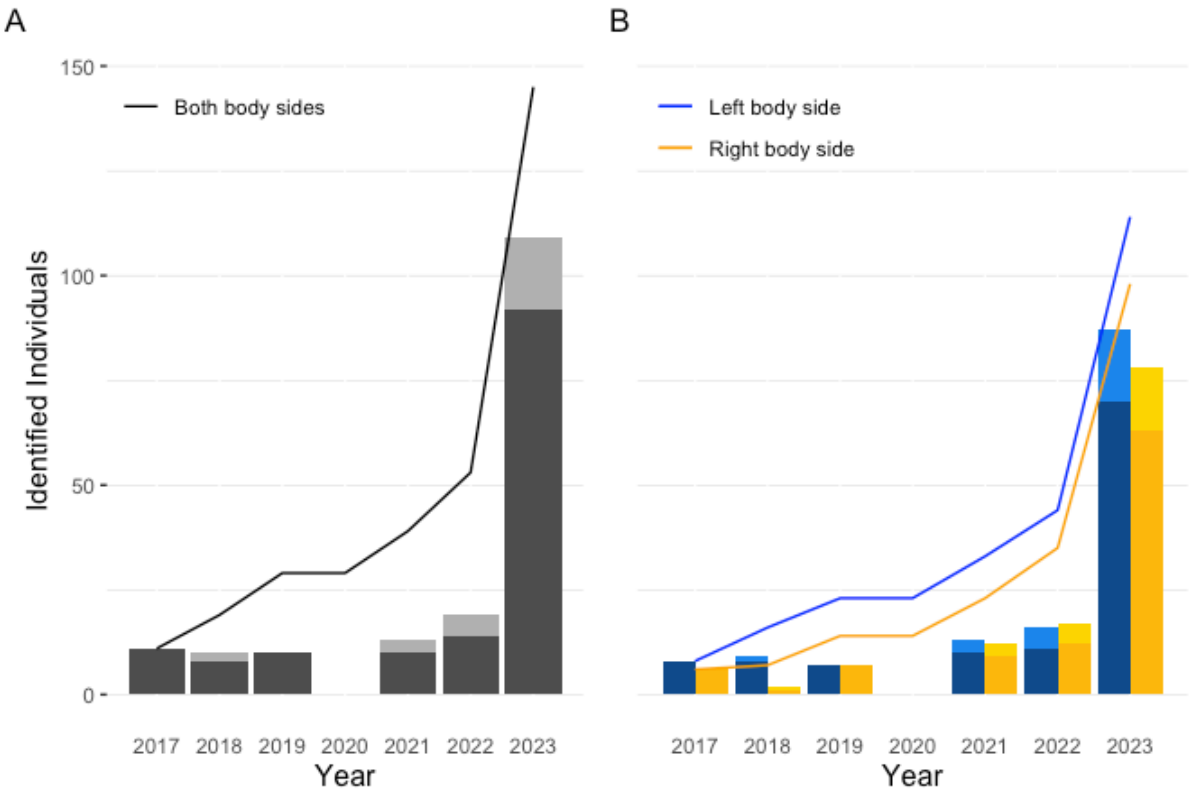

Figure 10: Cumulative Discovery Curves. A. The black curve shows the total number of individuals which have been identified from either their left or their right side up to the relevant year. The bars demonstrate the number of newly described individuals of that year (dark grey) and of individuals which have already been seen in one of the years before (bright grey). B. The same information is plotted separately for either side of the body (blue: left, orange: right).

Besides the stagnation in 2020, the photo ID progress appears to make a relatively constant progress from 2017 to 2022 in the number of newly identified as well as re-sighted individuals. In 2023 both of these numbers show a steep increase. Even though the number for the right body side is overall slightly lower, all curves show the same trends.

3.4 Sex Determination

It was possible to identify two individuals in the ID catalogue as females, based on available pictures showing their primary sexual organs. 55 others were determined as females, because they at least once had a calf on their side. Therefore, about 39% of

the catalogue were determined as females. For the rest of the IDs the sex stays unknown. For the temporary IDs all females had to be determined as such due to the presence of a calf on their side. No pictures showing primary sexual organs were available for this group. About 22 % of the temporary IDs were determined as females. The numbers of females and adults with unknown sex in the identification group excluding the calves and juveniles are shown in Table 5.

Table 5: The number of females and adults of which the sex is unknown in the different identification groups. In addition to the numbers of individuals of a certain sex in the two identification groups, the list below the table tells which of the individuals in the catalogue (see Appendix) were determined as females.

Identification group	Females	Adult, unknown sex
Temporary IDs	26	91
Catalogue IDs	57*	88

*two determined as females by visible primary sexual organs, 55 by the presence of a calf on their side.

The two individuals which were described as females based on their visible primary sexual organs on some of the pictures of GG072 and GG103.

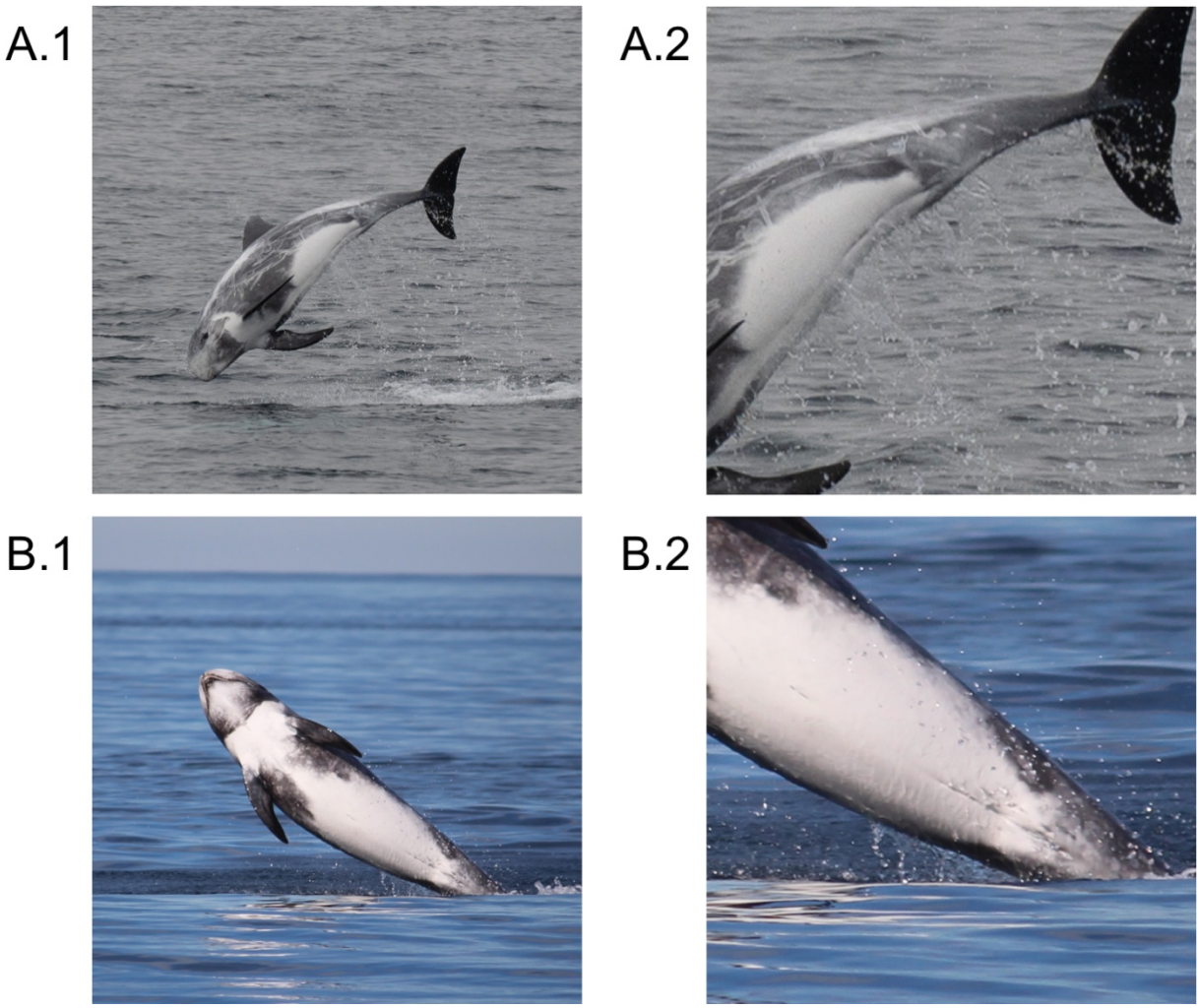

Figure 11: Visual primary sexual organs for the sex determination of the individuals GG072 (A) and GG103 (B). By zooming in on the primary sexual organs (A.2, B.2) the sex can be determined of the individuals which can be identified as GG072 (A.1) and (B.1).

Following individuals were determined as females by the presence of a calf on their side: GG007, GG009, GG010, GG011, GG012, GG013, GG014, GG015, GG016,

GG018, GG019, GG020, GG021, GG022, GG024, GG026, GG030, GG033, GG039, GG040, GG041, GG043, GG046, GG048, GG049, GG050, GG051, GG053, GG054, GG055, GG056, GG057, GG058, GG059, GG060, GG061, GG063, GG065, GG066, GG067, GG068, GG070, GG073, GG074, GG087, GG088, GG089, GG090, GG097, GG100, GG101, GG102, GG106, GG136, and GG145.

3.5 Risso's Dolphins in the Northeast Atlantic

The literature review on Risso's dolphins sightings in the Northeast Atlantic showed several results. Information was found in scientific publications (Chosson et al., 2023; Jefferson et al., 2014; Kiszka, 2018), a global (OBIS, 2023) and a national databank (Artsdatabanken, 2024), in a social media group (Facebook. MASNN - Marine Animal Stranding Network Norway, 2022) as well as from a whale watching company based in the Faroe Islands. Artsdatabanken is a citizen science platform and anyone can share unrevised information. This can cause the misidentification of the species in some cases. If the entries clearly showed a different species or were at least questionable, they were not considered for further analyses. Upon contacting the Faroese whale watching company Faroe Islands Whale Watch (FIWW) they shared a list with all the sighting records they know of in Faroese waters (FIWW, personal communication). Some of the sightings of this list are described more detailed in Bloch et al. (2012). The data points with the highest latitudes from OBIS were stated to come from the 'Institute of Marine Research' (IMR). So, these were further investigated for additional information and confirmed by the IMR (IMR, personal communication). Furthermore, catalogues were exchanged with scientists from places where the presence of Risso's dolphins is well known. Those places include Ireland (Felce, 2012; Seán O'Callaghan, personal communication), the north of France (Oihana Olhasque, personal communication), and Scotland (WDC, 2022a, b). The records from the different sources are demonstrated in Table 6.

Table 6: Recorded sightings in the Northeast Atlantic from reviewed sources. A. Institute of Marine Research, Norway (IMR); B. Ocean Biodiversity Information System (OBIS); C. Artsobservasjoner.no; D. Marine Animal Stranding Network Norway (MASNN); E. Marine and Freshwater Research Institute, Iceland (MFRI); F. Faroe Islands Whale Watch (FIWW).

A

Latitude	Longitude	Date	Information
76.33 N	13.58 E	04/07/2005	Alive, 5 individuals
74.42 N	16.35 E	11/05/2015	Alive, 3 individuals
73.02 N	19.13 E	24/08/2009	Alive, 20 individuals
71,80 N	28.05 E	11/07/2005	Alive, 2 individuals
69.33 N	16.00 E	1998	Alive, 2 individuals
66.82 N	13.25 E	23/06/1997	Alive, 15 individuals
64.40 N	10.47 E	20/02/2014	Alive, 1 individual
63.95 N	11.17 E	1982	Alive, 1 individual
63.67 N	10.73 E	1987	Alive, 1 individual
59.67 N	10.62 E	19/05/1986	Alive, 2 individuals

B

Latitude	Longitude	Date	Information
First 10 entries described in A.			
66.43 N	25.74 W	19/07/2004	
60.9 N	0.55 W	02/04/1981	
60.85 N	0.77 W	03/09/1980	
60.81 N	0.80 W	10/03/2006	
60.79 N	0.82 W	30/04/2000	
60.76 N	0.90 W	22/03/1970	
60.76 N	0.90 W	14/09/1976	
60.76 N	0.88 W	11/10/2002	
391 further entries			

C

Latitude	Longitude	Date	Information
69.53 N	15.38 E	02/08/2023	Alive, 20 individuals
69.46 N	15.58 E	27/08/2017	Alive, 2 individuals
69.42 N	15.66 E	11/08/2023	Alive, 25 individuals
69.42 N	15.66 E	12/08/2023	Alive, 20 individuals
69.35 N	16.18 E	19/07/2022	Alive, 10 individuals
63.36 N	8.50 E	31/01/2020	Stranded/ dead, 1 individual
63.21 N	8.04 E	23/02/2014	Stranded/ dead, 1 individual
62.41 N	5.62 E	23/03/2013	Stranded/ dead, 1 individual

D

Latitude	Longitude	Date	Information
No exact location; Rogaland, Norway		16/05/2022	Stranded/dead

E

Latitude	Longitude	Date	Information
65.16 N	21.09 W	12/07/2022	Stranded/ 1 alive, 1 dead

F

Latitude	Longitude	Date	Information
62.38 N	7.85 W	28/08/2009	4 individuals observed from a fishing boat
62.37 N	6.18 W	22/09/2011	20 individuals estimated
62.35 N	6.27 W	04/10/2023	40 individuals estimated
62.30 N	6.92 W	07/05/2017	A pod observed from land
62.18 N	6.68 W	28/08/1979	1 individual separated from its pod and driven into the bay and onto the beach, killed*
62.17 N	6.66 W	16/09/2009	Several pods, around 300 individuals estimated in total, 3 driven to the beach and killed, hunt stopped by local authorities before more individuals were killed*
62.11 N	7.04 W	13/02/2018	A dead female washed up on the beach
61.61 N	6.90 W	03/04/2010	21 individuals killed in a dolphin drive*
61.60 N	6.85 W	10/04/2010	Possibly individuals which escaped from the drive one week earlier
61.57 N	6.82 W	30/04/2011	15 individuals estimated
61.54 N	6.73 W	11/06/2018	A pod sighted east of Froðba
		16/09/2015	A drive involving Risso's dolphins was interrupted by Sea Shepherd*
		04/09/2019	A pod sighted east of the islands, information from a video posted on Facebook
		26/09/2020	A pod sighted from the ferry Smyril
		05/11/2022	Information from a Facebook post

*It is not legal to hunt and kill Risso's dolphins in the Faroe Islands, because too little is known about the species in Faroese waters. The animals which were hunted and killed were said to be mistaken for another species.

The sighting records which are listed in Table 6 were also plotted on a map for better visualisation (Figure 12). The different marks show which source the relevant information originated from.

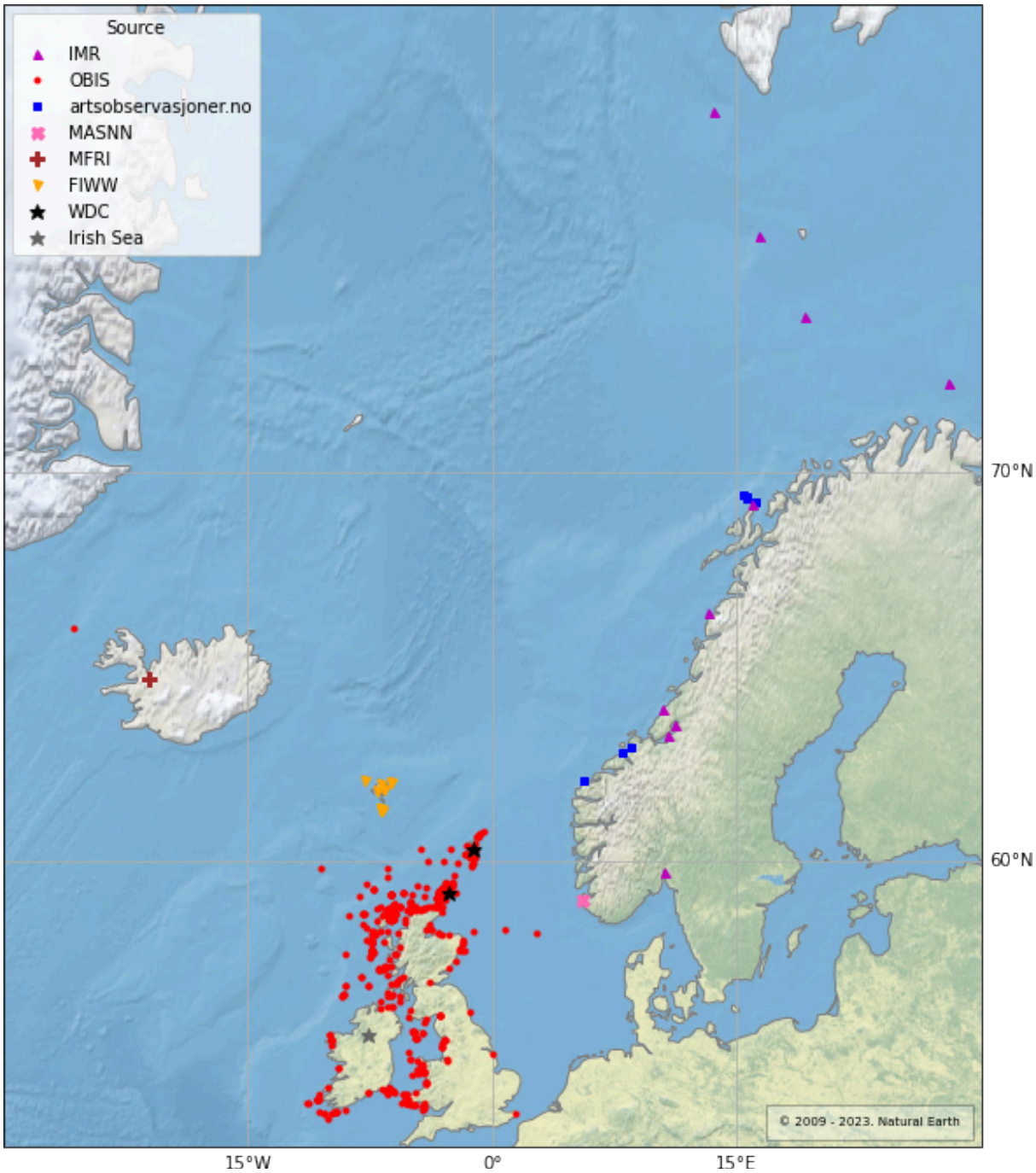

Figure 12: Previous Risso's dolphins sightings in the Northeast Atlantic. The map shows the locations where Risso's dolphins were seen previously. The source of the relevant sighting is indicated by the shape and colour of the marker. The purple triangles are included in the OBIS databank (OBIS, 2023) and were confirmed by the IMR (IMR, personal communication), red dots are from OBIS (OBIS, 2023), the blue squares from the Artsobservasjoner databank (Artsdatabanken, 2024), the pink cross is from the Facebook group (Facebook. MASNN - Marine Animal Stranding Network Norway, 2022), the brown cross from an Icelandic publication (Chosson et al., 2023), and the orange triangles from a whale watching company in the Faroe islands (FIWW, personal communication). The black and grey stars show places from which Risso's dolphins ID-catalogues are available (black: Scotland (WDC, 2022a, b), grey: Ireland (Felce, 2012; Seán O'Callaghan, personal communication).

4. Discussion

4.1 Variation in the Data Collection

Whale watching first started in the study area in 1987. That there is only a single documented sighting in this area in 1998 before the regular sightings in the study period suggests that the species was not commonly present there before.

There are several factors which lead to a variation in the data collection. One factor is the weather. The study area is on the open ocean and cannot be reached in bad conditions. This brings a natural variation in the data collection. Bad weather windows have a definite impact on the presence of whale watching and research vessels going to Bleik Canyon. Another factor is that the focus of the whale watching companies and research organisations can also be shifted to other regions and whale species. If for example killer whales are sighted closer to shore, the whale watching boats will usually not go out further to search for other whales. There certainly is a variation throughout the seasons of the year too. The number of whale watching trips run by Whalesafari Andenes, which is meant to give an indication about the effort in the data collection, shows that the boat presence around the Bleik Canyon is a lot higher in summer than in winter.
The missing information about the number of whale watching trips operated by Whale2Sea leaves a big gap especially in the discussion about the seasonality of Risso's dolphins presence in the area. Because Whale2Sea has smaller boats, they sometimes run trips between off-season and main season when the touristic demand is not high enough to make it affordable to go out with a big boat. Therefore, the effort, symbolised by the number of whale watching trips, could have been relatively higher in April, May, September, and October. A big part of the data originates from the Whale2Sea trips. Therefore, a comparison of the sighting records to the effort invested by the company would be an important piece of information to know how likely it actually is to encounter Risso's dolphins outside the months between June and September.
The lower number of Risso's dolphins sightings in 2020 and 2021 are probably underestimations compared to the other years and caused by fewer tourists in the area and therefore lower demand in whale watching tours in the first two summers of the COVID-19 pandemic.
The increase of the number of Risso's dolphins sighting days throughout the summers within the last two years seems severe. Different factors can play a role on how often Risso's dolphins are encountered though. 2023 was the first year of the author in the region. This could at least indirectly have had an impact on the effort made to study the species. By encouraging other people to take photos and record sightings it is likely that the data acquisition in 2023 had a higher focus than in previous years. Additionally, with the author one more person with high interest in this study was out on the water at the Bleik Canyon many times. Therefore, it can be suspected that the number of individuals in the area was overestimated in comparison to the other years, although the number of present individuals in the area like in all years of this study is still underestimated because it has never been possible to identify every single observed individual so far. To summarise, in 2023 the underestimation of present individuals in the study area is most likely smaller than in the other years of the study due to higher effort in the data collection.

Although with lower effort in winter, sperm whales (*Physeter macrocephalus*) are studied all year round in the study area by Whale2Sea and by Zoë Morange in particular who is writing her PhD on this species. Killer whales which follow big schools

of spring-spawning herring (*Clupea harengus*) into the fjords further north are even studied with an increased effort in the winter in Northern Norway by Norwegian Orca Survey (Eve Jourdain), but not in the area of the Bleik Canyon.

Outside the study area, Risso's dolphins in the North Atlantic are studied all year round by the Nova Atlantis Foundation around Karin Hartman on Pico, Azores (Hartman et al., 2008), by Association Al Lark in the north of France in close relation to dolphin watching tours (Association Al Lark), and around Scotland by WDC mostly based on shore based observations and citizen scientists (Hodgins et al., 2024). The data collection effort in the Azores is comparatively higher than the effort invested in the study area. The effort of the other two mentioned research projects is probably lower or similar, although this is hard to compare due to the different ways of collecting the data.
Research projects completely dedicated to one species and independent from tourism companies do not face such a big variation in effort over the year or at least they can specifically decide when it makes sense to invest this effort. Data collection based on watching from shore and citizen scientists is restricted in other ways. As the data gets typically collected from greater distance in average the quality of the data is lower than when the animals can get approached by boat.
Even though the effort in data collection varies when working in cooperation with whale watching companies this offers a great opportunity to accumulate a lot of data with very low financial effort. Especially in summer several boats roam the area, can find the animals, document encounters and take photos at the same time.

4.2 Bleik Canyon as Risso's Dolphins Habitat

Canyons are known for their productivity. The increased turnover of the water masses brings nutrients up to the surface waters where phytoplankton can thrive. This has an effect on all trophic levels and makes underwater canyons a suitable habitat for cetaceans (Breen et al., 2020; Chicote et al., 2023; David & Di-Méglio, 2012; Moors-Murphy, 2014).
The encounter locations seem to fit with the location of the Bleik Canyon quite well. In particular the south-eastern end of the canyon seems to be more frequented by this species. Because whale watching boats often pass through exactly this area when they head out into the middle of the canyon to listen with directional hydrophones in the search for sperm whales, there might be a bias towards more encounters in the south-eastern part of the canyon. Risso's dolphins seem to prefer the deeper waters on the slope of the canyon and were less sighted in shallower waters. Otherwise the vast majority of sightings would not stop so precisely in the area where it gets shallower. In general, Risso's dolphins tend to stick to the continental slopes (Azzellino et al., 2008; Jefferson et al., 2014), around the British Isles they have been observed in shallower waters though (De Boer et al., 2013; Hodgins et al., 2024; Stevens, 2014).
There are several possible explanations for the relatively low number of re-sighted individuals in the study area between the different years. One of them is that even among the catalogue IDs less than half of the individuals are described from both body sides. Among the temporary IDs and the juveniles and calves this number is even lower. This fact increases the chance of missing out on possible re-sightings in the evaluation of the taken photos. Another explanation can be that these dolphins do not tend to stay or come back to exactly one specific spot but rather a wider geographic area. This explanation can also be intertwined with the possibility that the population is actually a lot bigger than the number of identified individuals and that those identified individuals are only the smallest part of the whole population. These two possibilities

would also reduce the chance of re-identifying individuals from sightings in previous years.
In the study area, Risso's dolphins share their habitat with several other cetacean species: sperm whales (*Physeter macrocephalus*) frequent the deeper waters along the continental slope, long-finned pilot whales (*Globicephala melas*) have a slight preference for the deep waters, but also enter the shallower waters in Andfjord, killer whales (*Orcinus orca*) and minke whales (*Balaenoptera acutorostrata*) can be seen in deep waters just as well as in the shallow waters close to the coast.

4.3 Risso's dolphins as a Summer Visitor to the Study Area

The facts that these dolphins have only been encountered in summer and that the summer sea surface temperatures in this region are at the lower end of their typical distribution range may lead to the assumption that these animals leave the area in winter and probably move further south where the water does not cool down to so low temperatures. It cannot be ruled out that they stay there though. The lower number of whale watching trips might be the reason why they are not observed in other periods of the year.
Risso's dolphins in Scotland possibly also show seasonality in some areas. The highest number of sightings in the area around Orkney and Shetland is recorded in the months between July and September. But the higher sighting numbers over the summer could just as well only be lead back to the increased effort in the data collection in this period (Hodgins et al., 2024).
Other species come to the study area at certain times of the year in response to the availability of specific prey types. Killer whales are present in the spring when lumpfish (*Cyclopterus lumpus*) is abundant (Jourdain et al., 2019). Killer and humpback whales (*Megaptera novaeangliae*) used to come to the area in winter (Jourdain & Vongraven, 2017) and nowadays only pass through accompanied by fin whales (*Balaenoptera physalus*) in autumn and spring after the wintering grounds of the spring-spawning herring have moved further north.

4.4 Photo ID as a Powerful Tool in Cetacean Research

For photo identification in dolphins the shape of the dorsal fin is the common way to tell different individuals apart from each other (Hammond et al., 1990). Some individuals have nicks in the trailing edge of their dorsal fins, others have partially or completely collapsed dorsal fins. For some bigger whale species like sperm whales and humpback whales the fluke is used to identify different individuals (Hammond et al., 1990).
Individual Risso's dolphins can be identified either by their dorsal fin or by the patterns on their skin which is often even more unique for a specific individual in this species. Through social interactions, hunts and other activities, Risso's dolphins accumulate scars on their body, which stay visible for their entire life (MacLeod, 1998). Scars usually remain as bright stripes on the Risso's dolphins' skin, marks are less bright and come in the form of patches. Because these patterns are in many cases enough to certainly identify an individual, the perfect perpendicular angle of the photo towards the animal is often not needed.
The scars and marks made it a good way to identify individuals from different perspectives including from a bird's-eye view. Approaching the individuals in the study area by boat has many times been challenging and due to this, photos of high quality are not common. Barely any encounter, if any at all, ended with the photo collection of all animals in the group from one side. Thus, to gather more information both body sides were used to identify individuals and collect additional data, even though the left

side is the common one to identify and describe dolphin individuals (Hammond et al., 1990). The drone footage also added valuable data. But the available drone material was quite limited. Therefore, the body sides of several individuals could still not get matched to each other leading to the uncertainty about the number of individuals in the particular groups and overall identified.
Using both body sides in Photo ID projects is not uncommon (Hartman et al., 2008; WDC, 2022a, b). There are several reasons why it can make sense to do so. Difficulties in approaching animals or if it is not possible to approach them at all can be one, working from whale watching boats which do not have a preferred side of approach another one. In the end it is always in the hand of the person who conducts the study to decide what works best in this particular case. Using drones for photo ID is still in the beginning, but it has been used to study the movement of cetaceans within their group in several studies (Fettermann et al., 2022; Gies et al., 2024; Hartman et al., 2020)
Overall it can be summarised that Photo ID proved to be a powerful tool when working with Risso's dolphins and can even be further enhanced by combining it with drone footage. While this is a method which has been widely used in the field of cetacean research there is still potential for improvement. The application of artificial intelligence software can help to increase the efficiency when comparing large numbers of new photos to the existing data. Convolutional neural networks have already been applied in photo-ID of Risso's dolphins (Maglietta et al., 2018, 2020; Renò et al., 2022).

4.5 Social Structure

During the study period, several types of groups were observed in the study area. Some consisted of almost only adult females with calves on their sides. But most likely some other groups which were observed consisted of mostly adult males. These two group types fit into the concept of social stratified units described by Hartman et al. (2008) based on studies conducted on Pico, Azores. Apart from those two group types bigger groups have also been observed with individuals possibly from both sexes and all different age groups.
The social structure can also give a hint on who these dolphins are and where they come from, as "resident" Risso's dolphins in the Azores are organised in social stratified units and "offshore" Risso's dolphins come in larger groups composed of individuals of both sexes and different age groups (Karin Hartman, Nova Atlantis Foundation, personal communication).
In contrast to other dolphin species kinship is not a driver for the association with other individuals in the social stratified units of the Risso's dolphins, whereas in killer whale group associations for example kinship is the main driver (Bigg et al., 1990; Jourdain et al., 2024).

4.6 Proposed Modified Distribution Range

In the Bleik Canyon Risso's dolphins are a common visitor in the summer now. The total number of individuals and the fact that some individuals have come back to the area in subsequent years in a row show that those are not only some animals which got lost and ended up there by mistake (Eckerle et al., 2024). It is safe to say that the species is now regularly found far outside what was thought to be their distribution range and their presence seems to be increasing. With so many regular Risso's dolphins sightings far outside their known distribution range (Kiszka, 2018) there is reason to argue for extending its borders (Figure 13). Therefore, this region should be included in their distribution range.

The species was not documented in the literature of the Faroe Islands, even though the Faroese have a close relationship to the sea and have been actively hunting for whales for a long time (Fielding, 2021; FIWW, personal communication). Only since 2009 they seem to have become more common in this area. But the Faroe Islands are probably on the very edge of their distribution range, because encounters there are a lot less regular and rarer than they have become in Northern Norway.

Most likely the Bleik Canyon represents the Northern limit of their distribution as there have not been any regular observations and the sea surface temperatures are below the typical range for this species. The observations in those areas by survey vessels are very spread out and unregular. Even though specialists are onboard on those surveys, it is possible that the species was not correctly identified in some cases. Nevertheless, it cannot be excluded that they are common even further north (e.g. 76.33°N, IMR/OBIS data: Table 6A) due to the fact that this part of the North East Atlantic is not as highly frequented by vessels recording encounter data of cetacean species and therefore the presence of the species further north could have been missed so far. Distribution shifts were recently reported for other cetaceans (Jourdain et al., 2021; Nøttestad et al., 2015). There are studies about the range extensions further north into Arctic waters of copepods (Freer et al., 2022), birds (Vihtakari et al., 2018), and fish (Berge et al., 2015; Gordo-Vilaseca et al., 2023).

Additionally to the recorded sightings outside the species' distribution range in the Northeast Atlantic, there are several documentations by OBIS outside the distribution range in the South Atlantic. These documentations all state from acoustic detections between October and December 2019 conducted by the University of St Andrews (Elwen et al., 2023). The vocalisation of Risso's dolphins is not extensively studied, but it is known that they share characteristics in their vocalisation with several other cetacean species (Neves, 2013). Upon contacting Thomas Webber, who was mentioned as responsible person for the data entries in the OBIS databank, he stated that there were no concurrent visual observations to the acoustic detections. On top of that, the classification of the vocalisations can only be assigned to delphinids in general and not to a specific species (Thomas Webber, Scottish Association for Marine Science, personal communication).

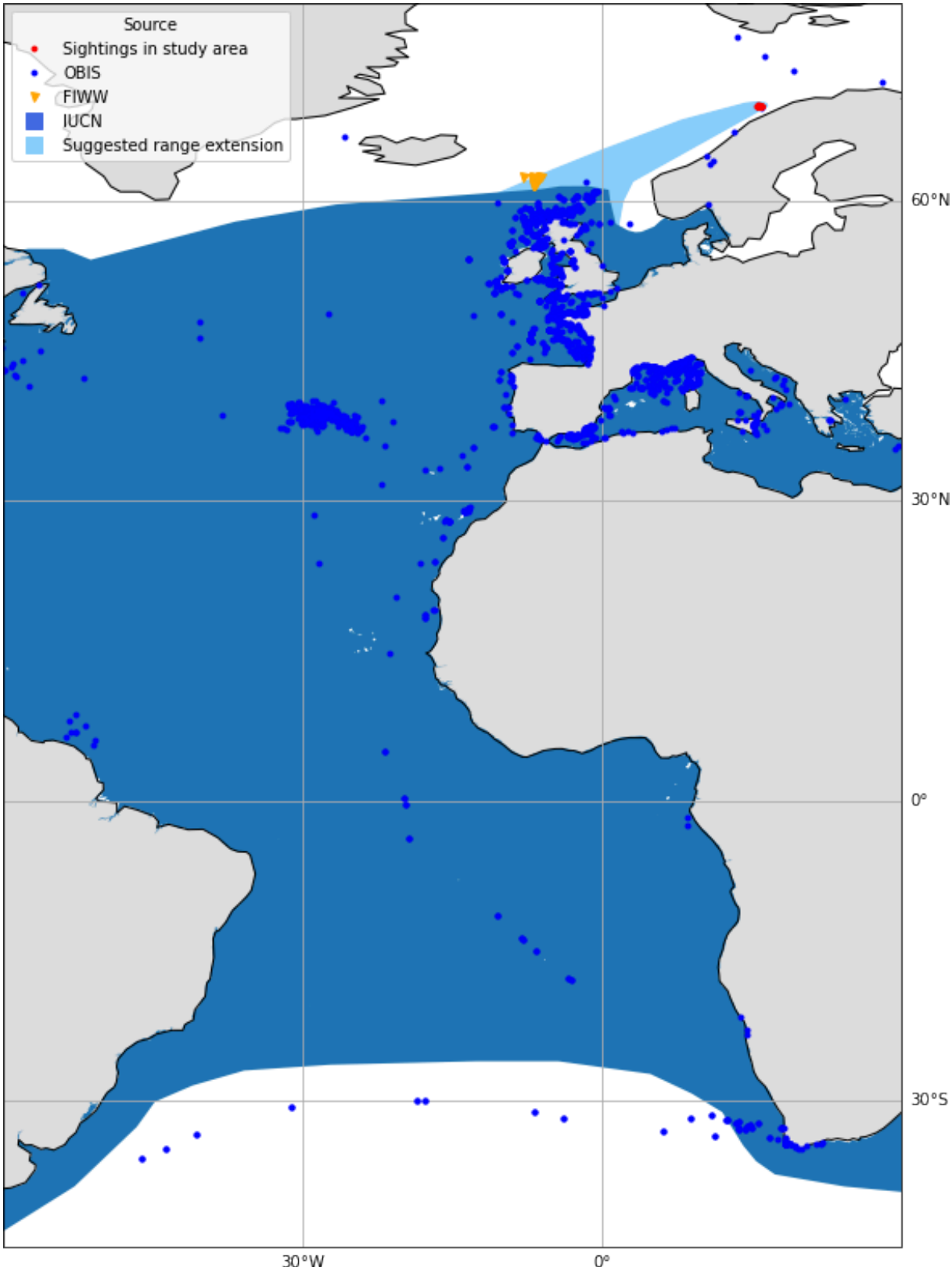

Figure 13: Suggested Risso's dolphins distribution in the Atlantic based on new data. The suggested new distribution range includes the study area (red dots) and ends close to the Faroe Islands (FIWW, orange triangles) (FIWW, personal communication). The darker blue area shows the distribution of the species according to The IUCN Redlist (Kiszka, 2018), the blue dots sighting records from OBIS (OBIS, 2023), and the lighter blue area the suggested addition to the species' distribution in the Northeast Atlantic.

In the following, possible reasons for the extended distribution range will be discussed. One reason for the range extension could be that they follow a range extension of their prey. Risso's dolphins are known to feed almost exclusively on cephalopods (Blanco et al., 2006; Bloch et al., 2012; Cockcroft et al., 1993; Evacitas et al., 2017; Luna et al., 2022; Oztürk et al., 2007; Pauly et al., 1998; Plön et al., 2020; Würtz et al., 1992). However, it has not been possible to further investigate the Risso's dolphins' diet in the study area. Cephalopods are not targeted by the fisheries in Norway and there are no statistics about the relevant species in bycatch of fishing vessels (IMR, personal communication). In 2023, a research vessel took eDNA samples at several places in the Bleik Canyon. The results of those samples are yet to be published but could at least provide information about what cephalopod and other potential prey species there are in the canyon, even if it cannot ultimately be proven what the dolphins diet consists of. However, the question is not only what they feed on, but also when. In other places they have been observed to feed mostly during the night, when they dive down to find their prey at the upper end of the diurnal vertical migration range (Rone et al., 2022; Visser et al., 2021). In the summer of the Arctic, when the sun does not set, this migration has been observed to be highly reduced (Berge et al., 2014; Blachowiak-Samolyk et al., 2006). If this has an impact on the Risso's dolphins feeding behaviour is yet to be studied.

Another reason to explain this range extension is the increase of the water temperatures in the Arctic. An exact number for the minimum sea surface temperature Risso's dolphins like cannot be given. It is believed to be around 12 °C though (Karin Hartman, Nova Atlantis Foundation, personal communication). It is known that the temperatures in the Arctic increase faster than in most other places of the globe (Rantanen et al., 2022). This can also be observed in the area of the Bleik Canyon. Figure 14 shows the sea surface temperatures measured by 'National Aeronautics and Space Administration' (NASA) satellites in August every year since 2005 at the position 69.5 °N, 15.5 °E which is at the north-western end of the canyon (NASA).

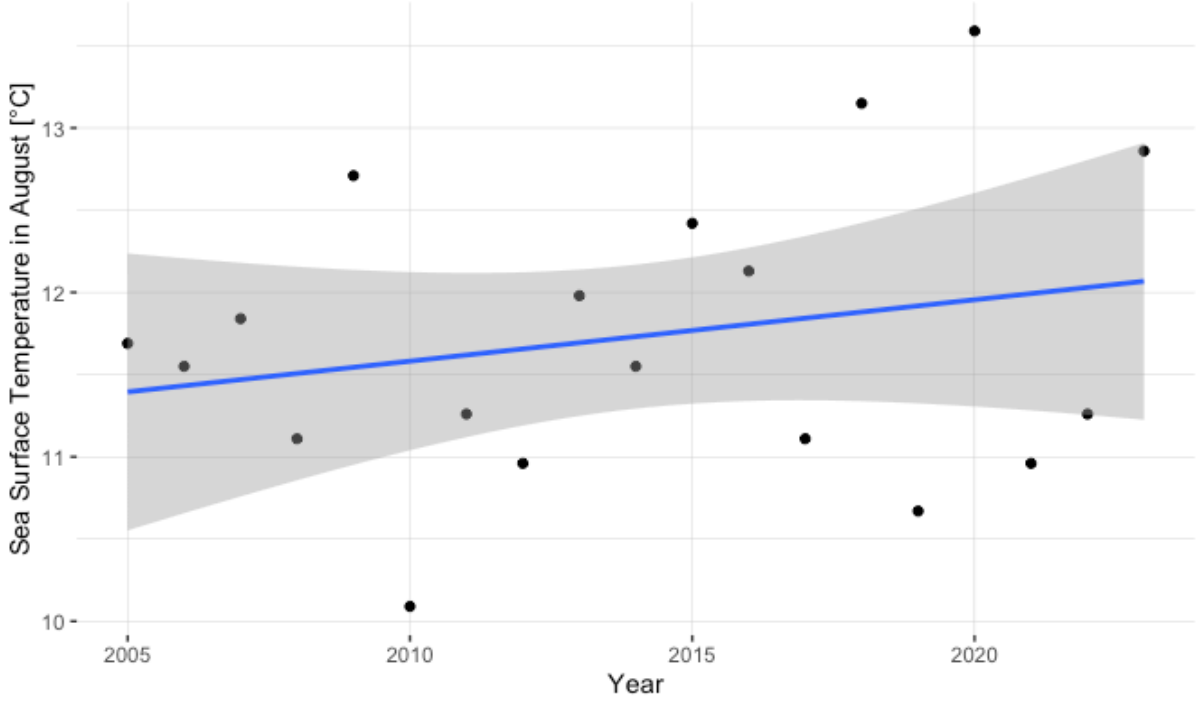

Figure 14: Sea surface temperature in the area of the Bleik Canyon. The data points represent the temperatures in August of the relevant year. The blue line shows the linear trend with the confidential interval of 95 % in grey (NASA).

The increased number of sightings of Risso's dolphins in the study area indicates that the species has already reacted to the changing conditions of warmer waters and/or prey availability and has therefore expanded their distribution range further north. It seems likely that this trend will continue over the next years and it will be become more and more common to be encounter Risso's dolphins in the Bleik Canyon.

The term Atlantification of the Arctic describes the change of the water masses in the North East Atlantic. Warmer, more saline waters spread out further and further north (Asbjørnsen et al., 2020). The effect this has on different species (Freer et al., 2022; Gordo-Vilaseca et al., 2023; Vihtakari et al., 2018) and in particular on cetacean populations has been investigated recently. According to Nøttestad et al. (2015) higher numbers of toothed whales were observed in Norwegian waters in response to the higher availability of prey species, whereas humpback whales were observed less often. Killer whales followed the shift of one of their key prey species the spring-spawning herring into the wintering grounds which have shifted further north (Jourdain et al., 2021). Regarding those changes in the Northeast Atlantic ecosystem it makes sense that they have an impact on the Risso's dolphins' distribution as well. MacLeod (2009) already predicted this change of the species' distribution range in a study 15 years ago.

Finally, looking at the question where these dolphins come from, it can be ruled out though that they come from the North and made it all the way from the pacific side of Russia. Even in Eastern Russia they are not very common (Ryazanov & Ryazanova, 2023) and the waters north of Russia are far too cold for the species. If these animals had split off from the population in the Azores, they would have made it a very long way. That they made their way up the Norwegian coast also seems unlikely. The waters in the south of Norway are highly frequented by all sorts of vessels, however, there are only few sighting records, many of which are of stranded individuals (Artsdatabanken, 2024; Facebook. MASNN - Marine Animal Stranding Network Norway, 2022; IMR, personal communication). If they had followed the coast they would probably have been detected earlier. So, the most apparent explanation is that their distribution range extension followed the continental slope. In most places the slope is far from the coast and not frequented by many boats. Out there they could have spread out for several years without having been observed regularly earlier. Possibly nursery pods came to the canyon first in the hope to find a place to avoid pressure from males (Hartman et al., 2014; Karin Hartman, personal communication). The males could have followed after a while in the search of females to mate with.
As there were no matches to be found in any of the catalogues this new Norwegian catalogue was compared to, the individuals in this study probably do not belong to a population which has been described and regularly observed before. The open seas along the continental slope are with high chance also the place where those individuals spend the rest of the year when they are not found in the Bleik Canyon area.

5. Conclusions

This study can be seen as the starting point to reveal the secrets behind the appearance of the Risso's dolphins in Northern Norway.
The distribution range of the Risso's dolphin should be adjusted at least to the data that is now available. But the presence of the species in the area of the Bleik Canyon raises more questions some of which can hopefully be answered in the future with more data available.
Biopsy samples taken from the Risso's dolphins in Northern Norway and the comparison of their DNA to individuals from other parts of the Atlantic could reveal the origin of this range extension. However, approaching the animals close enough to take biopsy samples is a challenging endeavour. For this reason, it will be a challenge to try and get those samples.
Figuring out how their pods are composed and comparing the social structure to that from other places might also help to find out where these dolphins come from and might tell even more about their movement patterns. Enhanced photo ID work and the combination of the information collected by taking photos from the boats and additional drone material could be the key to this issue. It has been proven that it is possible to identify individuals from the birds-eye view, but this perspective also gives a good opportunity to see the movement and connection of different individuals to each other. Mother-calf pairs can easily be made out and because the dolphins are very well visible through the water from this perspective counting the number of individuals in a group is made easier than while taking pictures from the boat. On top of that the drone can be used to match body sides of the individuals which makes the data more robust and a more precise estimation about how many different individuals roam the area can be made.
Capture-recapture models can be applied to estimate the population size around the Bleik Canyon (Urian et al., 2015). At this point the amount of data is probably still too low to make adequate estimations. Additionally, the maximum number of individuals which come to the area might still not be reached in the habitat shift of this part of the population. Another tool which has not been used at all is acoustics. Placing permanent hydrophones in the waters around the canyon and passive acoustic monitoring (Webber et al., 2022) could give a clue when the species is to be found there, even on bad weather days when the boats do not go out or in the off season when there are generally less whale watching trips. Attaching tags on some individuals could tell us more about where they go when it gets colder and about their diving behaviour. This again is connected with their feeding behaviour. Faecal samples could be collected to find out more about what the Risso's dolphins feed on in the Bleik Canyon. However, like the biopsy sampling and the attachment of tags collecting the samples would face the challenge of approaching the dolphins close enough by boat and finding the right moment for any of these methods.
However, many questions remain. Future studies can possibly answer these questions and explain the reasons, but also the implications for other species and the whole ecosystem these new inhabitants of the Bleik Canyon bring with them. Despite that, the example of the Risso's dolphin can help to understand changes happening everywhere in the Arctic ecosystem.

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Erklärung zur Bachelorarbeit

Hiermit versichere ich, dass die vorliegende Arbeit von mir selbstständig verfasst wurde und dass keine anderen als die angegebenen Quellen und Hilfsmittel benutzt wurden. Diese Erklärung erstreckt sich auch auf in der Arbeit enthaltene Graphiken, Zeichnungen, Kartenskizzen und bildliche Darstellungen.

Bachelor's thesis statement of originality

I hereby confirm that I have written the accompanying thesis by myself, without contributions from any sources other than those cited in the text and acknowledgements. This applies also to all graphics, drawings, maps and images included in the thesis.

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Ort und Datum Place and date	Unterschrift Signature

Appendix

Table 7: List of IDs documented in the relevant year.

2017	2019	2022	2023	2023	2023	2023
GG_j001	GG_t009	GG_t010	GG_j045	GG_t085	GG057	GG115
GG_j015	GG_t089	GG_t011	GG_j046	GG_t087	GG058	GG116
GG_j016	GG_t090	GG_t012	GG_j047	GG_t088	GG059	GG117
GG_t007	GG_t091	GG_t013	GG_j048	GG_t092	GG060	GG118
GG_t020	GG007	GG_t014	GG_j049	GG_t093	GG063	GG119
GG_t021	GG016	GG012	GG_j050	GG_t094	GG064	GG120
GG_t022	GG037	GG016	GG_j051	GG_t096	GG065	GG121
GG_t023	GG038	GG017	GG_j052	GG_t097	GG066	GG122
GG_t024	GG040	GG019	GG_j053	GG_t098	GG067	GG123
GG_t025	GG041	GG021	GG_t009	GG_t099	GG068	GG124
GG_t044	GG060	GG025	GG_t015	GG_t100	GG071	GG125
GG001	GG061	GG043	GG_t016	GG_t101	GG072	GG126
GG002	GG062	GG045	GG_t017	GG_t102	GG073	GG127
GG003	GG063	GG046	GG_t018	GG_t103	GG074	GG128
GG004		GG047	GG_t019	GG_t104	GG075	GG129
GG005	**2020**	GG048	GG_t045	GG_t105	GG076	GG130
GG014	GG_j018	GG049	GG_t046	GG_t106	GG077	GG131
GG027	GG_j019	GG050	GG_t047	GG_t107	GG078	GG132
GG028	GG_t002	GG051	GG_t048	GG_t108	GG079	GG133
GG029	GG_t003	GG052	GG_t049	GG_t109	GG080	GG134
GG030	GG_t004	GG069	GG_t050	GG_t110	GG081	GG135
GG054	GG_t039	GG070	GG_t051	GG_t111	GG082	GG136
	GG_t040	GG073	GG_t052	GG_t112	GG083	GG137
2018	GG_t041	GG101	GG_t053	GG_t113	GG084	GG138
GG_j007	GG_t042		GG_t054	GG_t114	GG085	GG139
GG_j017	GG_t043	**2023**	GG_t055	GG_t115	GG086	GG140
GG_t001		GG_j011	GG_t056	GG_t116	GG087	GG141
GG_t008	**2021**	GG_j012	GG_t057	GG_t117	GG088	GG142
GG_t026	GG_j003	GG_j013	GG_t058	GG_t118	GG089	GG143
GG_t027	GG_j004	GG_j014	GG_t059	GG_t120	GG090	GG144
GG_t028	GG_j005	GG_j021	GG_t060	GG003	GG091	GG145
GG_t029	GG_j020	GG_j022	GG_t061	GG007	GG092	
GG_t030	GG_t005	GG_j023	GG_t062	GG009	GG093	
GG_t031	GG_t006	GG_j024	GG_t063	GG010	GG094	
GG_t032	GG012	GG_j025	GG_t064	GG011	GG095	
GG_t033	GG013	GG_j026	GG_t065	GG013	GG096	
GG_t034	GG014	GG_j027	GG_t067	GG015	GG097	
GG_t035	GG015	GG_j028	GG_t068	GG016	GG098	
GG_t036	GG016	GG_j029	GG_t069	GG017	GG099	
GG_t037	GG017	GG_j030	GG_t070	GG018	GG100	
GG_t038	GG018	GG_j031	GG_t071	GG019	GG101	
GG001	GG019	GG_j032	GG_t072	GG020	GG102	
GG004	GG021	GG_j033	GG_t073	GG023	GG103	
GG006	GG022	GG_j034	GG_t074	GG026	GG104	
GG008	GG024	GG_j035	GG_t075	GG033	GG105	
GG018	GG039	GG_j036	GG_t076	GG041	GG106	
GG031	GG066	GG_j037	GG_t077	GG042	GG107	
GG032		GG_j038	GG_t078	GG044	GG108	
GG034	**2022**	GG_j039	GG_t079	GG045	GG109	
GG035	GG_j002	GG_j040	GG_t080	GG047	GG110	
GG036	GG_j008	GG_j041	GG_t081	GG050	GG111	
	GG_j009	GG_j042	GG_t082	GG053	GG112	
2019	GG_j010	GG_j043	GG_t083	GG055	GG113	
GG_j006	GG_j011	GG_j044	GG_t084	GG056	GG114	