InterMed

An international project to study and protect the cetaceans of the Mediterranean Sea

Funded by ***Blue Planet - Virgina Böger Stiftung X.X.***

Coordinated by Fondazione Acquario di Genova and WWF Switzerland.

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INTERMED

FINAL SCIENTIFIC REPORT

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1. Introduction

The Mediterranean is a semi-enclosed sea, embedded between Eurasia and Africa and connected to the Atlantic Ocean through a natural, 59-km wide channel, the Strait of Gibraltar. It is an oligotrophic sea (Pujo-Pay *et al*., 2011; Tanhua *et al*., 2013), with a low level of primary productivity and biomass compared with the Atlantic, but owing to its geological history and particular conformation, it is believed to host a high level of biodiversity, with more than 17,000 reported marine species, of which about one-fifth are considered endemic (Coll *et al*., 2010).

At present, the regular presence of nine species of cetaceans, all of Atlantic origin, is reported by the monitoring and research campaigns that have been conducted in the area (Notarbartolo di Sciara and Tonay, 2021). Among odontocetes, the striped dolphin (*Stenella coeruleoalba*), the common bottlenose dolphin (*Tursiops truncatus*), the common dolphin (*Delphinus delphis*), the Risso's dolphin (*Grampus griseus*), the long-finned pilot whale (*Globicephala melas*), and the rough-toothed dolphin (*Steno bredanensis*), belonging to the family Delphinidae, as well as the Cuvier's beaked whale (*Ziphius cavirostris*) and the sperm whale (*Physeter macrocephalus*), belonging to the family Ziphiidae and Physeteridae respectively, are considered resident alongside the fin whale (*Balaenoptera physalus*), belonging to the family Balaenopteridae, which is the only regularly sighted mysticete. Four more species, namely, the killer whale (*Orcinus orca*), the false killer whale (*Pseudorca crassidens*), the minke whale (*Balaenoptera acutorostrata*), and the humpback whale (*Megaptera novaeangliae*), are considered occasional visitors to the Mediterranean basin (Notarbartolo di Sciara, 2002; Notarbartolo di Sciara and Tonay, 2021; Boisseau *et al*., 2010; Arcangeli *et al*., 2017; Panigada *et al*., 2017; Pace et *al*., 2019).

The Black Sea harbour porpoise (*Phocoena phocoena relicta*, Phocoenidae) is a subspecies of harbour porpoise that inhabits the Black Sea and the neighbouring waters of the Marmara Sea (Gaskin, 1984; Öztürk and Öztürk, 1996) and is rarely seen in the northern Aegean Sea (Cucknell *et al*., 2016). It is considered to be a relict species, once distributed throughout the Mediterranean Sea (Frantzis *et al*., 2001; Fontaine, 2016).

The presence of *Phocoena phocoena relicta* in the Black Sea suggests that, in the past, the Mediterranean had hosted a higher biodiversity in terms of cetacean species. With reference to modern times, it is believed that the common dolphin, assessed as quite rare in Mediterranean waters (Bearzi *et al*., 2022), may once have been abundant (perhaps the most abundant species in the basin) and experienced a sudden decrease following the middle of the last century (but the trend could have started earlier) (Cagnolaro, 1996; Cagnolaro *et al*., 2012). It is not known, however, whether other species have experienced similar trends, following the progressive increase in both direct and indirect anthropogenic pressures. Moreover, some species, such as the long-finned pilot whale or the Cuvier's beaked whale, although considered regularly present in the Mediterranean, have a limited distribution and their sighting outside some specific areas is quite exceptional (Verborgh *et al*., 2016; Podestà *et al*., 2016). The lack of historical data, even relatively recently, does not allow comparison with the pre-industrial period and prevents us from knowing whether these species were once more abundant and widespread than today or whether the Mediterranean Sea, owing to its naturally oligotrophic conditions, offers only a few areas compatible with their survival.

The InterMed project was conceived as the continuation of the TursioMed project (2017-2019) in the three-year period 2020-2022 (Table 1), to update the current knowledge on cetacean presence

and diversity in the Mediterranean Sea, analyzing in aggregate form the data collected by many different research units over a period of 16 years (2004-2019).

In more detail, the objectives of the project were the following:

- consolidation of the research network connected to the Intercet platform and update of the data loaded on web-based GIS platform;
- analysis of the data in aggregate form to assess the presence and distribution of cetaceans in the study areas covered by the network;
- share on the Intercet platform the photo-identification data of the common bottlenose dolphin (*T. truncatus*), Risso's dolphin (*G. griseus*), Cuvier's beaked whale (*Z. cavirostris*), and sperm whale (*P. macrocephalus*) to investigate the spatial behaviour and movements of these species;
- identification of the geographical units of the common bottlenose dolphin, Risso's dolphin, Cuvier's beaked whale, sperm whale, and related areas of residence and home ranges;
- implementation of a research campaign in the Strait of Sicily to investigate the presence of cetaceans in this important area connecting the western and eastern basins of the Mediterranean Sea.

A monetary contribution was proposed to each partner as a support for the time needed to upload their data to Intercet, the common platform used for data sharing (see below). This contribution was proportional to the size of the dataset to be shared and therefore to the time required for the loading process.

A total of 27 partners from 7 Mediterranean countries have joined the InterMed project, sharing their data in the common database (Table 2).

Spain: EDMAKTUB Association; University of Barcelona (FLT Med Network); Associació Cetàcea; SUBMON.

France: Association BREACH Méditerranée; EcoOcéan Institut; MIRACETI.

Italy: Accademia del Leviatano Onlus; Tethys Research Institute (CSR); Delfini del Ponente APS; Centro Internazionale in Monitoraggio Ambientale - Fondazione CIMA; Menkab, il respiro del mare; Golfo Paradiso Whale Watching; Fondazione Acquario di Genova; CE.TU.S. Cetacean Research Centre; APS Sotto al Mare; Oceanomare Delphis Onlus; Associazione CRAMA; MareTerra Onlus; CNR-IAS; MeRiS - Mediterraneo Ricerca e Sviluppo APS; MarEco Osservatorio della Natura; Ce.S.R.A.M. - Centro Studi e Ricerca Ambiente Marino.

Slovenia: Morigenos – Slovenian Marine Mammal Society.

Türkiye: Marine Mammals Research Association/Denìz Memelileri Araştirma Derneği.

Israel: Morris Kahn Marine Research Station, University of Haifa.

Tunisia: SPA/RAC; Agence de protection et d'Aménagement du Littoral.

The first year (2020) was dedicated to the expansion and consolidation of the network. During the second year and first quarter of the third year the partners uploaded their data on the Intercet platform and the research campaign was carried out in Sicilian waters (2021). In the third year (2022) field research was carried out in Tunisian waters and the uploaded data were validated and analysed in aggregate form (see Figure 1).

Table 1. – Time schedule of the InterMed project

	2020				2021				2022			
	I	II	III	IV	I	II	III	IV	I	II	III	IV
Expansion/consolidation of the research network												
Data loading to Intercet												
Research campaigns in the Strait of Sicily												
Data validation and analysis												

2. The Intercet platform

Intercet (https://www.intercet.it/) is a web-based GIS platform developed by Acquario di Genova for Regione Liguria within the GIONHA project (Governance and Integrated Observation of marine Natural Habitat) as an operational tool for the sharing and integrated analysis of data relating to cetaceans and sea turtles in the Pelagos Sanctuary. Today Intercet is the regional platform of Liguria and is managed by Fondazione Acquario di Genova through a non-profit agreement with the Liguria Region itself. Thanks to the TursioMed and InterMed projects, the network connected to Intercet has been extended to a large portion of the Mediterranean Sea and the data flow to the common database has increased significantly.

3. Material and methods

3.1. Data sharing

Each partner involved in the InterMed project shared data collected under favourable weather conditions (sea state <4 on the Douglas scale) in the respective study area on the Intercet platform. The overall sampling period extends from 2004 to 2022 (see Table 2 for details of each partner). The data shared on the Intercet platform are as follows:

- sampling tracks in the respective study areas;
- sighting points of the target species (all cetaceans);
- photographic data for species recognition (optional for all species);
- photographic data for individual photo-identification (*T. truncatus, G. griseus, Z. cavirostris, P. macrocephalus*).

3.2. Analysis of the sampling effort and sightings

The sampling effort (effort tracks) implemented by the InterMed partners was mapped using the software ArcGIS Desktop 10.5 (ESRI). The data shared by the partners within the InterMed project (effort tracks and sightings) were then aggregated with the data shared within the TursioMed project, collected in the time interval 2004-2016. For all the subsequent analyses we then selected the data collected within the time interval 2004-2019 (see Table 3).

The total sampling effort (TursioMed+InterMed), implemented between 2004-2019, was then remapped and measured within a grid of 20 × 20 km cells (km travelled within each sampling cell), as in the work of Mannocci and co-authors (2018) and Gnone *et al*. (2023).

The data relating to the sightings (sighting points) of the target species (all cetaceans), collected by the TursioMed+InterMed partners between 2004-2019 were also aggregated on the map to display the distribution of the species within the sampled areas.

3.3. Encounter Rate

Data on sampling effort and sightings were correlated to measure the encounter rate (ER = sightings/km of sampling effort) for each species in the sampling cells. The ER analysis was performed only on those cells with a sampling effort greater than the diagonal of the same cells (effort ≥ 28 km). Following an exploratory analysis of the available data, this threshold appears to be able to mitigate possible effort defects, at least for the objectives for which the ER analysis was used in this report (large-scale distribution maps).

3.4. Analysis of photo-identification data

The validation and matching process of the photo-identification data was carried out in collaboration with EcoOcéan Institut for the sperm whale, Tethys Research Institute for the Risso's dolphin, Fondazione CIMA for the Cuvier's beaked whale, while Fondazione Acquario di Genova handled the photographic data of the common bottlenose dolphin. At first, a dedicated manual with indication about photos quality and selection was created for each of the four species selected (*T. truncatus, G. griseus, Z. cavirostris, P. macropephalus*) and sent to the project partners (annex 1). The manuals contained indication on how to rate the photos according to i) the whale (or dolphin) body part visible in the photograph, ii) the image quality, and iii) the grade of distinctiveness of the individual.

Each partner sorted the photo identification data in its own photographic catalogue. Subsequently, a cross-matching analysis was implemented to identify possible matches between catalogues and track the movements of the animals across the study areas. The photo-identification data coming from the TursioMed+InterMed network were finally compared with the complete photo-identification database of the Intercet platform.

The cross-matching of the common bottlenose dolphin photo-ID data was carried out with the help of the finFindR software (https://github.com/haimeh/finFindR) and validated by an expert researcher.

The results of the matching process between catalogues were used for the following analyses.

3.4.1. Connectivity analysis between photo-identified individuals (network connectivity) and cluster identification.

Following the matching, a network outline was drawn using the Spring embedding visualization (Eades, 1984; Fruchterman and Reingold, 1991) in NetDraw (Borgatti, 2002). This was performed selecting those individuals sighted and recognised through photographic identification on at least 4 occasions (including the first identification event). Two animals were assumed to be associated in the network if sighted in the same group on at least one occasion, following a 0–1 criterion (0, never sighted together; 1, sighted together at least once). To identify the clusters within the network, we carried out a Girvan–Newman analysis, based on edge betweenness measurements (Freeman, 1977; Girvan and Newman, 2002; Lusseau and Newman, 2004; Newman and Girvan, 2004). The best division for the network was identified using a modularity index Q, where the highest Q value indicates the best division (Newman and Girvan, 2004; Efron, 1979). This index varies between 0 (community structure no better than in a random network) and 1 (strong community structure) and it can be considered meaningful if it falls in the range 0.3–0.7 (Chen et al., 2009).

Each identified cluster was assigned a different colour, which was maintained in all the figures to facilitate the comprehension of the analytical process.

3.4.2. Identification and mapping of the geographical units.

Following the connectivity analysis and cluster identification, all the sightings of the individuals selected (all the individuals with at least 4 captures, see above) were then plotted on the map using the same cluster colours, to identify the areas of distribution of the individuals belonging to each cluster.

3.4.3. Minimum Convex Polygon (MCP) analysis.

As for the sperm whale, we have used the minimum convex polygon technique (Mohr, 1947) to draw the movements of the photo-identified individuals with at least two captures. Each (convex) polygon includes all the sighting points of the same individual and describes the maximum recorded movements, as a simplified representation of its home range. In case of only two captures, the analysis draws a segment between the two sightings.

4. Results

The InterMed partners shared on the common platform a total of 245,379 km of sampling effort, carried out in the respective study areas, which resulted in 6985 sightings of cetaceans (see Table 2, Figure 1). The data were then aggregated with those shared on Intercet within the TursioMed project to be analysed in aggregate form (Table 3, Figure 2).

The aggregation of data shared on the Intercet platform within the TursioMed+InterMed project by all the partners resulted in a total of 983,186 km of sampling effort collected between 2004-2019 and 25,805 sightings of cetaceans, referable to 14 species (Table 3, Figure 3): *S. coeruleoalba* 11,495 (44.55%); *T. truncatus* 7561 (29.30%); *D. delphis* 716 (2.77%); *G. griseus* 374 (1.45%); *G. melas* 342 (1.33%); *Z. cavirostris* 631 (2.45%); *P. macrocephalus* 1376 (5.33%); *B. physalus* 3326 (12.89%); *S. bredanensis* 1 (0.004%); *O. orca* 1 (0.004%); *P. phocoena relicta* 28 (0.11%); *M. bidens* 1 (0.004%); *B. acutorostrata* 2 (0.008%); *M. novaeangliae* 2 (0.008%). The total number of sightings (25,805) also includes 51 multispecies encounters: *S. coeruleoalba* + *D. delphis* = 34; *S. coeruleoalba* + *G. griseus* = 5; *S. coeruleoalba* + *T. truncatus* = 2; *S. coeruleoalba* + *B. physalus* = 4; *G. griseus* + *D. delphis* = 1; *G. griseus* + *T. truncatus* = 3; *T. truncatus* + *B. physalus* = 1; *G. melas* + *Z. cavirostris* = 1.

About 92% of the sightings refers to only 4 species (Figure 4): *S. coeruleoalba* (44.55%); *T. truncatus* (29.30%); *B. physalus* (12.89%); *P. macrocephalus* (5.33%).

Table 2. - Summary table of the contribution of each InterMed partner to the common database. Please note that not all the partners collected and/or shared the photo—ID data on the common platform (last column).

N	RESEARCH GROUP	COUNTRY	STUDY AREA	MSFD SUBZONE	PERIOD	EFFORT (km)	N SIGHT.	Photo-ID
1	EDMAKTUB Association	Spain	Catalonia	West. Med. Sea	2017	2000	64	NO
2	University of Barcelona - FLT Med Network	Spain	Catalonia	West. Med. Sea	2018-2020	6939	160	NO
3	Associació Cetàcea	Spain	Catalonia	West. Med. Sea	2013-2019	6831	178	YES
4	SUBMON	Spain	Catalonia	West. Med. Sea	2018-2019	3284	54	YES
5	Association BREACH Méditerranée	France	Gulf of Lion	West. Med. Sea	2017-2019	2341	51	YES
6	EcoOcéan Institut	France	Gulf of Lion, French Riviera, Corsica	West. Med. Sea	2011-2020	20,773	833	YES
7	MIRACETI	France	Gulf of Lion, French Riviera, Corsica	West. Med. Sea	2019	3224	127	YES
8	Accademia del Leviatano Onlus	Italy	NW Mediterranean	West. Med. Sea	2016-2018	35,637	548	NO
9	Tethys Research Institute - CSR	Italy	Liguria W, French Riviera	West. Med. Sea	2019	7541	738	YES
10	Delfini del Ponente APS	Italy	W Liguria	West. Med. Sea	2017-2019	6983	105	YES
11	Fondazione CIMA	Italy	Ligurian Sea	West. Med. Sea	2004-2018	41,149	1967	YES
12	Menkab, il respiro del mare	Italy	W Liguria	West. Med. Sea	2017-2019	0	89	YES
13	Golfo Paradiso Whale Watching	Italy	Liguria	West. Med. Sea	2017-2019	9408	524	YES
14	Fondazione Acquario di Genova	Italy	E Liguria	West. Med. Sea	2017-2019	5135	160	YES
15	CE.TU.S. Cetacean Research Centre	Italy	Tuscany	West. Med. Sea	2018-2019	3010	40	YES
16	APS Sotto al Mare	Italy	Lazio	West. Med. Sea	2019	1924	13	YES
17	Oceanomare Delphis Onlus	Italy	Eastern Tyrrhenian Sea	West. Med. Sea	2017-2019	11,873	159	YES
18	Associazione CRAMA	Italy	Northwest Sardinia	West. Med. Sea	2018-2019	2627	12	YES
19	MareTerra Onlus	Italy	NE Sardinia, Lampedusa	West. Med. Sea	2007-2019	13,740	432	YES
20	CNR-IAS - Istituti di Ricerca Marina	Italy	Strai of Sicily	Ionian Sea and Centr. Med.	2011-2021	5078	102	YES
21	MeRiS - Mediterraneo Ricerca e Sviluppo APS	Italy	Strait of Sicily	Ionian Sea and Centr. Med.	2017-2019	5542	84	YES
22	MarEco Osservatorio della Natura	Italy	Lampedusa	Ionian Sea and Centr. Med.	2018-2019	2593	68	YES
23	Ce.S.R.A.M. - Centro Studi e Ricerca Ambiente Marino	Italy	E Calabria	Ionian Sea and Centr. Med.	2019	2190	14	NO
24	Morigenos - Slovenian Marine Mammal Society	Slovenia	Gulf of Trieste	Adriatic Sea	2017-2018	0	71	NO
25	DMAD - Marine Mammals Research Association	Türkiye	Southeast Adriatic, Bosphorus	Aegean-Levantine Sea	2018-2019	7096	101	YES
26	Morris Kahn Marine Research Station, University of Haifa	Israel	Eastern Mediterranean	Aegean-Levantine Sea	2005-2020	37,436	274	YES
27	Agence de protection et d'Aménagement du Littoral	Tunisia	Strait of Sicily	Ionian Sea and Centr. Med.	2022	1023	17	YES
			TOTAL			**245,379**	**6985**	

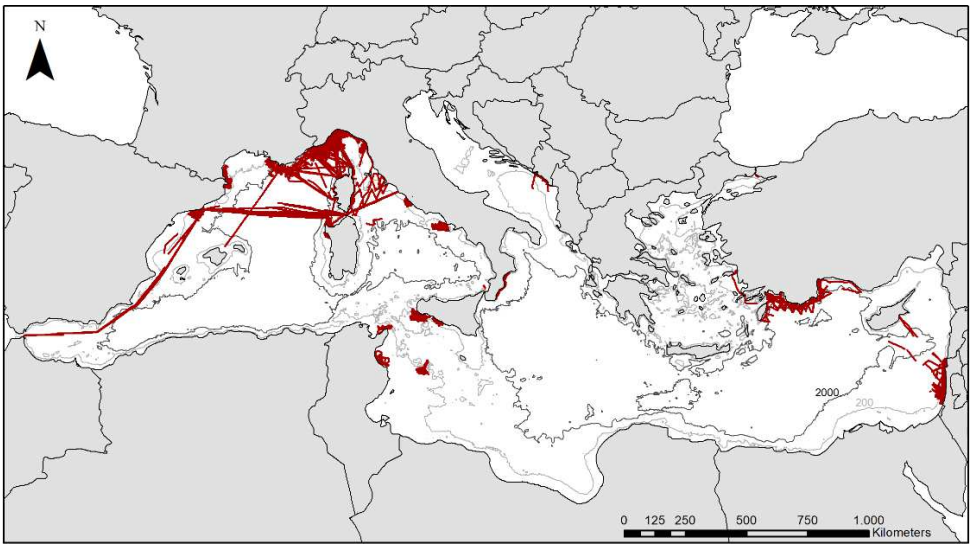

Figure 1. - Aggregated sampling tracks of the InterMed partners (245,379 km).

Table 3. - Summary table of the contribution of each partner (TursioMed+InterMed) to the common dataset (the effort and sightings are referred to the time interval 2004-2019). *Tt*: *Tursiops truncatus*; *Sc*: *Stenella coeruleoalba*; *Dd*: *Delphinus delphis*; *Gg*: *Grampus griseus; Gm*: *Globicephala melas; Zc: Ziphius cavirostris; Pm: Physeter macrocephalus; Bp: Balaenoptera physalus; Sb: Steno bredanensis; Oo: Orcinus orca; Pp: Phocoena phocoena relicta; Mb: Mesoplodon bidens; Ba: Balaenoptera acutorostrata; Mn: Megaptera novaeangliae.*

N	RESEARCH GROUP	CODE	PERIOD (all data)	EFFORT (km) (2004-2019)	N SIGHT. (2004-2019)	SIGHTING PER SPECIES (2004-2019)													
						Sc	*Tt*	*Dd*	*Gg*	*Gm*	*Zc*	*Pm*	*Bp*	*Pp*	*Ba*	*Mn*	*Mb*	*Oo*	*Sb*
1	Accademia del Leviatano	AdL	2012-2018	93,208	1554	788	87	10	19	8	33	59	549	0	1	0	0	0	0
2	Agence de protection et d'Aménagement du Littoral	SPA	2022	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	Alnilam Research and Conservation	ARC	2004-2011	28,605	1402	477	210	404	35	212	35	10	20	0	0	0	0	0	0
4	APS Sotto al Mare	SAM	2019	1924	13	0	13	0	0	0	0	0	0	0	0	0	0	0	0
5	Associació Cetàcea	AC	2013-2019	6832	178	107	33	1	12	0	1	7	17	0	0	0	0	0	0
6	Association BREACH Méditerranée	BR	2013-2019	6095	227	41	146	2	2	1	0	0	37	0	0	1	0	0	0
7	Associazione CRAMA	CRM	2019-2019	3361	39	0	36	0	0	0	0	0	3	0	0	0	0	1	0
8	Bottlenose Dolphin Reasearch Institute (BDRI)	BDR	2004-2013	12,402	1662	14	1637	5	0	0	0	0	6	0	0	0	0	0	0
9	Ce.S.R.A.M. - Centro Studi e Ricerca Ambiente Marino	CES	2019	2191	14	5	9	1	0	0	0	0	0	0	0	0	0	0	0
10	CE.TU.S. Cetacean Research Centre	CC	2003-2019	26,648	648	55	572	7	4	0	0	3	11	0	0	1	0	0	0
11	CNR-IAS - Istituti di Ricerca Marina	CG	2011-2021	3459	72	1	63	5	0	0	0	0	3	0	0	0	0	0	0
12	Delfini del Ponente APS	DDP	2017-2019	6983	105	37	60	0	0	3	0	3	2	0	0	0	0	0	0
13	DISTAV-Università di Genova	UGE	2005-2008	15,591	49	0	49	0	0	0	0	0	0	0	0	0	0	0	0
14	DMAD - Marine Mammals Research Association	LA	2011-2019	13,321	330	1	227	44	0	0	8	22	0	28	0	0	0	0	0
15	EcoOcéan Institut	EOI	1997-2020	68,927	2645	1656	72	2	34	40	1	180	660	0	0	0	0	0	0
16	EDMAKTUB Association	EDM	2017	2000	64	47	14	1	2	0	0	0	0	0	0	0	0	0	0
17	Fondazione Acquario di Genova	DM	2001-2022	30,524	330	42	277	4	2	0	2	2	4	0	0	0	0	0	0
		CDM	2007-2021	40,822	917	674	36	7	18		107	40	44	0	0	0	0	0	0
18	Fondazione CIMA (partially FLT Med Network)	CIM	2004-2018	90,425	4060	2366	69	12	52	22	218	152	1169	0	0	0	0	0	0
19	Gaia Research Institute Onlus (FLT Med Network)	FER	2014-2018	23,797	124	71	50	0	0	0	3	0	0	0	0	0	0	0	0
20	Golfo Paradiso WhaleWatching	GP	2017-2019	9408	524	374	16	3	6	0	103	8	16	0	0	0	0	0	0
21	IMMRAC	IM	2017-2018	10,237	35	0	27	7	1	0	0	0	0	0	0	0	0	0	0
22	Istanbul University and Turkish Marine Research Foundation	TCR	2005-2008	7191	114	30	63	21	2	0	0	1	0	0	0	0	0	0	0
23	Ketos (FLT Med Network)	KT	2004-2017	53,323	673	405	157	60	17	1	2	7	23	0	0	0	0	0	1
24	MarEco Osservatorio della Natura	MEO	2018-2019	2594	68	0	63	0	5	0	0	0	0	0	0	0	0	0	0
25	MareTerra Onlus	MT	2012-2019	22,155	503	1	502	0	0	0	0	0	0	0	0	0	0	0	0
		MTL	2007-2009	3438	148	0	147	1	0	0	0	0	0	0	0	0	0	0	0
26	Menkab, il respiro del mare	MKB	2017-2019	0	89	57	3	1	1	0	10	14	2	0	1	0	0	0	0
27	MeRiS - Mediterraneo Ricerca e Sviluppo APS	MRS	2016-2019	6852	93	0	92	1	0	0	0	0	0	0	0	0	0	0	0
28	MIRACETI (Gecem)	GC	1992-2019	41,585	883	327	337	3	50	10	2	40	118	0	0	0	0	0	0
29	Morigenos - Slovenian Marine Mammal Society	MOR	2002-2018	0	622	1	622	0	0	0	0	0	0	0	0	0	0	0	0
30	Morris Kahn Marine research station, University of Haifa	MKI	2005-2020	30,855	248	0	233	14	1	0	0	0	0	0	0	0	0	0	0
31	Oceanomare Delphis Onlus	ODO	2004-2019	66,765	1243	599	132	35	30	2	0	401	44	0	0	0	0	0	0
32	SEA ME Sardinia Onlus	SMS	2011-2013	4291	507	271	38	2	4	0	64	10	117	0	0	0	1	0	0
33	SUBMON	SBN	2010-2019	4896	77	0	76	0	3	0	0	0	0	0	0	0	0	0	0
34	Tethys Research Institute - CSR	TRI	1990-2019	90,960	3431	2452	60	4	52	30	37	400	397	0	0	0	0	0	0
35	Tethys Research Institute - IDP	IDP	2004-2016	52,223	872	5	851	16	0	0	0	0	0	0	0	0	0	0	0
36	Thalassa Ricerca e Formazione	ION	2008-2017	12,777	190	142	37	20	4	0	0	0	0	0	0	0	0	0	0
37	Tunisian Dolphin Project	TDP	2015-2016	1423	39	0	39	0	0	0	0	0	0	0	0	0	0	0	0
38	Università di Pisa (FLT Med Netowork)	LBA	2008-2016	43,464	330	160	114	6	2	0	0	6	44	0	0	0	0	0	0
		LGA	2012-2016	27,698	321	183	79	3	3	0	5	10	38	0	0	0	0	0	0
39	University of Barcelona (FLT Med Network)	UB	2018-2020	6282	153	106	4	14	13	13	0	1	2	0	0	0	0	0	0
40	University of Torino, Life and System Biology Department	LAM	2008-2016	7655	209	0	209	0	0	0	0	0	0	0	0	0	0	0	0
	TOTAL			**983,186**	**25,805**	**11,495**	**7561**	**716**	**374**	**342**	**631**	**1376**	**3326**	**28**	**2**	**2**	**1**	**1**	**1**

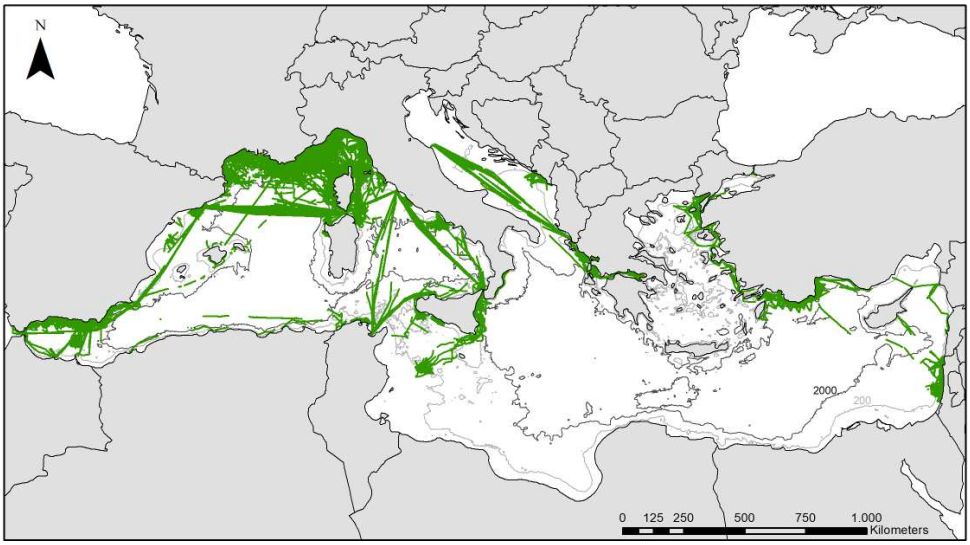

Figure 2. - Aggregated sampling tracks (2004-2019) of TursioMed+InterMed partners (983,186 km).

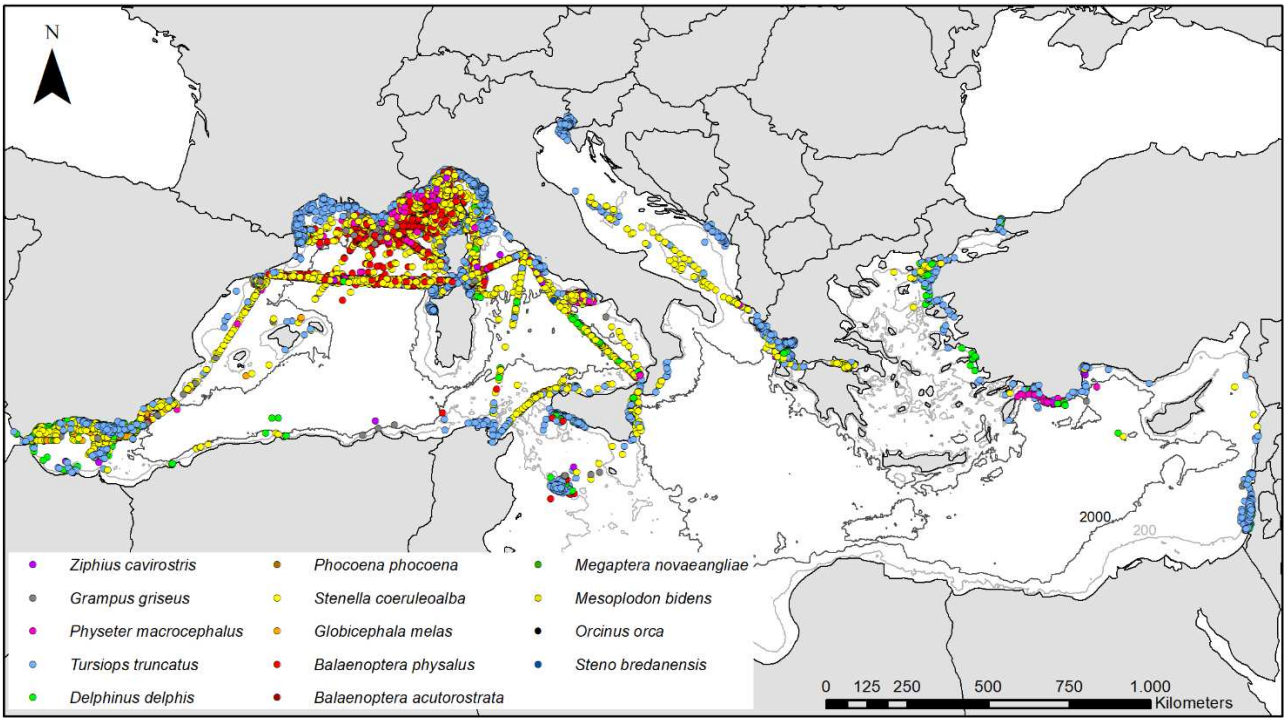

Figure 3. - Distribution of sightings (all cetaceans) recorded by the TursioMed+InterMed network in the period 2004-2019 (25,805 sightings).

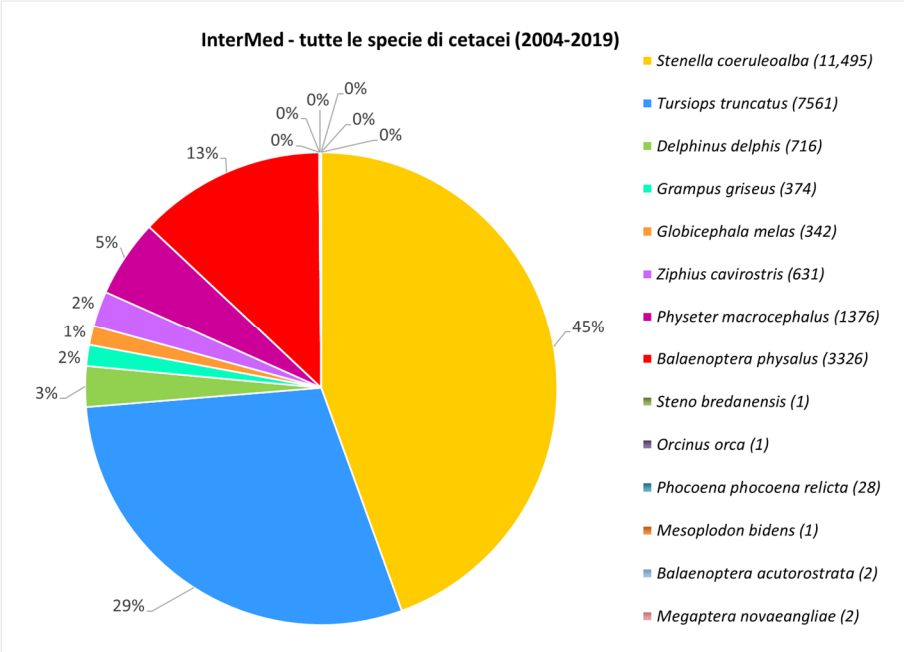

Figure 4. - Percentage distribution of sightings (all cetaceans) recorded by the TursioMed+InterMed network in the period 2004-2019 (25,805 sightings). Note that some sightings were multi-species, so the total does not correspond to the sum of sightings per species.

However, the distribution of the species is uneven and it changes significantly according to the area and the macro-habitat. In Table 4 and Figure 5 we analysed the presence of the regular species in relation to the three main bathymetric domains: the continental shelf (0-200 m), the continental platform (200-2000 m), and the pelagic domain above the abyssal plain (>2000 m). Within the continental shelf domain (0-200 m), the common bottlenose dolphin is confirmed as the only dominant species, with 7022 sightings (88.54 %), while in the continental slope domain

(200-2000 m) and in the pelagic one (>2000 m) the striped dolphin predominates with 6644 sightings (64.06%) and 4374 sightings (58.58 %) respectively.

Most of the other species seem to find their habitat in the offshore domains, outside the continental shelf (>200 m), with a possible preference for the slope waters (200-2000 m). The fin whale, however, shows a clear preference for the deep waters of the pelagic domain (>2000 m), where it is the second most sighted species with 2291 sightings (30.68 %).

Table 4. – Distribution of sightings in relation to the main bathymetric domains. *Sc: S. coeruleoalba; Tt: T. truncatus; Dd: D. delphis; Gg: G. griseus; Gm: G. melas; Zc: Z. cavirostris; Pm: P. Macrocephalus; BP: B. physalus* (note that some sightings were multi-species, so the total does not correspond to the sum of sightings per species).

Specie	**0-200 m**		**200-2000 m**		**>2000 m**		**TOTALE**	
	Avv.	%	Avv.	%	Avv.	%	Avv.	%
Sc	477	6.01	6644	64.06	4374	58.58	11,495	44.61
Tt	7022	88.54	485	4.68	54	0.72	7561	29.34
Dd	274	3.45	388	3.74	54	0.72	716	2.78
Gg	20	0.25	255	2.46	99	1.33	374	1.45
Gm	1	0.01	259	2.50	82	1.10	342	1.33
Zc	2	0.03	540	5.21	89	1.19	631	2.45
Pm	10	0.13	941	9.07	425	5.69	1376	5.34
Bp	147	1.85	888	8.56	2291	30.68	3326	12.91
Total	**7931**	100	**10,371**	100	**7467**	100	**25,769**	100

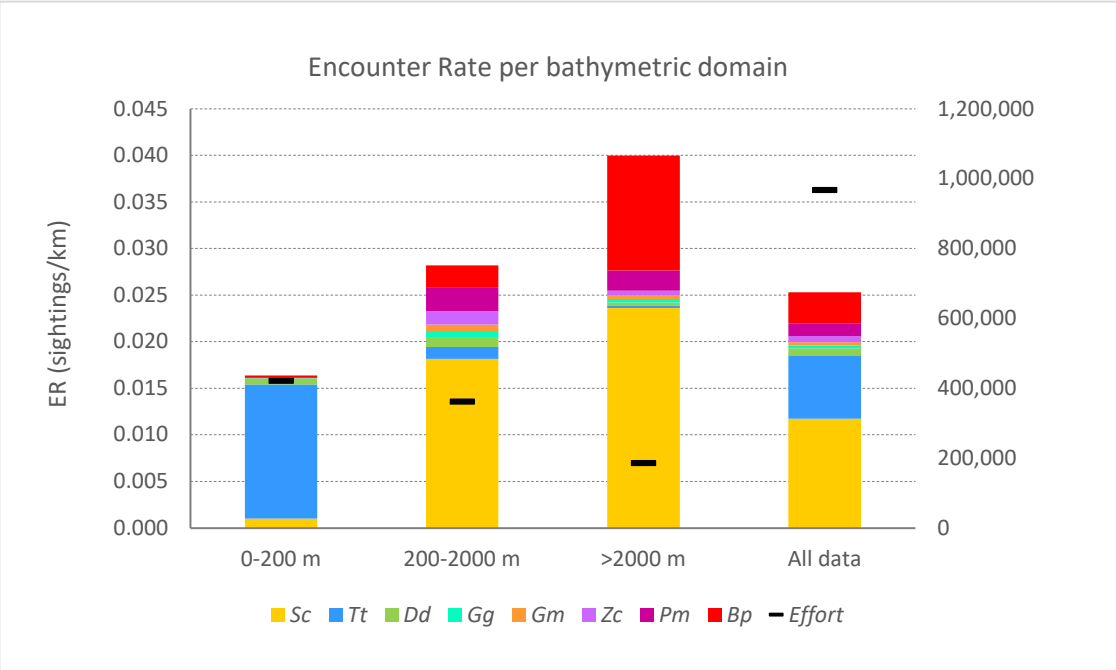

Figure 5. – Encounter rate of the regularly sighted species in relation to the bathymetric domains (*Sc: S. coeruleoalba; Tt: T. truncatus; Dd: D. delphis; Gg: G. griseus; Gm: G. melas; Zc: Z. cavirostris; Pm: P. macrocephalus; BP: B. physalus).*

4.1. Encounter Rate maps

As already mentioned in the Material and Methods section, the Encounter Rate analysis (ER) was carried out only on those cells with a sampling effort greater than the diagonal of the same cells (effort ≥ 28 km), to mitigate possible effort defects (Figure 6).

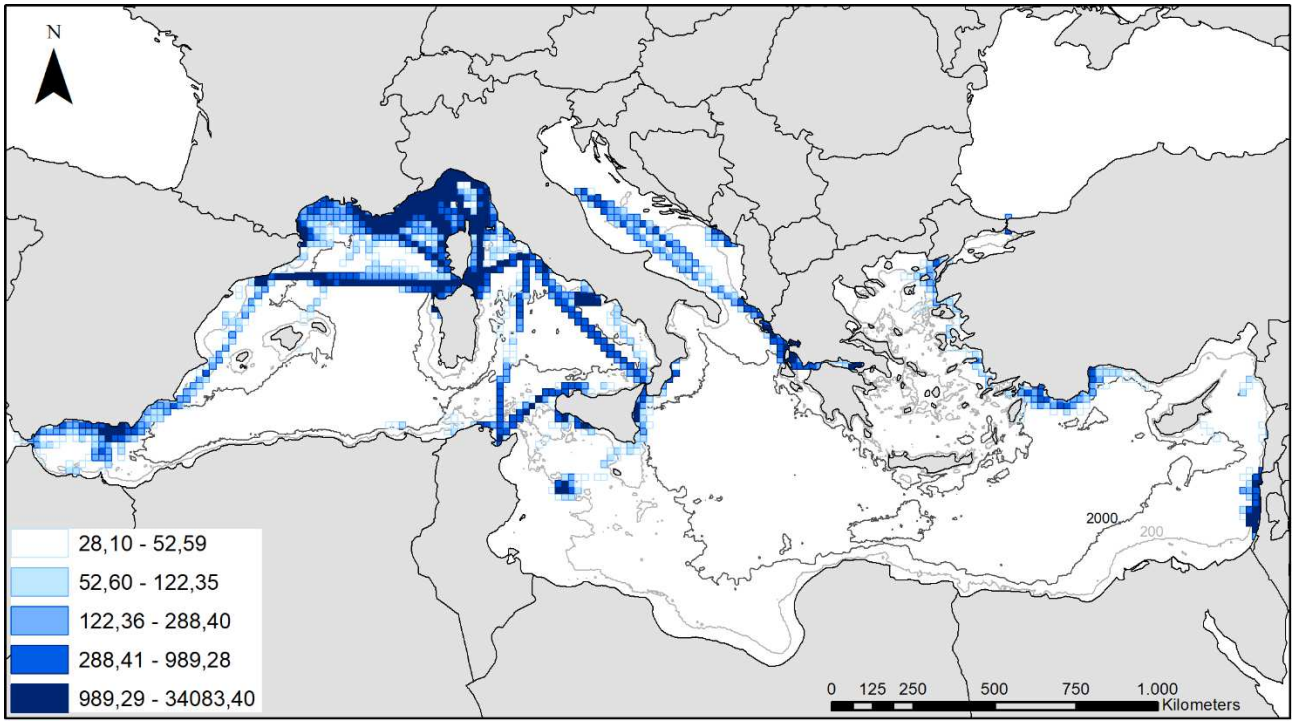

Figure 6. - Distribution and density of sampling effort measured in kilometres per cell (20x20 km, effort >28 km). Only cells with effort >28 km were selected for the ER analysis and maps.

The maps below (Figures 7-14) present the sightings distribution and ER for each of the regularly sighted species (one species for each page).

- Striped dolphin (*Stenella coeruleoalba*)

The striped dolphin is the species with the highest number of sightings (11,495, 44.55 %) and has been sighted in all the sampled areas, with a clear preference for pelagic waters outside the continental shelf (>200 m). The encounter rate is greater in the north-western portion of the basin and in the Alborán Sea (Figure 7).

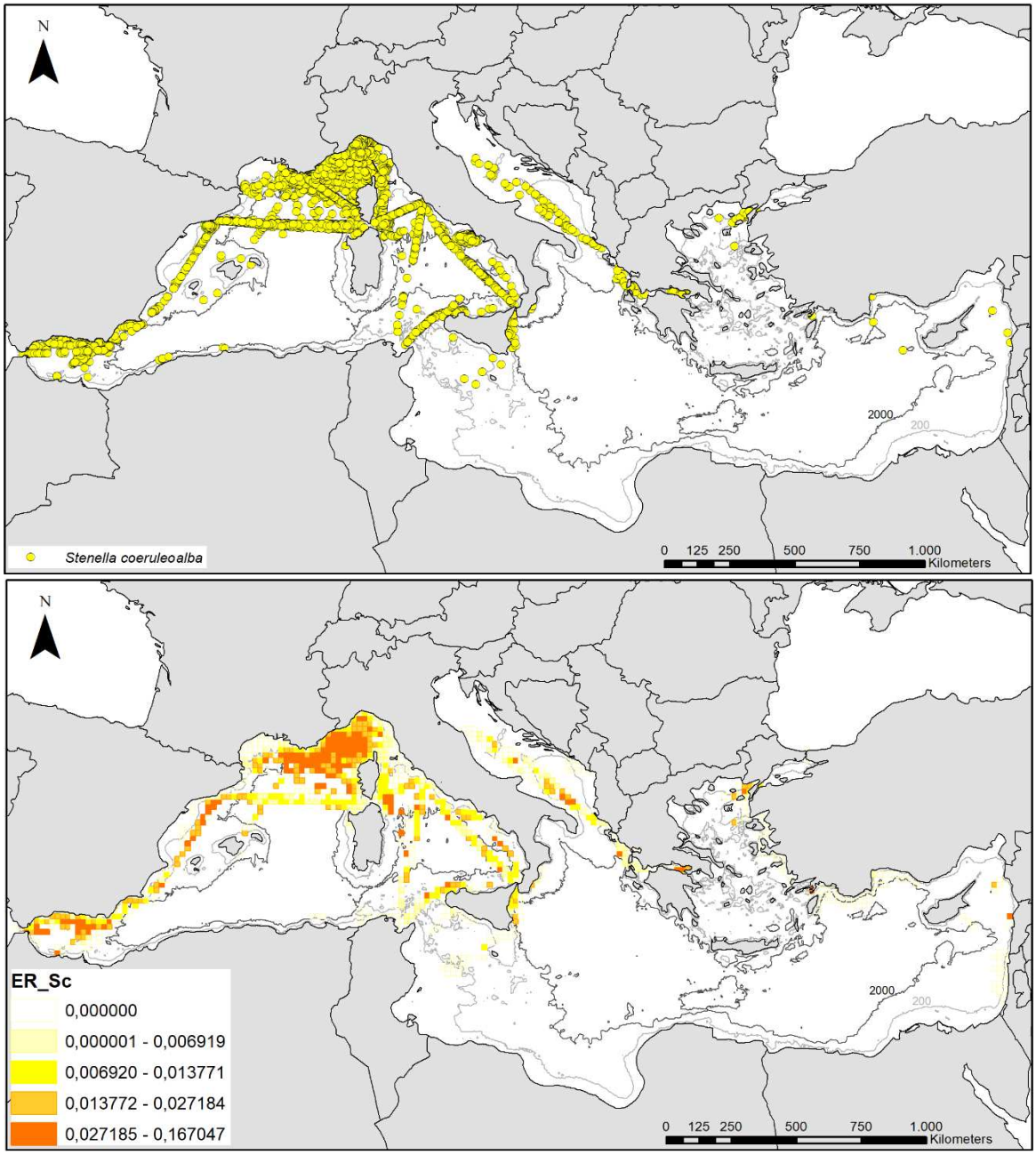

Figure 7. – Sighting distribution (top) and ER (bottom) of the striped dolphin (11,495 sightings, sampling cells with effort >28 km).

- Common bottlenose dolphin (*Tursiops truncatus*)

The common bottlenose dolphin has been spotted on 7561 occasions (29.30 %) and is therefore the second most sighted species after the striped dolphin (Figure 8). It has been sighted by all the research units and is the only species showing a clear preference for continental shelf waters (<200 m). This preference is evident in all the study areas covered by the network, except the Alborán Sea where this species is also sighted in the slope domain (200–2000 m). The only species with which the common bottlenose dolphin shares the continental shelf macro-habitat are the common dolphin (which shows a ubiquitously distribution in the different study areas, see below) and the Black Sea harbour porpoise (limited to the Bosphorus).

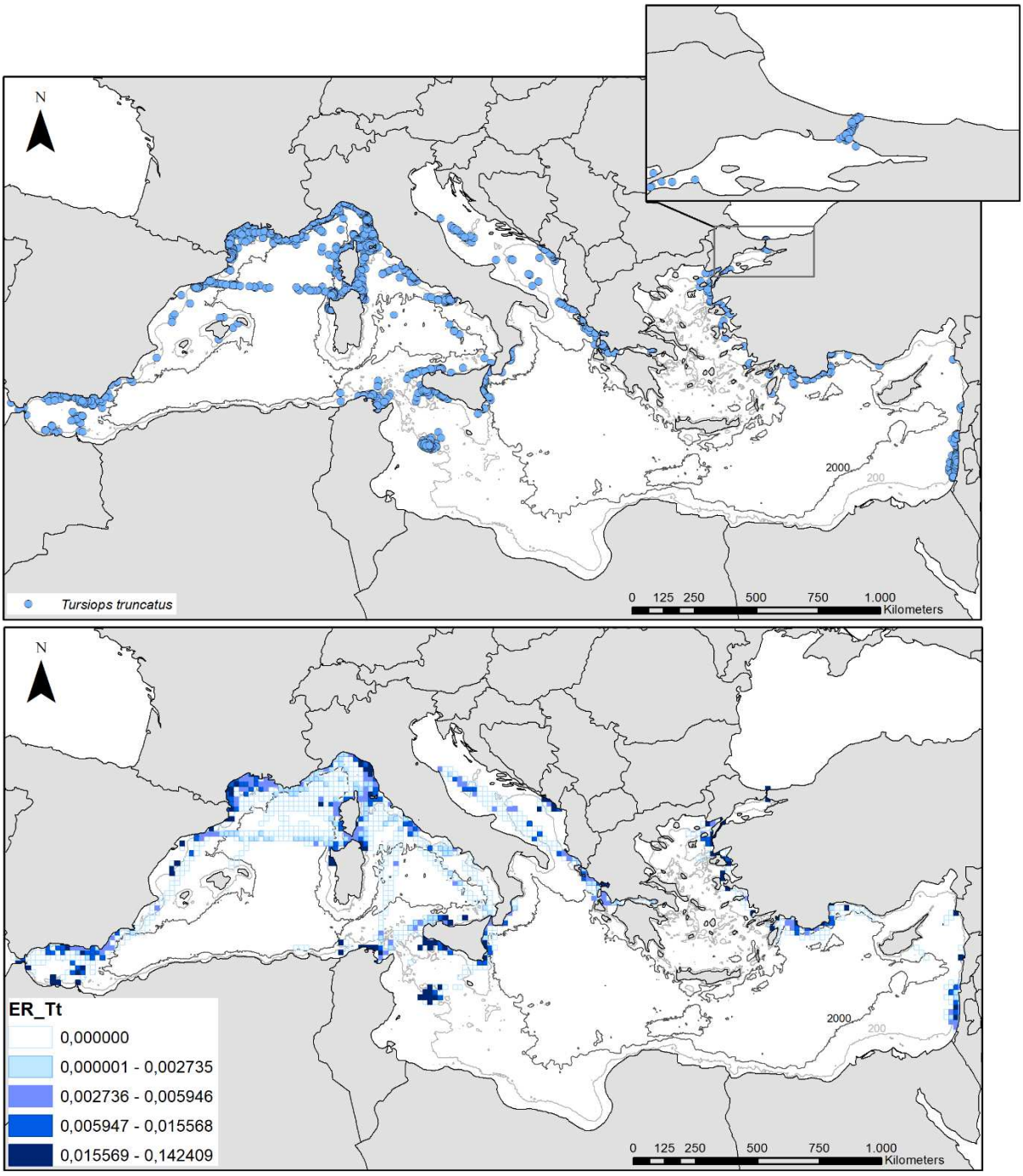

Figure 8. – Sighting distribution (top) and ER (bottom) for the common bottlenose dolphin (7561 sightings, sampling cells with effort >28 km).

- Common dolphin (*Delphinus delphis*)

The common dolphin (Figure 9) is the fifth species for number of sightings (716; 2.77 %). Most sightings (403) are reported in the Alborán Sea, while on 34 occasions the common dolphin has been spotted in groups of striped dolphins. This species is the only one sighted both in pelagic waters and over the continental shelf, with significant differences across areas (see also Table 4, Figure 5): in the Alborán Sea, where the common dolphin shows the highest ER, it's sighted in both offshore and shelf waters; in the Tyrrhenian Sea, it's seen mainly in pelagic waters; in the Aegean-Levantine Sea the common dolphin seems to prefer the upper edge of the continental slope and shelf domains, in close relationship with the common bottlenose dolphin and the Black sea harbour porpoise (limited to the Bosphorus and adjacent areas).

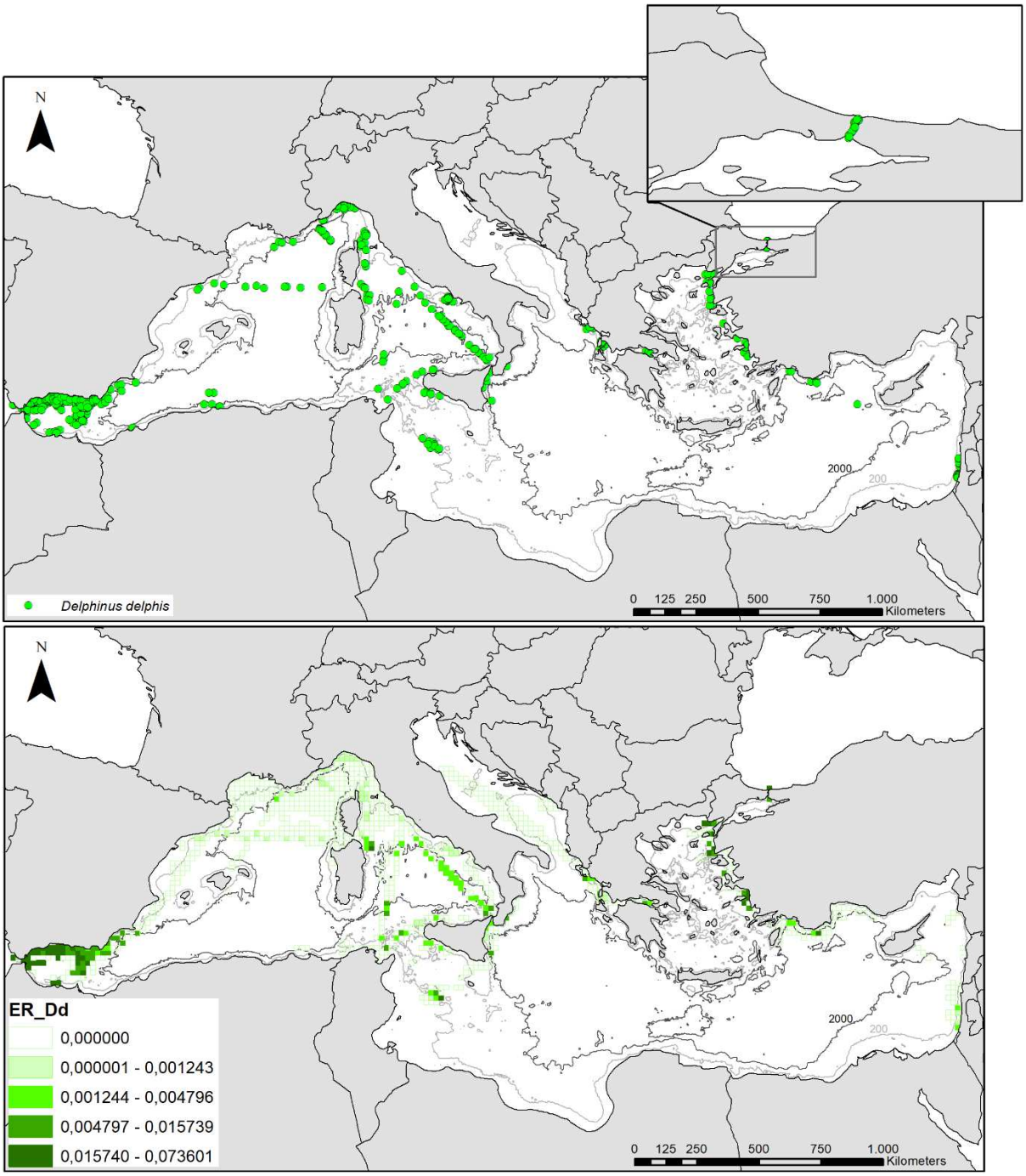

Figure 9. – Sighting distribution (top) and ER (bottom) of the common dolphin (716 sightings, sampling cells with effort >28 km).

- Risso's dolphin (*Grampus griseus*)

The Risso's dolphin is the seventh species for number of sightings (374; 1.45 %). It has been sighted in almost all the sampled areas of the western basin, in pelagic waters and over the continental slope (very rarely the Risso's dolphin has been sighted in the continental shelf domain), but with a relatively low ER (Figure 10). In the eastern basin, the presence of this species appears to be particularly scarce, but the lack of data relating to the pelagic waters in this portion of the Mediterranean prevents reliable analysis.

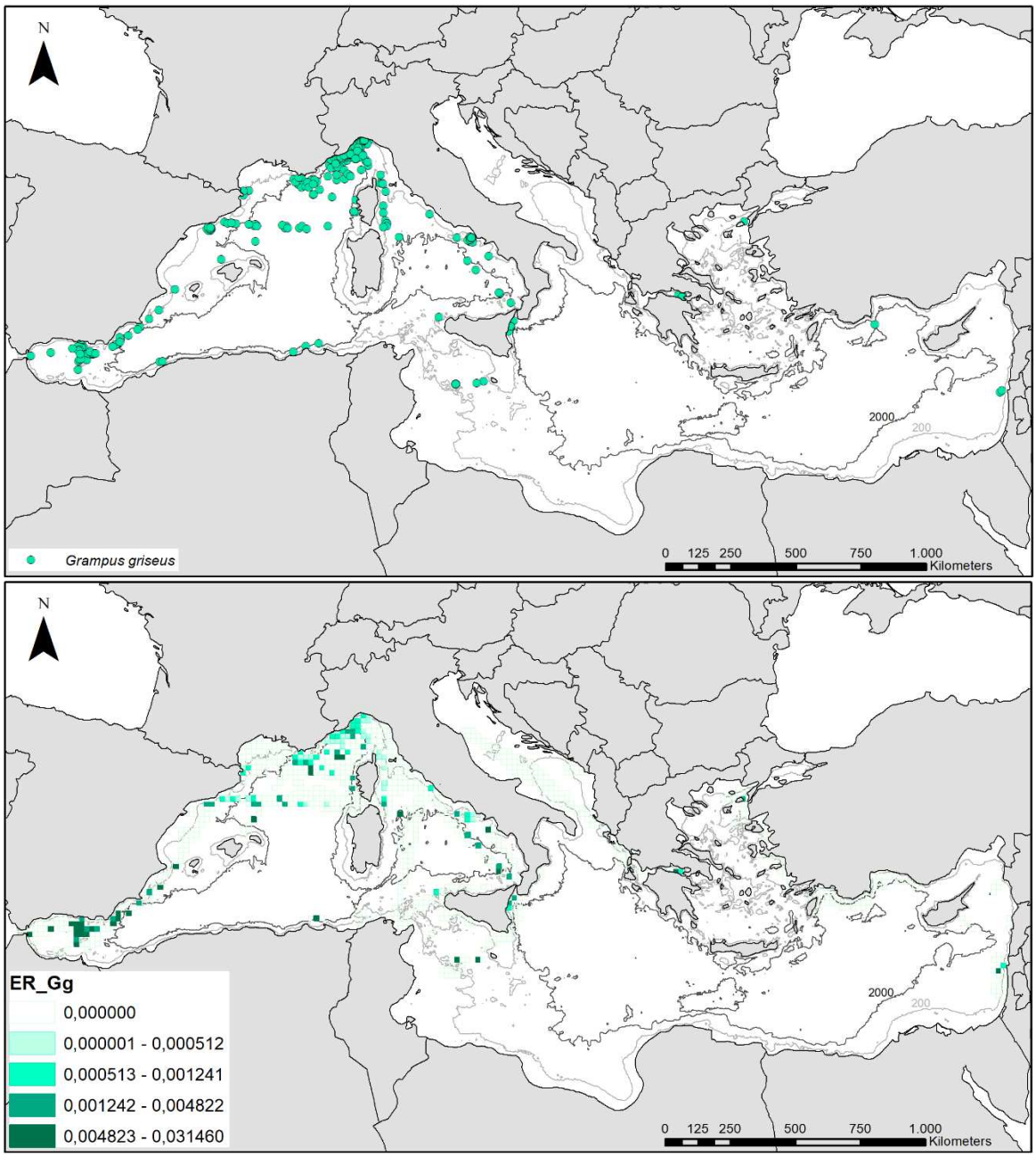

Figure 10. – Sighting distribution (top) and ER (bottom) of the Risso's dolphin (374 sightings, sampling cells with effort >28 km).

- Long-finned pilot whale (*Globicephala melas*)

The long-finned pilot whale is the eighth species for sightings, with 342 encounters (1.33 %). The ER analysis shows an uneven presence, concentrated in two hot spots: the Alborán Sea and the northernmost portion of the western basin, which includes the Pelagos Sanctuary (Figure 11). In the rest of the Mediterranean covered by the network, the pilot whale is nearly absent, but we should consider that the sampling coverage excludes most of the pelagic waters of the eastern basin. In the two identified hot spots, the pilot whale is seen only in pelagic waters, outside the continental shelf border.

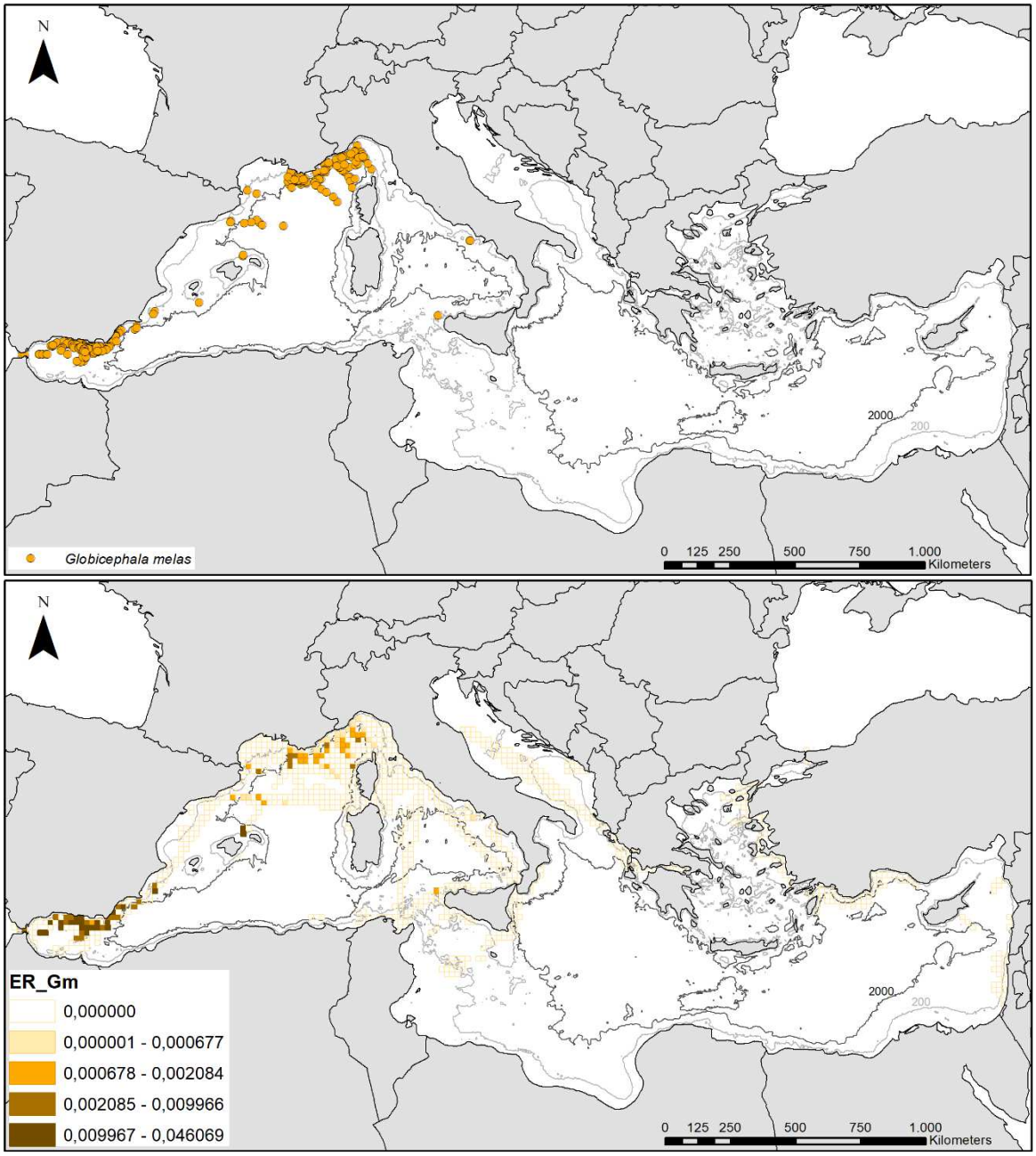

Figure 11. - Sighting distribution (top) and ER (bottom) of the long-finned pilot whale (342 sightings, sampling cells with effort >28 km).

- Cuvier's beaked whale (*Ziphius cavirostris*)

With 631 sightings (2.45 %), the Cuvier's beaked whale is the sixth species for sightings reported by the TursioMed+InterMed network (Figure 12). With reference to the sampled areas, this species shows a high ER in only three well-defined areas of the offshore domain: the Alborán Sea, the northernmost portion of the Ligurian Sea (included within the Pelagos Sanctuary) and an area located east of the Strait of Bonifacio (the so-called canyon of Caprera). In the rest of the areas sampled by the TursioMed+InterMed network the Cuvier's beaked whale is very rare (or absent), especially in the southern portion of the Mediterranean and throughout the eastern basin. In these macro-areas, however, the effort data are scarce or absent, especially in pelagic waters, preventing from reliable analysis (Figure 12). The data coverage also excludes the Hellenic Trench, which is believed to be a core area for deep divers such as the Cuvier's beaked whale and the sperm whale (Frantzis *et al.*, 2014; Podestà *et al.*, 2016).

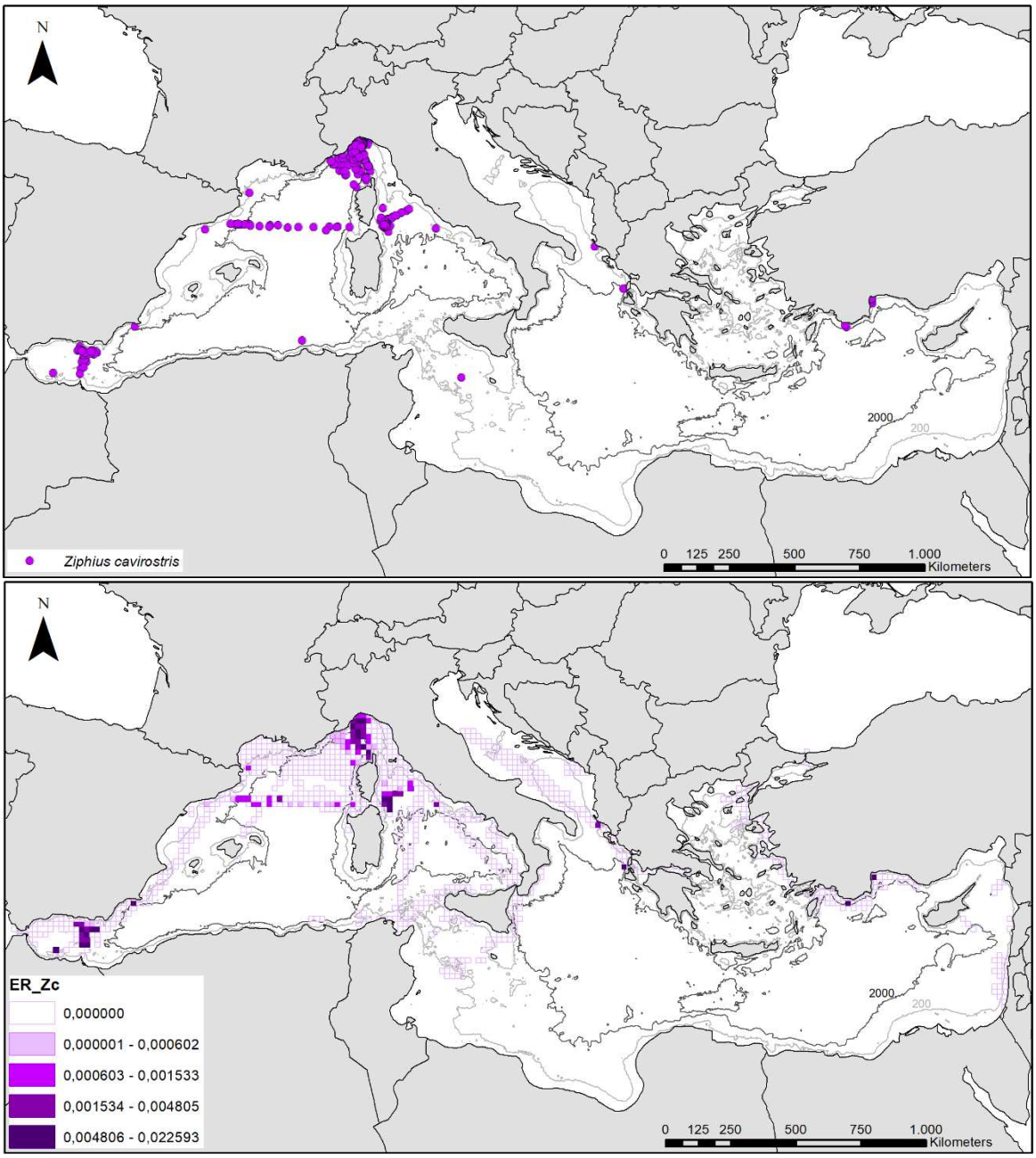

Figure 12. - Sighting distribution (top) and ER (bottom) of the Cuvier's beaked whale (631 sightings, sampling cells with effort >28 km).

- Sperm whale (*Physeter macrocephalus*)

The sperm whale is the fourth species for sightings in the areas sampled by the TursioMed+InterMed network (1376 sightings, 5.33 %). This species seems to prefer the offhsore domains and its sightings over the continental shelf are very rare (Figure 13). With reference to the data collected by the TursioMed+InterMed project, the species shows a greater ER in the north western basin (in particular in the western portion of the Pelagos Sanctuary) and in an area between Ischia and Ventotene, off the coast of Campania (Italy). Sperm whale sightings are rare or absent in the southern Mediterranean and throughout the eastern basin, where however the sampling effort is scarce or absent, especially in the pelagic context. The data coverage also excludes the Hellenic Trench, which is believed to be a core area for deep divers such as the sperm whale and Cuvier's beaked whale (Frantzis *et al.*, 2014; Podestà *et al.*, 2016).

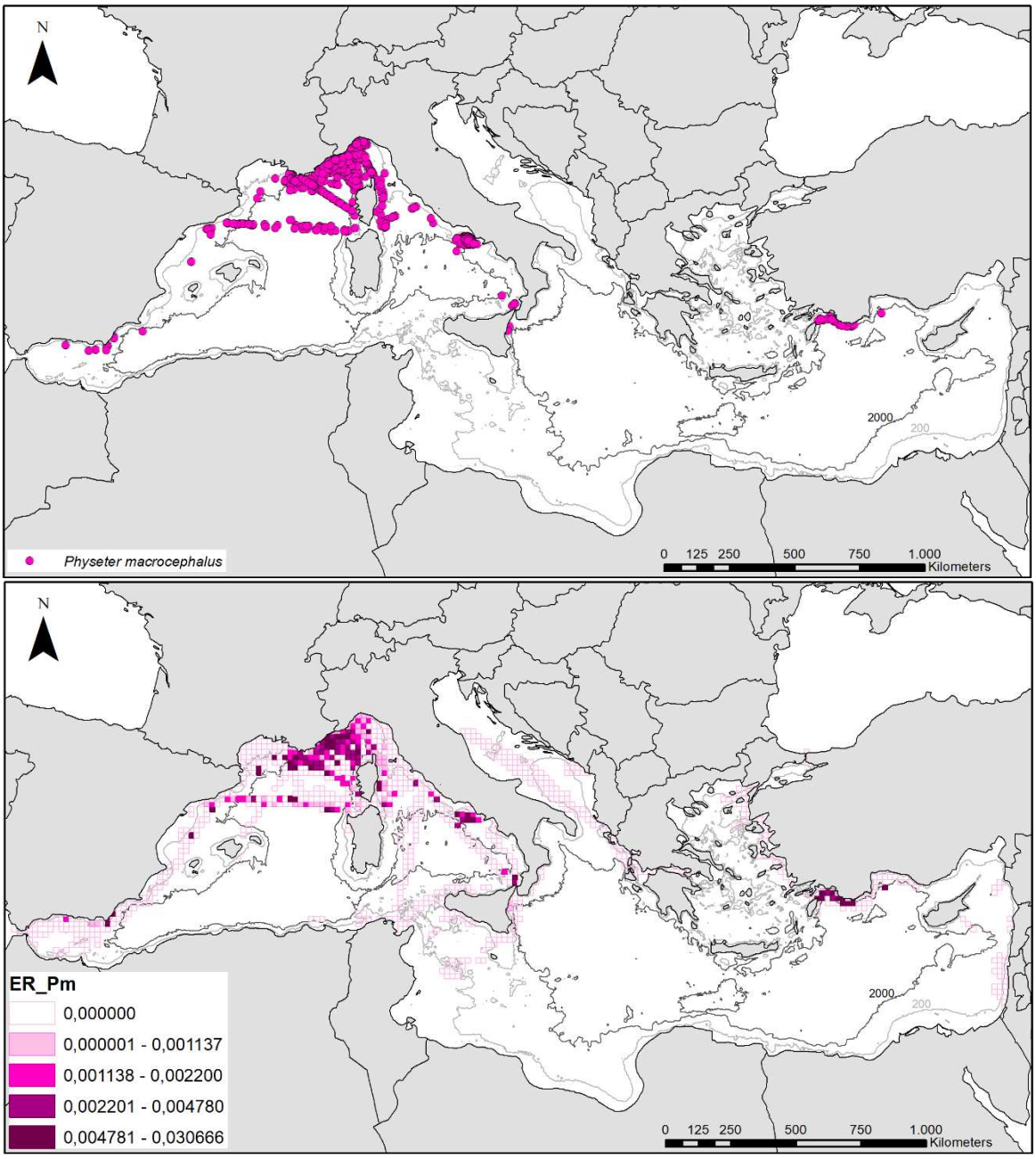

Figure 13. - Sighting distribution (top) and ER (bottom) of the sperm whale (1376 sightings, sampling cells with effort >28 km).

- Fin whale (*Balaenoptera physalus*)

With 3326 encounters (12.89 %), the fin whale is the third species for sightings. Like most Mediterranean species, the fin whale also seems to prefer the offshore waters and its sightings over the continental shelf are occasional. The species shows a major ER in the northern portion of the western basin, which includes the Pelagos Sanctuary, while in the eastern basin there has been no sighting of this species. However, data from this macro area are scarce, especially as regards the pelagic context (Figure 14).

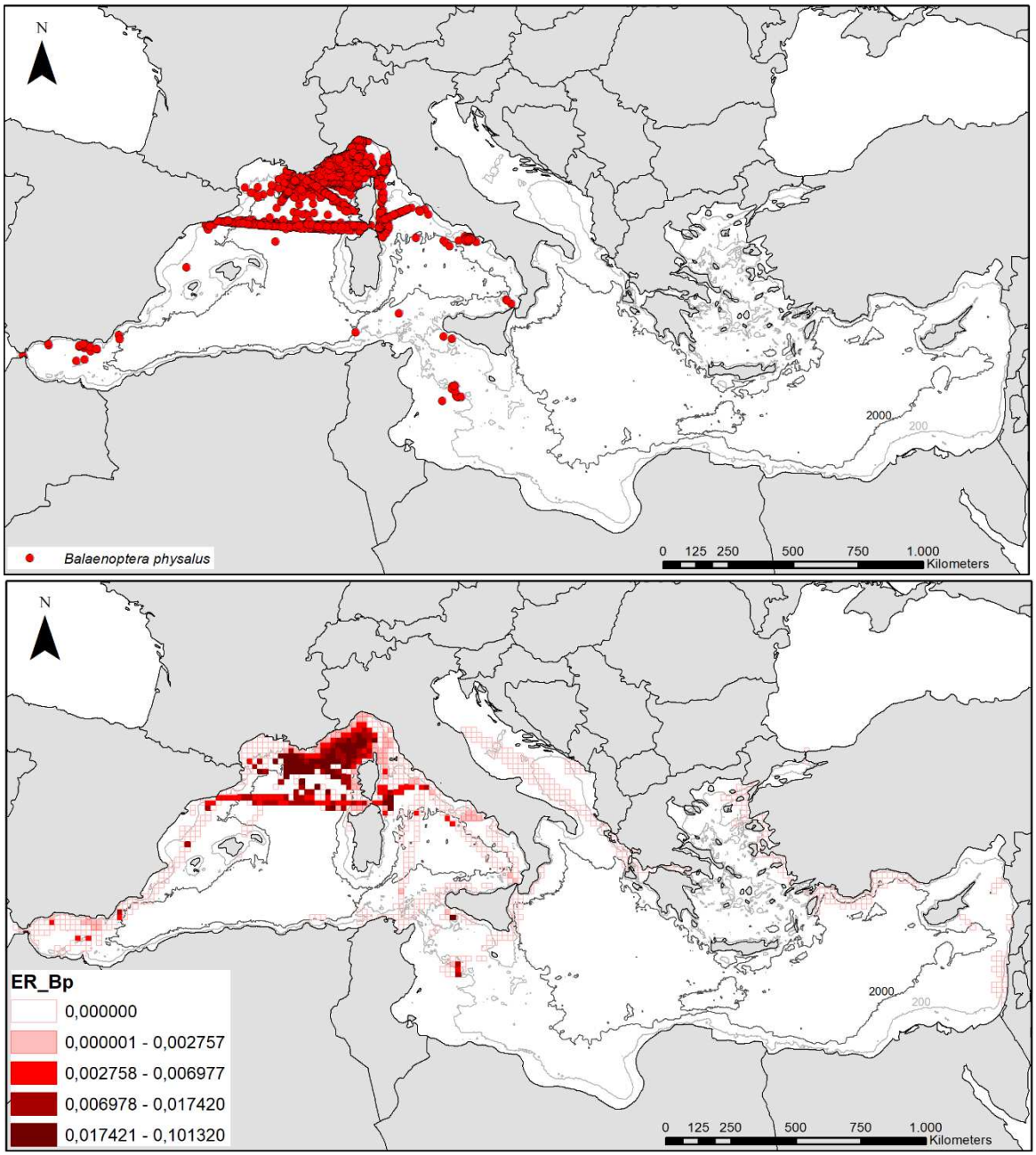

Figure 14. - Sighting distribution (top) and ER (bottom) of the fin whale (3326 sightings, sampling cells with effort >28 km).

- Black Sea harbour porpoise (*Phocoena phocoena relicta*) and occasional species (*Steno bredanensis*, *Orcinus orca*, *Mesoplodon bidens*, *Balaenoptera acutorostrata*, *Megaptera novaeangliae*)

With 28 sightings (0.11 %), the harbour porpoise is one of the least sighted species in the Mediterranean context. All sightings come from the Bosphorus and the immediately adjacent waters in the Marmara Sea. This result is consistent with the literature limiting the distribution of this subspecies to the Black Sea and the Marmara Sea (Tzalkin, 1940; Frantzis et al., 2001).

The remaining species (*Steno bredanensis, Orcinus orca, Mesoplodon bidens, Balaenoptera acutorostrata, Megaptera novaeangliae*) have been sighted only on 1 or 2 occasions within the sampling interval 2004-2019 (Figure 15). The presence of these cetaceans in the Mediterranean context therefore appears quite exceptional, at least in relation to the areas covered by the TursioMed+InterMed network.

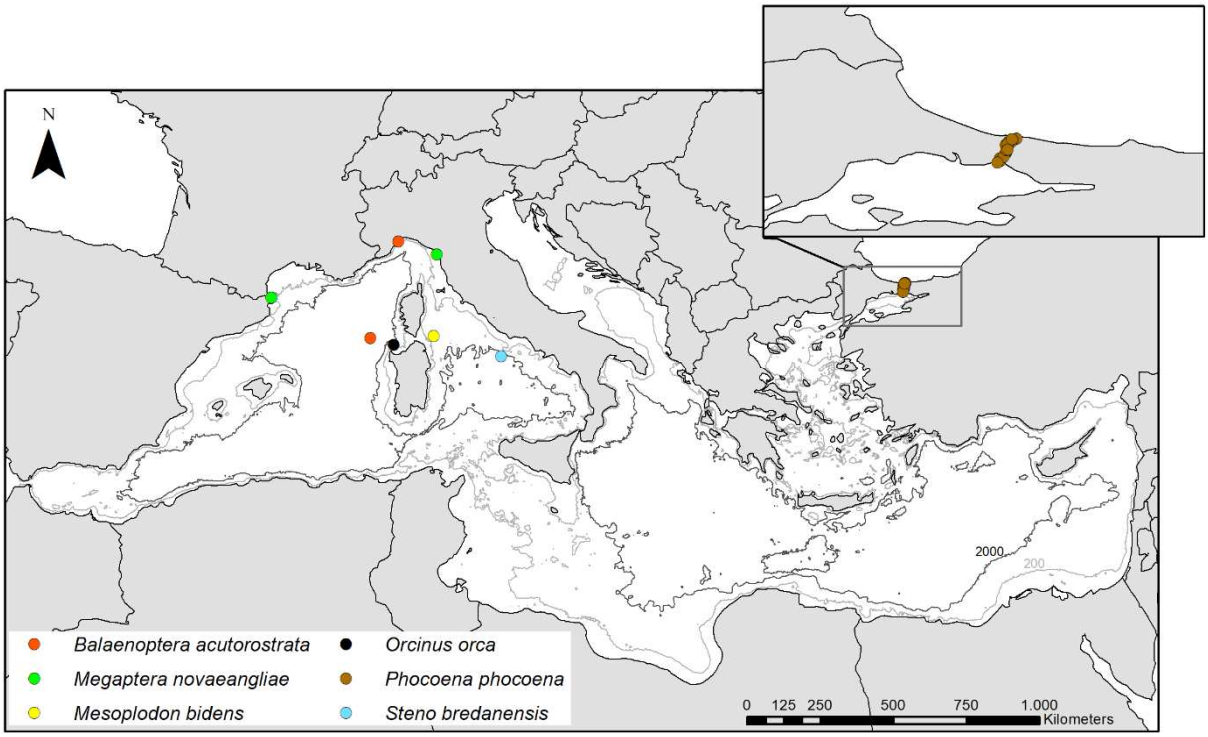

Figure 15. - Sighting distribution of the Black Sea harbour porpoise (28 sightings) and occasional species (*S. bredanensis*: 1; *O. orca*: 1; *M. bidens*: 1; *B. acutorostrata*: 2; *M. novaeangliae*: 2).

4.2. Results from the analysis of photo-identification data

The photo-identification data shared on the common platform (Intercet) within the TursioMed+InterMed projects concern four species: the common bottlenose dolphin (*T. truncatus*), the Risso's dolphin (*G. griseus*), the Cuvier's beaked whale (*Z. cavirostris*), and the sperm whale (*P. macrocephalus*). In the analysis process, the data were also compared with the photo-ID data already included in the Intercet database and around 25,000 images have been examined, validated, and matched.

- Common bottlenose dolphin (*T. truncatus*)

A total of 6041 individuals were identified through photographic data, divided into 36 catalogues pertaining to each research group (remember that not all research groups collected photo identification data, see Table 2). This number (6041) should be considered as the gross number of

dolphins identified, ignoring possible matches between catalogues. The cross matching was implemented to identify possible correspondences and the software finFindR (https://github.com/haimeh/finFindR) was used as a valuable tool to support and speed up the analysis process, making possible to semi-automatically compare the photo-identification images. Through the cross matching, 1834 correspondences were identified, and the net number of individuals thus decreased to 4866 (see Table 5). Most of the matches (cells in green) were found in contiguous sampling areas.

Table 5. – Results of the cross matching between catalogues (*T. truncatus*). The cells with n>0 are highlighted in green. AC: Associació Cetàcea; ARC: Alnilam research and Conservation; AT: ARPAT; BB: Office de l'Environnement de la Corse; BDR: Bottlenose Dolphin Research Institute; BR: Association BREACH; CA: Association CARI; CC: CE.TU.S. Cetacean Research Centre; CG: CNR-IAS - Istituti di Ricerca Marina; CRM: Associazione CRAMA; DDP: Delfini del Ponente APS; DM: Delfini Metropolitani – Fondazione Acquario di Genova; EOI: EcoOcéan Institut; GC: GECEM-MIRACETI; GI: GIS3M-MIRACETI; IDP: Ionian Dolphin Project – Tethys Research Institute; ION: Thalassa Ricerca e Formazione; KT: Ketos; LA: Marine Mammal Research Association – DMAD; LAM: University of Torino, Life and System Biology Department; MEO: MarEco Osservatorio della Natura; MKI: Morris Kahn Marine research station, University of Haifa; MOR: Morigenos; MRS: MeRiS - Mediterraneo Ricerca e Sviluppo APS; MT: MareTerra Onlus; MTL: MareTerra Onlus; ODO: Oceanomare Delphis Onlus; PC: Parc naturel regional de Corse; PE: Pelagos; RS: Regione Sardegna; SAM: APS Sotto al Mare; SBN: SUBMON; SPA: Agence de protection et d'Aménagement du Littoral; TDP: Tunisian Dolphin Project; TRI: Tethys Research Institute-CSR; UGE: Università di Genova - DISTAV.

	n ind.	AC	ARC	AT	BB	BDR	BR	CA	CC	CG	CRM	DDP	DM	EOI	GC	GI	IDP	ION	KT	LA	LAM	MEO	MKI	MOR	MRS	MT	MTL	ODO	PC	PE	RS	SAM	SBN	SPA	TDP	TRI	UGE
AC	127	127																																			
ARC	539	0	539																																		
AT	126	0	0	126																																	
BB	95	0	0	0	95																																
BDR	48	0	0	0	16	48																															
BR	609	24	3	0	0	0	609																														
CA	17	0	0	0	0	0	0	17																													
CC	390	0		38	0	0	0	0	390																												
CG	23	0	0	0	0	0	0	0	0	23																											
CRM	37	0	0	0	2	0	0	0	0	0	37																										
DDP	69	0	0	4	0	0	0	0	31	0	0	69																									
DM	306	0	0	35	0	0	1	0	183	0	0	33	306																								
EOI	285	15	3	0	0	0	118	0	0	0	0	0	1	285																							
GC	860	27	2	1	10	2	156	3	8	0	0	2	7	127	860																						
GI	7	0	0	0	0	0	0	0	0	0	0	0	0	0	1	7																					
IDP	123	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	123																				
ION	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16																			
KT	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15																		
LA	241	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	241																	
LAM	48	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	48																
MEO	49	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	49															
MKI	189	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	189														
MOR	170	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	170													
MRS	79	0	0	1	0	0	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	79												
MT	101	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	101											
MTL	129	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18	9	0	0	0	0	129										
ODO	237	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	237									
PC	36	0	0	0	0	0	0	4	1	0	0	0	0	0	9	1	0	0	0	0	0	0	0	0	0	0	0	0	36								
PE	199	0	0	39	0	0	0	0	94	0	0	11	86	0	4	0	0	0	0	0	0	0	0	0	2	0	0	0	0	199							
RS	6	0	0	0	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6						
SAM	85	0	0	0	0	0	0	0	2	0	0	1	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	34	0	1	0	85					
SBN	356	33	0	0	0	0	26	0	0	0	0	0	0	15	29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	356				
SPA	39	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	39			
TDP	48	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	48		
TRI	168	2	0	4	0	0	14	3	39	0	0	34	59	10	48	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17	0	2	4	0	0	168	
UGE	169	0	0	23	0	0	0	0	90	0	0	18	95	0	2	0	0	0	0	0	0	0	0	0	1	0	0	0	0	39	0	1	0	0	0	40	169
Total (gross)	6041																																				
Total matches	1834	101	8	145	30	5	315	10	450	1	3	99	250	152	94	1	0	0	0	0	20	9	0	0	3	0	0	34	0	57	0	3	4	0	0	40	
Total (net)	4866																																				

InterMed

InterMed + altri progetti

Altri progetti

To measure the degree of sharing between catalogues, the SRI (Simple Ratio Index, Ginsberg and Young, 1992) was calculated (Table 6) according to the following formula:

SRI = X / a + b – X

Where:

a = total number of individuals in the catalogue a.

b = total number of individuals in the catalogue b.

X = number of individuals shared between a and b.

As shown in table 6, the cells with SRI values >0.1 (highlighted in orange) are quite rare (16 cells out of 71) and correspond to neighbouring or contiguous areas.

Table 6. - SRI (Simple Ratio Index) between photo-identification catalogues of *T. truncatus* (in green values > 0; in orange values > 0.1). AC: Associació Cetàcea; ARC: Alnilam research and Conservation; AT: ARPAT; BB: Office de l'Environnement de la Corse; BDR: Bottlenose Dolphin Research Institute; BR: Association BREACH; CA: Association CARI; CC: CE.TU.S. Cetacean Research Centre; CG: CNR-IAS - Istituti di Ricerca Marina; CRM: Associazione CRAMA; DDP: Delfini del Ponente APS; DM: Delfini Metropolitani – Fondazione Acquario di Genova; EOI: EcoOcéan Institut; GC: GECEM-MIRACETI; GI: GIS3M-MIRACETI; LAM: University of Torino, Life and System Biology Department; MEO: MarEco Osservatorio della Natura; MRS: MeRiS - Mediterraneo Ricerca e Sviluppo APS; MT: MareTerra Onlus; MTL: MareTerra Onlus; ODO: Oceanomare Delphis Onlus; PC: Parc naturel regional de Corse; PE: Pelagos; RS: Regione Sardegna; SAM: APS Sotto al Mare; SBN: SUBMON; SPA: Agence de protection et d'Aménagement du Littoral; TRI: Tethys Research Institute-CSR; UGE: Università di Genova - DISTAV.

	n ind.	AC	ARC	AT	BB	BDR	BR	CA	CC	CG	CRM	DDP	DM	EOI	GC	GI	LAM	MEO	MRS	MT	MTL	ODO	PC	PE	RS	SAM	SBN	SPA	TRI	UGE
AC	127	127																												
ARC	539	0	539																											
AT	126	0	0	126																										
BB	95	0	0	0	95																									
BDR	48	0	0	0	0.126	48														InterMed										
BR	609	0.034	0.003	0	0	0	609													InterMed + other projects										
CA	17	0	0	0	0	0	0	17												Other projects										
CC	390	0		0.079	0	0	0	0	390																					
CG	23	0	0	0	0	0	0	0	0	23																				
CRM	37	0	0	0	0.015	0	0	0	0	0	37																			
DDP	69	0	0	0.021	0	0	0	0	0.072	0	0	69																		
DM	306	0	0	0.088	0	0	0.001	0	0.357	0	0	0.096	306																	
EOI	285	0.038	0.004	0	0	0	0.152	0	0	0	0	0	0.002	285																
GC	860	0.028	0.001	0.001	0.011	0.002	0.119	0.003	0.006	0	0	0.002	0.006	0.125	860															
GI	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0012	7														
LAM	48	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	48													
MEO	49	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.002	49												
MRS	79	0	0	0.005	0	0	0	0	0.004	0.01	0	0	0	0	0	0	0	0	79											
MT	101	0	0	0	0	0	0	0	0	0	0.022	0	0	0	0	0	0	0	0	101										
MTL	129	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.113	0.053	0	0	129									
ODO	237	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	237								
PC	36	0	0	0	0	0	0	0.082	0.002	0	0	0	0	0	0.01	0.024	0	0	0	0	0	0	36							
PE	199	0	0	0.136	0	0	0	0	0.190	0	0	0.043	0.205	0	0.004	0	0	0	0.007	0	0	0	0	199						
RS	6	0	0	0	0.02	0.059	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6					
SAM	85	0	0	0	0	0	0	0	0.004	0	0	0.007	0.005	0	0.001	0	0	0	0	0	0	0.118	0	0.004	0	85				
SBN	356	0.073	0	0	0	0	0.028	0	0	0	0	0	0	0.024	0.024	0	0	0	0	0	0	0	0	0	0	0	356			
SPA	39	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	39		
TRI	168	0.007	0	0.014	0	0	0.018	0.016	0.075	0	0	0.167	0.142	0.023	0.049	0	0	0	0	0	0	0	0	0.049	0	0.008	0.008	0	168	
UGE	169	0	0	0.085	0	0	0	0	0.192	0	0	0.082	0.250	0	0.002	0	0	0	0.004	0	0	0	0	0.119	0	0.004	0	0	0.135	169

Following the cross matching, a network outline was drawn for all the individuals spotted on at least 4 occasions (1217 individuals), using the Spring embedding visualization (Eades, 1984; Fruchterman and Reingold, 1991) in NetDraw (Borgatti, 2002). This shows 11 clusters of distinct points (Figure 16), where each point corresponds to an individual "captured" on at least 4 occasions. Four of these (Sardinia NW, Sicily SW, Slovenia and Bosphorus, see Figure 16) are actually composed by small sub-clusters, but we decided to join them in single units as they were originally connected in one network through individuals that were subsequently cut off by the 4 sightings threshold. A total of ten clusters correspond to distinct geographical units, since there are no links between these units and the others (Figure 16). The largest cluster, on the other hand, brings together individuals identified by two or more groups. Within this "macro-cluster" it is possible to identify at least 6 distinct aggregations, which are the result of the strongest attraction around the most connected points. To identify the boundaries between these aggregations, a Girvan-Newman analysis was implemented, based on the measurement of the connectivity (betweenness) of the bonds (Freeman, 1977; Girvan and Newman, 2002; Lusseau and Newman, 2004; Newman and Girvan, 2004). The Girvan-Newman analysis identifies 7 distinct clusters within the same macro-cluster, returning a network made up of a total of 17 clusters (Figure 16).

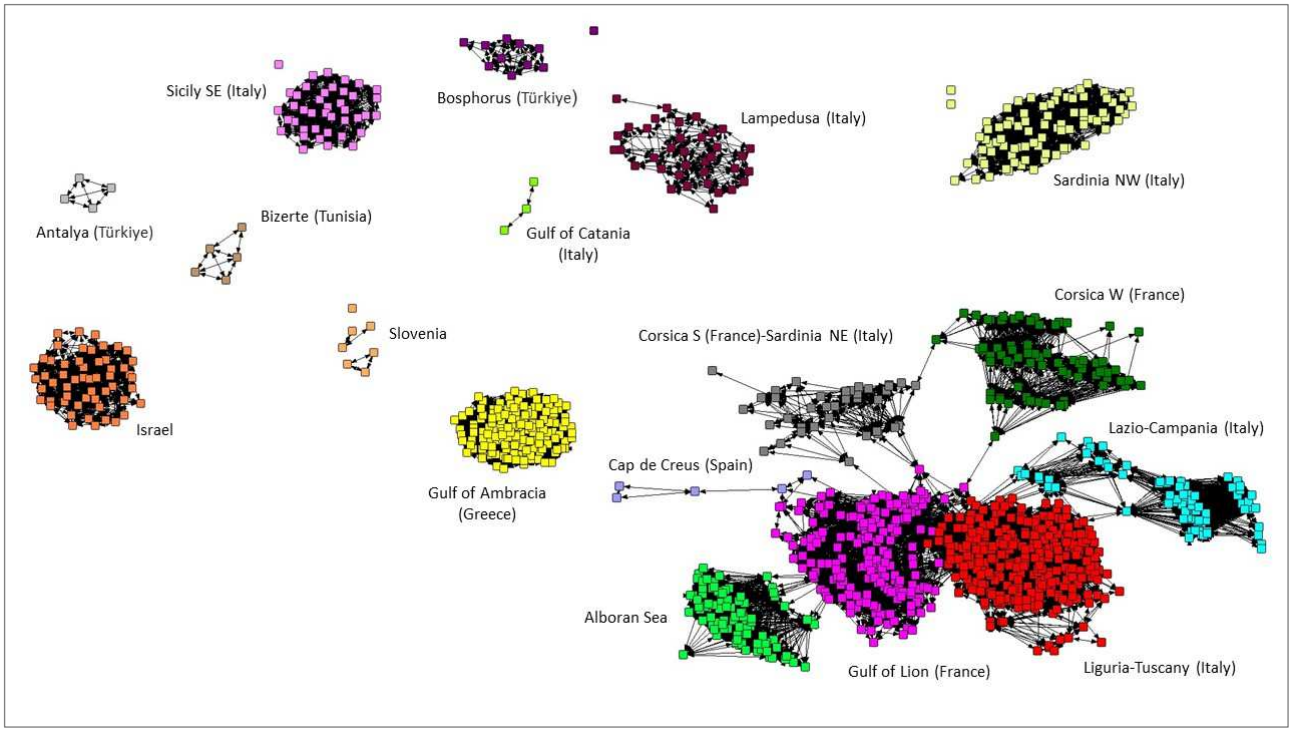

Figure 16. – The Spring embedding + Girvan-Newman analysis show 17 distinct clusters within the network. Each point represents an individual identified and "captured" on at least 4 occasions (1217 individuals in total).

Figure 17 shows the sighting points of the individuals belonging to each cluster, using the same colours. Each cluster-colour corresponds to a different geographical unit and the connectivity value is usually greater between contiguous units but with significant exceptions. The cluster represented in green, for example, which corresponds to the geographical unit of western Corsica, has minimal connectivity with the other neighbouring clusters, despite the proximity of the corresponding geographical units. This phenomenon is likely to be related to the habitat discontinuity, meaning the ecological distance between the areas of residence of the same units.

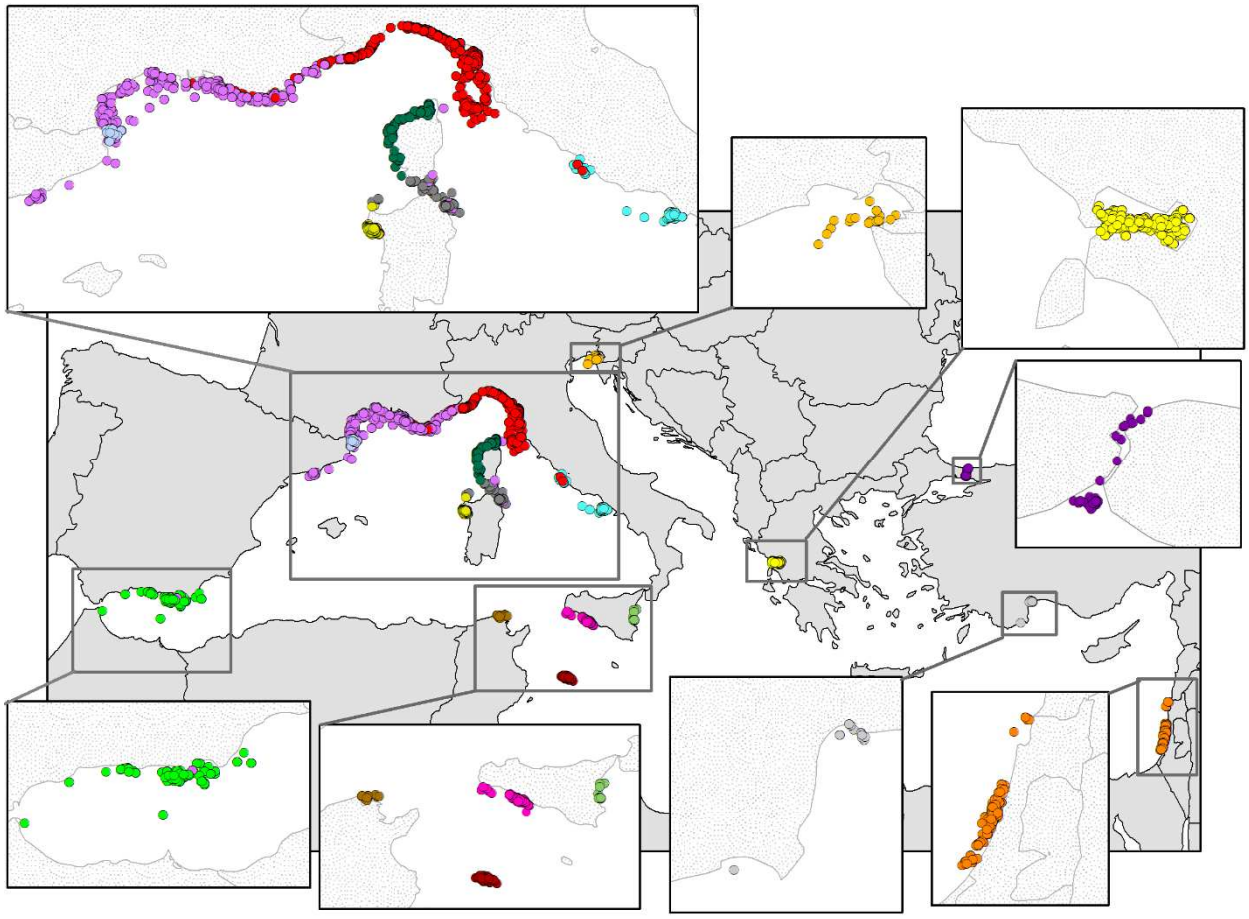

Figure 17. – Sighting position of the common bottlenose dolphins selected for the network analysis (Figure 16). The colours identify the cluster they belong to.

- Risso's dolphin (*G. griseus*)

As for the Risso's dolphin, nine photo-ID catalogues, related to nine different research units, have been uploaded to the Intercet platform: Associació Cetàcea (AC); Association BREACH (BR); CE.TU.S. Cetacean Research Centre (CC); Fondazione CIMA (CIM); EcoOcéan Institut (EOI); GECEM-MIRACETI (GC); MarEco Osservatorio della Natura (MEO); Oceanomare Delphis Onlus (ODO); Tethys Research Institute-CSR (TRI). The research groups covered two different study areas: the Ligurian Sea (NW Mediterranean Sea) and the Campanian Archipelago (Italy).

A total of 790 individuals were identified through the photographic data by the above-mentioned research units. This number (790) should be considered as the gross number of Risso's dolphins photo-identified, ignoring possible matches between catalogues. Through the cross matching, 155 correspondences were revealed (i.e. 155 individuals shared among the various catalogues) and the net number of individuals identified by the network thus decreased to 635 (Table 7). All the matches were found in contiguous sampling areas.

Table 7. - Results of the comparison between Risso's dolphin catalogues and related SRI (in brackets). Positive matches are highlighted in green. AC: Associació Cetàcea; BR: Association BREACH; CC: CE.TU.S. Cetacean Research Centre; CIM: Fondazione CIMA; EOI: EcoOcéan Institut; GC: GECEM-MIRACETI; MEO: MarEco Osservatorio della Natura; ODO: Oceanomare Delphis; TRI: Tethys Research Institute-CSR.

	n ind.	AC	BR	CC	CIM	EOI	GC	MEO	ODO	TRI
AC	**66**	**66**								
BR	**1**	0	**1**					InterMed		
CC	**5**	0	0	**5**				InterMed + other projects		
CIM	**45**	0	0	0	**45**					
EOI	**142**	0	0	0	**3** (0.016)	**142**				
GC	**171**	0	0	0	**4** (0.019)	**27** (0.094)	**171**			
MEO	**24**	0	0	0	0	0	0	**24**		
ODO	**46**	0	0	0	0	0	0	0	**46**	
TRI	**290**	0	0	0	**26** (0.084)	**42** (0.108)	**53** (0.130)	0	0	**290**
Total (gross)	**790**									
Total matches	**155**	0	0	0	33	69	53	0	0	
Total (net)	**635**									

The Spring embedding visualization and the Girvan-Newman analysis, performed on the individuals with at least four captures (120 individuals), identify two distinct clusters, the first one composed by 20 individuals and the second one composed by 100 individuals (Figure 18).

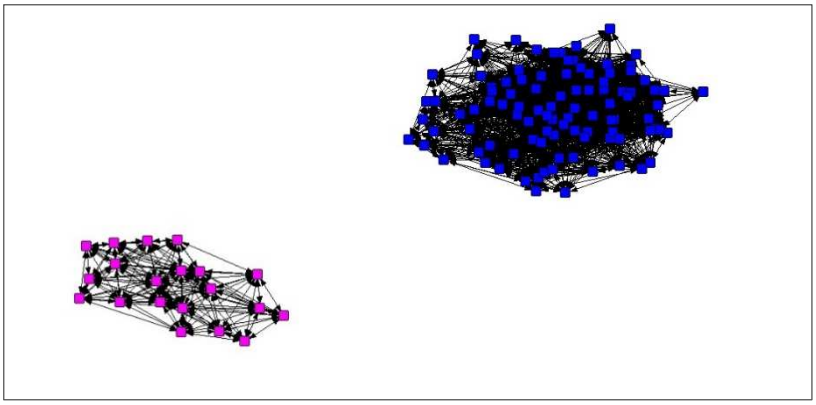

Figure 18. - The Spring embedding layout + Girvan-Newman analysis shows 2 distinct clusters within the Risso's dolphin network. Each point represents an individual identified and "captured" on at least 4 occasions (120 individuals in total, pink one 20 individuals, blue one 100 individuals).

In Figure 19 all sightings of the individuals selected for the network analysis are visualized on map, using the same cluster colours. The two clusters clearly correspond to two distinct geographical units, whose individuals have been sighted in the Ligurian Sea and in the Campanian Archipelago (Italy).

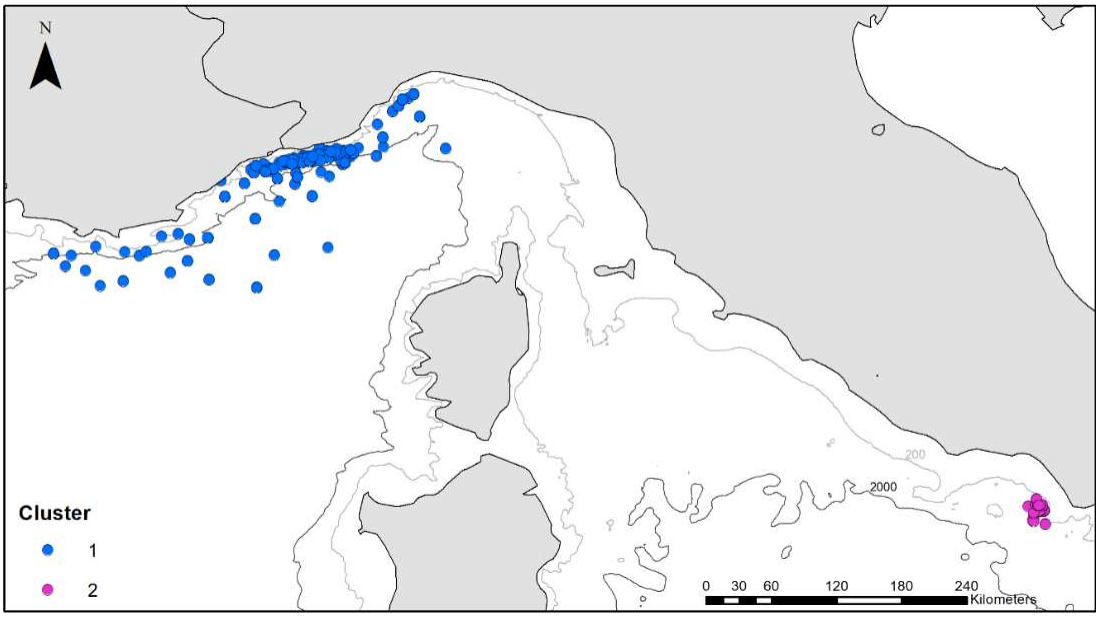

Figure 19. - Sighting position of the Risso's dolphins selected for the network analysis (Figure 18). The colours identify the cluster they belong to.

- Cuvier's beaked whale (*Z. cavirostris*)

As for the Cuvier's beaked whale, four photographic catalogues, related to four different research units, have been uploaded and analysed: CIMA Research Foundation (CIM); Tethys Research Institute (TRI); Golfo Paradiso Whale Watching (GP); DMAD - Marine Mammals Research Association (LA).

The four groups covered two different study areas: the Ligurian Sea (NW Mediterranean Sea) and the Antalya basin (Eastern Mediterranean Sea). CIM, GP and TRI operated mainly in the Ligurian Sea, generally covering three different contiguous subareas (with some spatial overlapping among the groups) over a core zone of about 10,000 km^2, including the Genoa Canyon, the western continental slope of Liguria and the Janua seamount. Photo-id data from the Antalya basin came from an area of <1000 km^2, extending over the Antalya canyon.

A total of 190 individuals were identified through photographic data of the catalogues related to each research unit. This number (190) should be considered as the gross number of the Cuvier's beaked whales photo-identified, ignoring possible matches between catalogues. Through the cross matching, 36 correspondences were recognized (i.e. 36 individuals shared among the various catalogues) and the net number of individuals identified by the network thus decreased to 155 (Table 8).

The total number of individuals photo-identified and recaptured was not sufficient to perform a network analysis, as was done for the common bottlenose dolphin and Risso's dolphin. Figure 20 shows the sighting points of the Cuvier's beaked whales photo-identified by each research group.

Table 8. - Results of the comparison between Cuvier's beaked whale catalogues and related SRI (in brackets). Positive matches are highlighted in green. CIM: Fondazione CIMA; TRI: Tethys Research Institute; GP: Golfo Paradiso Whale Watching; LA: Marine Mammal Research Association – DMAD.

	n ind.	CIM	TRI	GP	LA
CIM	**101**	**101**			
TRI	**64**	**13** (0.086)	**64**		
GP	**24**	**21** (0.202)	**2** (0.023)	**24**	
LA	**1**	0	0	0	**1**
Total (gross)	**190**				
Total matches	**36**	34	2	0	
Total (net)	**155**				

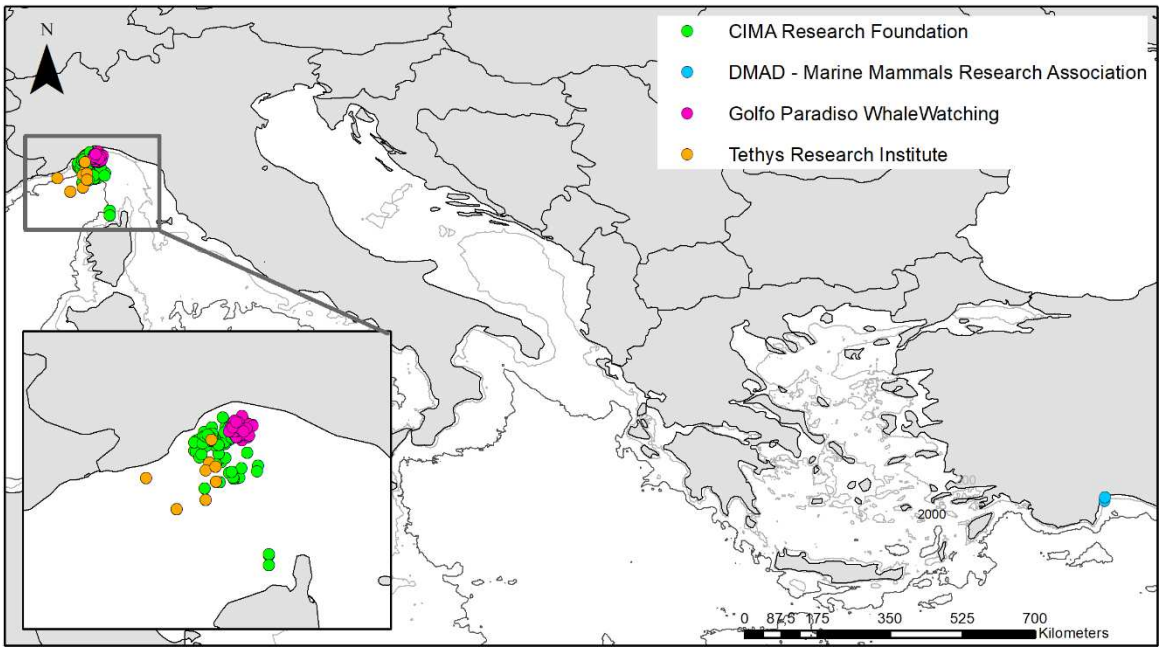

Figure 20. - Distribution of the sighting points of the Cuvier's beaked whales photo-identified by each research group.

- Sperm whale (*P. macrocephalus*)

As for the sperm whale, eight research units have uploaded their catalogues to the Intercet platform: Fondazione CIMA (CIM); Delfini del Ponente APS (DDP); Menkab, il respiro del mare (MKB); Tethys Research Institute-CSR (TRI); EcoOcéan Institut (EOI); Oceanomare Delphis Onlus (ODO); Associació Cetàcea (AC); Marine Mammal Research Association – DMAD (LA). The research groups covered two different study areas: the Ligurian Sea (NW Mediterranean Sea) and the Campanian Archipelago (Tyrrhenian Sea).

A total of 308 individuals were identified through the photographic data by the above-mentioned research units. This number (308) should be considered as the gross number of the sperm whales photo-identified, ignoring possible matches between catalogues. Through the cross matching, 45 correspondences were recognized (i.e. 45 individuals shared among the various catalogues) and the net number of individuals identified by the network thus decreased to 260 (Table 9).

The Girvan-Newman analysis, performed on the sperm whales “captured” at least four times (79 individuals) identified 8 clusters plus 16 single individuals (Figure 21). It should be mentioned that sperm whales, at least in the context of the Mediterranean Sea, rarely aggregate into large cohesive groups and are often sighted alone, especially in the northern regions, frequented mainly by subadult and adult males (Drouot-Dulau and Gannier, 2007). However, it is known that these whales can maintain acoustic contacts with conspecifics over long distances, forming dispersed groups (Schulz *et al*., 2008). The association criterion used for more "sociable" species, such as the common bottlenose dolphin or the Risso's dolphin, could therefore generate bias, underestimating the connectivity between individuals and producing supernumerary clusters.

Table 9. - Results of the comparison between sperm whale’s catalogues and related SRI (in brackets). Positive matches are highlighted in green. CIM: Fondazione CIMA; DDP: Delfini del Ponente; MKB: Menkab; TRI: Tethys Research Institute-CSR; EOI: EcoOcéan Institut; ODO: Oceanomare Delphis Onlus; AC: Associació Cetàcea.

	n ind.	CIM	DDP	MKB	TRI	EOI	ODO	AC	LA
CIM	**5**	**5**							
DDP	**3**	0	**3**				InterMed		
MKB	**2**	0	**1** (0.250)	**2**			InterMed + other projects		
TRI	**152**	**2** (0.013)	0	0	**152**				
EOI	**52**	**1** (0.018)	0	0	**20** (0.109)	**52**			
ODO	**92**	0	0	0	**17** (0.075)	**4** (0.029)	**92**		
AC	**1**	0	0	0	0	0	0	**1**	
LA	**1**	0	0	0	0	0	0	0	**1**
Total (gross)	**308**								
Total matches	**45**	3	1	0	37	4	0	0	
Total (net)	**260**								

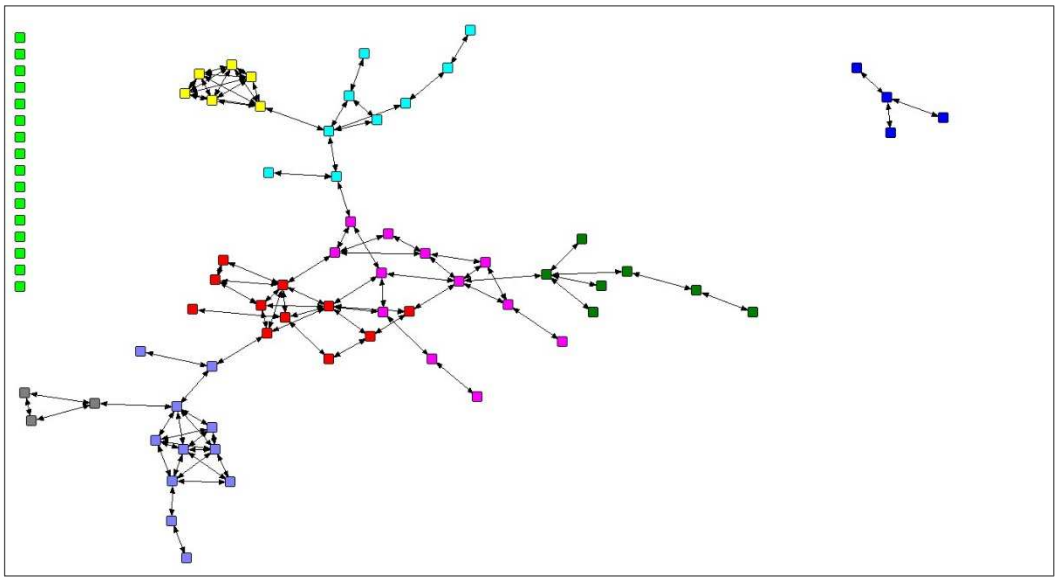

Figure 21. - The Spring embedding layout + Girvan-Newman analysis showing 9 clusters and 16 single individuals (green squares on the left) within the sperm whale network. Each point represents an individual identified and "captured" on at least 4 occasions (79 individuals in total).

In Figure 22, all sightings of the sperm whales selected for the network analysis are visualized on map, using the same cluster colours. The map shows an aggregation of colours in the Ligurian Sea (clusters 1, 2, 3, 4, 5, 6, 7) and in the Campanian Archipelago (clusters 2, 4, 7, 8). To better show the movements of the photo-identified individuals, we used the Minimum Convex Polygon (MCP) technique, selecting the individuals with at least two captures (157 individuals). We remind that, in case of only two captures, the MCP analysis shows a segment between the sighting points (Figure 23).

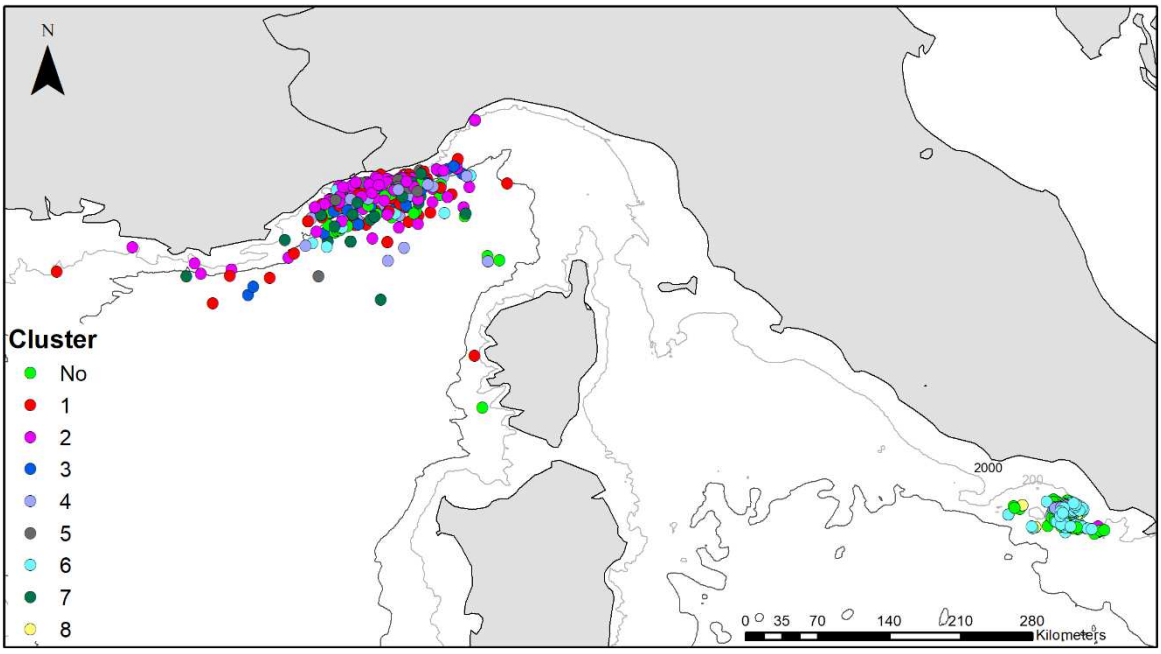

Figure 22. - Sighting position of the sperm whales selected for the network analysis (Figure 21). The colours identify the cluster they belong to.

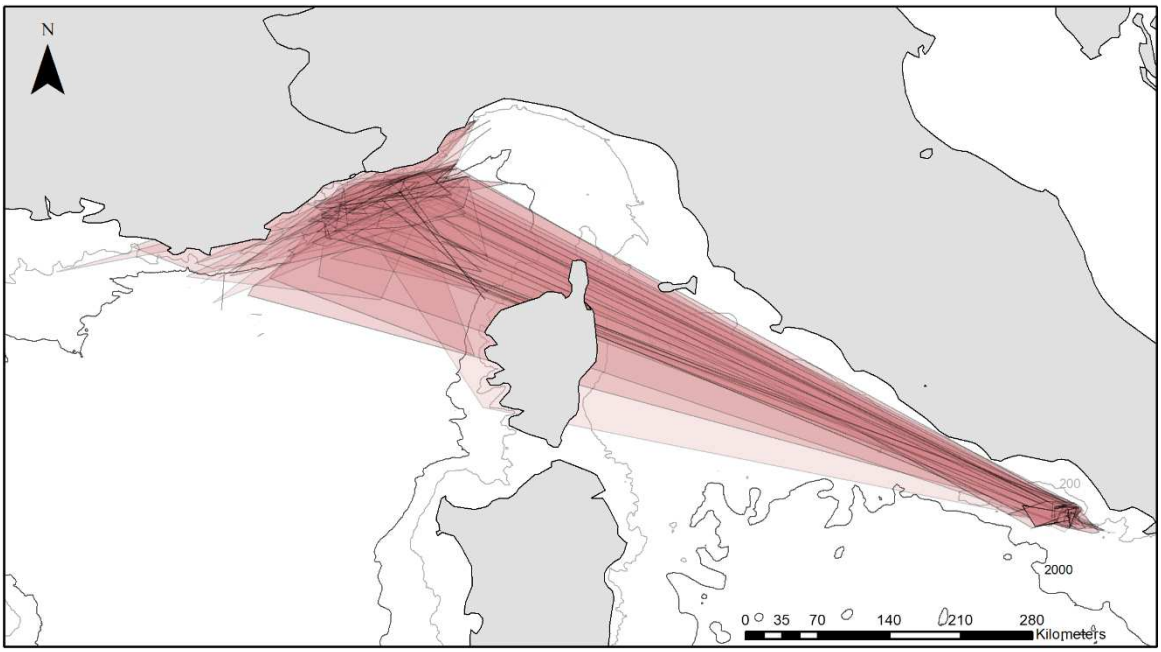

Figure 23. – Minimum Convex Polygons (MCPs) showing the movements of the photo-identified sperm whales with at least two captures (157 individuals). In case of only two captures, the MCP analysis shows a segment between the sighting points. The map shows 54 segments (individuals with only 2 captures) and 103 polygons (individuals with ≥3 captures).

5. Research campaign in the Strait of Sicily

Two different research campaigns were carried out in the Strait of Sicily, with the aim of improving our knowledge in this important area of the Mediterranean Sea, which connects the western and eastern basins.

The first campaign was carried out by CNR-IAS in 2021, on the Sicilian side of the strait (Banco Avventura). A total of 20 daily surveys were conducted, resulting in 1623 km of sampling effort (Table 10, Figure 24) and a total of 30 sightings (Figure 25), 23 of common bottlenose dolphin (*T. truncatus*) and 7 of common dolphin (*D. delphis*). The photographic data collected allowed 55 individuals of bottlenose dolphin to be photo-identified. All data were uploaded on the Intercet platform.

Table 10. – Sampling effort and relating sightings of the research campaign carried out by CNR-IAS in the Sicilian waters of the Strait of Sicily (see also Figure 24, 25). *Tt: T. truncatus; Dd: D. delphis.*

SAMPLING EFFORT				SIGHTINGS				
N	DATE (dd.mm.yyyy)	Intercet CODE	EFFORT (km)	Intercet CODE	SPECIES		GROUP SIZE	
					Tt	*Dd*	Tt	Dd
1	5.06.2021	210605_CG_IM_TBM001	84	210605_CG_IM_SBM001	0	1	-	6
				210605_CG_IM_SBM002	0	1	-	6
2	26.06.2021	210626_CG_IM_TBM001	79	210626_CG_IM_SBM001	1	0	2	-
3	8.07.2021	210708_CG_IM_TBM002	50	210708_CG_IM_SBM002	1	0	3	-
4	30.07.2021	210730_CG_IM_TBM003	50	210730_CG_IM_SBM003	1	0	3	-
5	31.07.2021	210731_CG_IM_TBM004	67	210731_CG_IM_SBM004	1	0	3	-
6	25.08.2021	210825_CG_IM_TBM017	87	-	0	0	-	-
7	26.08.2021	210826_CG_IM_TBM018	95	-	0	0	-	-
8	31.08.2021	210831_CG_IM_TBM005	95	210831_CG_IM_SBM005	1	0	2	-
				210831_CG_IM_SBM006	1	0	3	-
9	1.09.2021	210901_CG_IM_TBM006	119	210901_CG_IM_SBM003	0	1	-	3
				210901_CG_IM_SBM007	1	0	3	-
				210901_CG_IM_SBM008	1	0	1	-
10	7.09.2021	210907_CG_IM_TBM007	94	210907_CG_IM_SBM009	1	0	1	-
				210907_CG_IM_SBM010	1	0	3	-
				210907_CG_IM_SBM011	1	0	3	-
				210907_CG_IM_SBM012	1	0	4	-
11	8.09.2021	210908_CG_IM_TBM008	175	210908_CG_IM_SBM004	1	0	10	-
				210908_CG_IM_SBM013	1	0	6	-
				210908_CG_IM_SBM014	1	0	1	-
12	14.09.2021	210914_CG_IM_TBM009	102	210914_CG_IM_SBM005	0	1	-	100
				210914_CG_IM_SBM015	1	0	6	-
				210914_CG_IM_SBM016	1	0	1	-
13	15.09.2021	210915_CG_IM_TBM010	96	210915_CG_IM_SBM017	1	0	2	-
				210915_CG_IM_SBM018	1	0	7	-
14	21.09.2021	210921_CG_IM_TBM011	66	210921_CG_IM_SBM006	0	1	-	50
				210921_CG_IM_SBM019	1	0	2	-
15	3.10.2021	211003_CG_IM_TBM013	14	-	0	1	-	50
16	17.10.2021	211017_CG_IM_TBM015	84	-	0	0	-	-
17	18.10.2021	211018_CG_IM_TBM012	92	211018_CG_IM_SBM007	0	1	-	3
				211018_CG_IM_SBM020	1	0	2	-
18	19.10.2021	11019_CG_IM_TBM013	81	211019_CG_IM_SBM008	0	1	-	50
				211019_CG_IM_SBM021	1	0	4	-
				211019_CG_IM_SBM022	1	0	2	-
19	20.10.2021	211020_CG_IM_TBM016	89	-	0	0	-	-
20	8.11.2021	211108_CG_IM_TBM014	5	-	0	0	-	-
TOTAL			**1623**		**23**	**7**	**3.22***	**42.67***

*Average group size

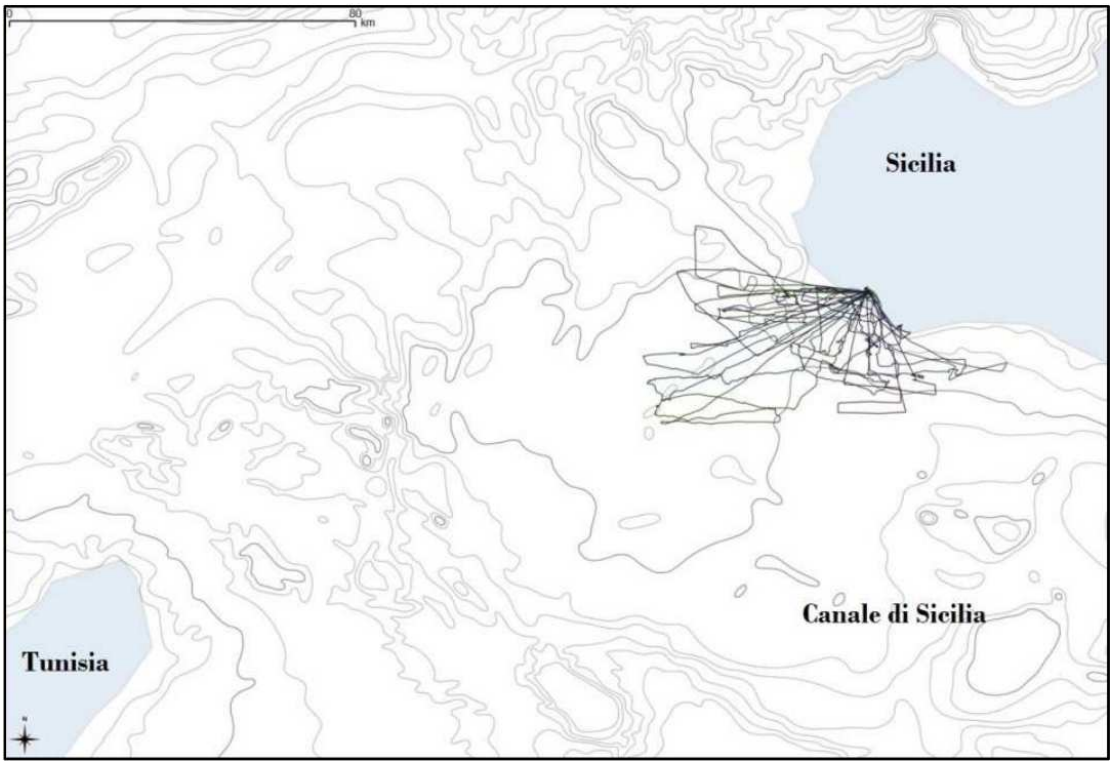

Figure 24. - Survey tracks of the research campaign carried out by CNR-IAS in the Sicilian waters of the Strait of Sicily (1624 km).

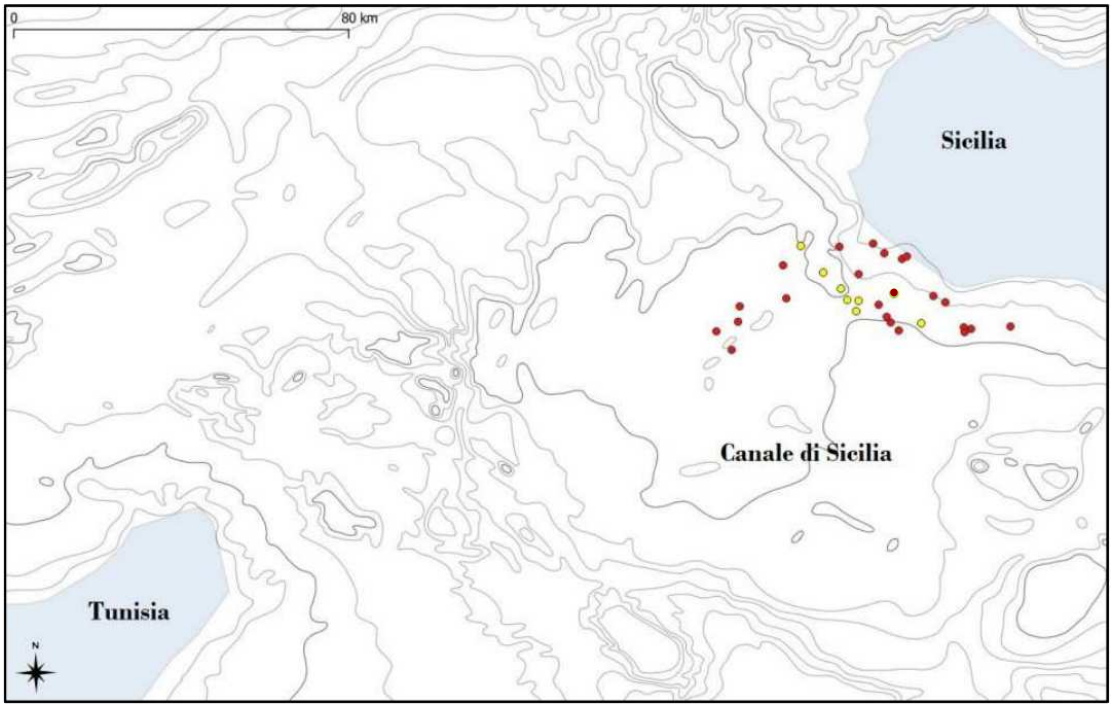

Figure 25. - Sighting points of the research campaign carried out by CNR-IAS in the Strait of Sicily. The red points indicate the sightings of *T. truncatus* (23), while the yellow points those of *D. delphis* (7).

The second research campaign was carried out by RAC/SPA (Regional Activity Centre for Specially Protected Areas) in collaboration with the Agence de protection et d'Aménagement du Littoral in 2022, on the Tunisian side of the strait (Gulf of Tunis and Gulf of Hammamet). A total of 9 daily surveys were conducted, resulting in 1270 km of sampling effort (Table 11, Figure 26) and a total of 17 sightings of common bottlenose dolphins (*T. truncatus*). The photographic data collected allowed 39 individuals of common bottlenose dolphin to be photo-identified. All data were uploaded on the Intercet platform.

Table 11. – Sampling effort and relating sightings of the research campaign carried out by SPA/RAC, in collaboration with Agence de protection et d'Aménagement du Littoral, in Tunisian waters of the Strait of Sicily (see also Figure 26).

N	DATE (dd.mm.yyyy)	SUB-AREA	Intercet CODE	EFFORT (km)	SIGHTINGS (*Tt*)		
					Intercet CODE	*Tt*	SIZE
1	9.04.2022	South	220409_SPA_IM_TCN001	133	220409_SPA_IM_SCN001	1	8
					220409_SPA_IM_SCN002	1	4
					220409_SPA_IM_SCN003	1	6
2	9.04.2022	South	220409_SPA_IM_TGL002	61	220409_SPA_IM_SGL001	1	1
					220409_SPA_IM_SGL002	1	4
					220409_SPA_IM_SGL003	1	3
3	5.06.2022	South	220605_SPA_IM_TCN003	196	220605_SPA_IM_SCN001	1	8
					220605_SPA_IM_SCN002	1	6
4	5.06.2022	South	220605_SPA_IM_TGL004	126	220605_SPA_IM_SGL001	1	4
					220605_SPA_IM_SGL002	1	5
5	6.06.2022	South	220606_SPA_IM_TGL005	111	220606_SPA_IM_SCN001	1	8
					220606_SPA_IM_SCN002	1	6
					220606_SPA_IM_SCN003	1	5
					220606_SPA_IM_SCN004	1	7
6	11.08.2022	North	220811_SPA_IM_TKU007	97	220811_SPA_IM_SKU001	1	9
8	13.08.2022	North	220813_SPA_IM_TKU008	192	220813_SPA_IM_SKU001	1	3
9	14.08.2022	North	220814_SPA_IM_TKU009	106	220814_SPA_IM_SKU001	1	1
TOTAL				**1270**		**17**	**5.18***

*Average group size

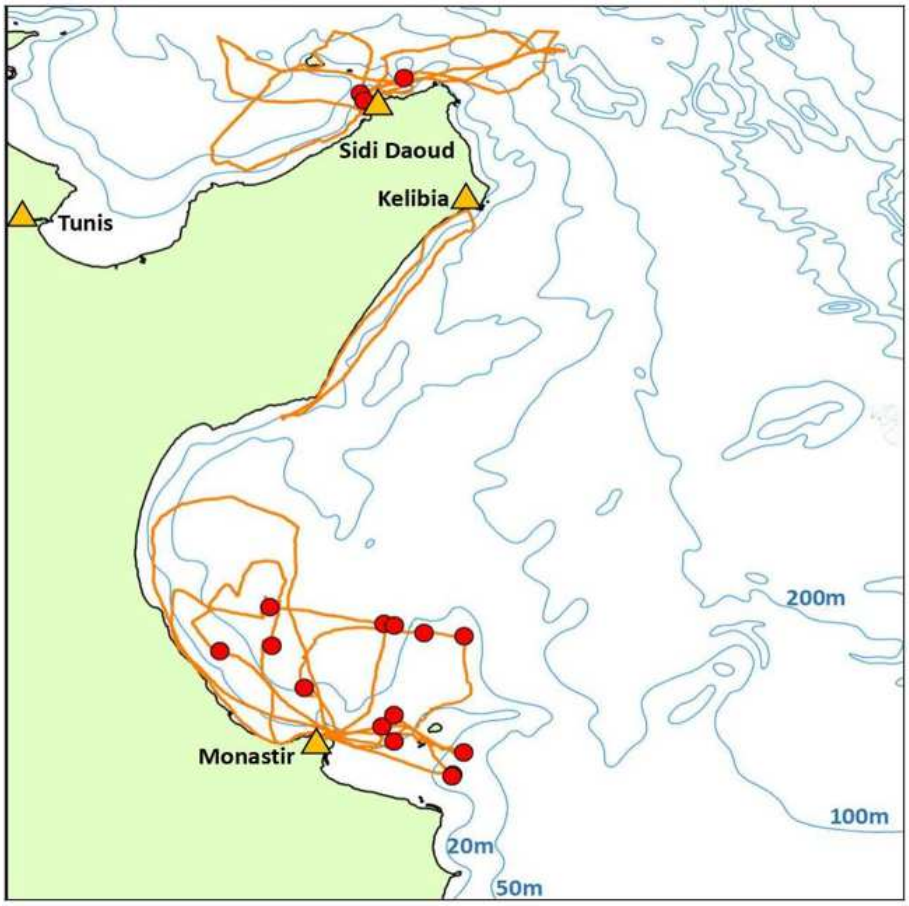

Figure 26. - Sighting points the research campaign carried out by SPA/RAC, in collaboration with Agence de protection et d'Aménagement du Littoral, in Tunisian waters of the Strait of Sicily (*T. truncatus*: 17).

6. Discussion of the results

Analyses of aggregated data confirm and strengthen the results of the TursioMed project (Gnone *et al*., 2022) and add new ones. Eight cetacean species (*Tursiops truncatus, Stenella coeruleoalba, Delphinus delphis, Grampus griseus, Globicephala melas, Ziphius cavirostris, Physeter macrocephalus, Balaenoptera physalus*) are regularly present in the Mediterranean Sea, with a different encounter rate between species and study areas. Over the total number of sightings analysed (25,805), 92% are attributable to only four species: striped dolphin (*S. coeruleoalba*), common bottlenose dolphin (*T. truncatus*), fin whale (*B. physalus*) and sperm whale (*P. macrocephalus*). However, it should be considered that the different species have a different degree of "sightability", depending on the size, the aggregation behaviour, the time spent diving and so on. It would therefore be hazardous to automatically infer that a more frequently sighted species is also more densely present in a given area. The Cuvier's beaked whale, for example, is a rather elusive species, due to prolonged dives, and its presence could therefore be underestimated. Moreover, the distribution of the different species varies significantly from area to area, and cetaceans that are scarcely sighted at basin level may be regularly found locally. In the Alborán Sea, for example, most of the species are regularly sighted and the dominant position of the above-mentioned species is not evident (actually, the fin whale and the sperm whale are even poorly sighted, possibly because of the average shallow waters). Also in the north-western Mediterranean Sea, which includes the Pelagos Sanctuary, it is possible to sight the less common species, such as the pilot whale or the Cuvier's beaked whale, which seem to find particularly favourable conditions in this area.

In relation to habitat preference, most species seem to find their habitat in offshore waters, beyond the limit of the 200 m isobath that marks the boundary of the continental shelf. In this context, the striped dolphin is the most sighted cetacean, with over 60% of total sightings. Over the continental shelf, on the contrary, the common bottlenose dolphin is the predominant species and almost 90% of sightings (88.54 %) concern this delphinid. Furthermore, the common bottlenose dolphin seems to be present in all the study areas covered by the research network (provided they are included within the continental shelf), although with different ER values. It is important to highlight, however, that the ER can be biased by many factors: the characteristics of the vessel used for sampling, the number and ability of the observers on board, the marine weather conditions in the different study areas, the behaviour of the animals with respect to the research vessel itself or to reference elements that could facilitate the sighting, etc. The ER may also vary according to the sampling effort implemented, especially for those species whose distribution may change according to season, such as the fin whale. For example, if the sampling effort implemented coincides with the seasonal presence of the species in the area, the resulting ER will be maximum, while if the sampling effort does not coincide or is implemented throughout the year, the ER will be lower. Therefore, caution must be exercised when comparing ER in different study areas.

The fin whale is the third species for number of sightings (3326) and shows a clear preference for pelagic waters >2000 m, where its sightings represent 30.68 % of the total. The presence of this large mysticete appears limited to the western basin (but we should always take into consideration the data shortage in the pelagic domain of the eastern basin), and its distribution seems to concentrate in the northern portion, which includes the Pelagos Sanctuary (Figure 14).

The sperm whale also finds its habitat in the pelagic domain, with a possible preference for deep waters at the edge of the continental slope and the abyssal plain. Its presence also appears limited to the western basin (with few exceptions), but again we should consider the poor data coverage in the eastern basin, especially in the pelagic domain. As already mentioned, the preference of the sperm whale and fin whale for pelagic-deep waters could explain their low presence in the Alborán Sea, whose average depth is 450 m.

The remaining species show a more heterogeneous distribution, often restricted to (or most prevalent in) the western basin (such as the pilot whale and the Risso's dolphin), fragmented (such as the Risso's dolphin) or limited to a few specific areas (such as the pilot whale and the Cuvier's beaked whale) and, as a general pattern, the encounter rate of most species seems to decrease from the Alborán Sea to the western basin and from the western basin to the eastern one, even if with considerable local variations.

Given this general pattern, the common dolphin shows a quite peculiar distribution. The encounter rate of this species is higher in the middle depth waters of the Alborán Sea, decreases in the western and central Mediterranean, where this species is mainly sighted in pelagic waters (usually a few individuals, mixed with large groups of striped dolphins), and re-increases in the Aegean Sea, where the common dolphin seems to find its preferred habitat at the upper edge of the continental slope, close to the platform, contributing to the local diversity of species (Figure 9).

In relation to the movement analysis, the common bottlenose dolphin is confirmed as a resident species, with most of the individuals showing a clear and long-lasting site fidelity. The analysis of connectivity within the network shows a rather clear clustering, where each cluster represents a sufficiently distinct geographical unit. The level of connectivity between clusters is a function of the geographical distance between the areas of residence but also of the continuity (or discontinuity) of habitats (the ecological distance). This is most probably the result of a specialization on the residence habitat, as already suggested by Carnabuci *et al*. (2016) and Vassallo *et al*., 2020. This specialization probably has a cultural component and is transmitted from one generation to the next in a matrilineal way (Kopps *et al*., 2014). However, as already emerged from the results of the TursioMed project, there is a minor number of individuals that shows far greater movements than the average, up to hundreds of kilometres (the so-called "long travellers"), and may represent a means of continuity between the different geographical units.
These results are quite consistent with those obtained by Gnone *et al*. (2011) in the Ligurian Sea and Boitani *et al*. (2022) around the coasts of Sicily.

As for the Risso's dolphin, the available data are much less than for the common bottlenose dolphin, and this is most probably a consequence of the lower presence and distribution of this species in the context of the Mediterranean Sea (at least in the sampling areas covered by the TursioMed+InterMed network). Still, it's possible to recognize a certain level of site fidelity, as none of the individuals photo-identified in the Ligurian Sea was re-sighted in the Campanian Archipelago and vice versa, neither where they sighted in other study areas covered by the InterMed network. This finding, if confirmed, could be of special interest for the ecology and conservation of this species. The Risso's dolphin is quite "sightable", due to the relatively large aggregation and the light color of the adult individuals. Nevertheless, in the common dataset analyzed this specie is the seventh for number of sightings (only 374 over 25,821) and, according to previous studies, its presence in some "traditional" areas, such as the north-western Mediterranean Sea and Pelagos Sanctuary, is becoming rarer (Azzellino *et al*., 2016). There's

however a common perception that the dolphins could have moved to other zones, shifting their traditional area of distribution. The data analyzed in this report, while rather sparse (but, as mentioned, the lack of data is also due to the low occurrence of the species), do not seem to support the hypothesis of a highly mobile species, as is the case with the sperm whale (see below).

The photo-identification data of the Cuvier's beaked whale regard only four research units, three of these operating in the Ligurian Sea and one in the Antalya basin (Türkiye). As in the case of the Risso's dolphin, the data shortage is a consequence of the limited distribution of the species on a Mediterranean level, but possibly also of the elusive behavior of this deep diver. Due to data shortage, we were not able to perform a network analysis. However, all the research units operating in the Ligurian Sea share some individuals, which seems to confirm a certain level of site fidelity, as already described for this species (Baird, 2019).

As for the sperm whale, eight research units shared their photo-identification data on the Intercet platform, one located off the coast off Catalonia (Balearic Sea, Spain), six along the north-eastern coast of the Pelagos Sanctuary, and one in the Campanian Archipelago (Tyrrhenian Sea, Italy). The data collected were enough to perform a network analysis, but, as already said, the association criterion used could have underestimated the connectivity between individuals in "dispersal groups", producing supernumerary clusters. Given that, all the clusters identified by the Girvan-Newman analysis (except one) are connected in one single super-cluster, suggesting that the sperm whales inhabiting the Mediterranean Sea may indeed all be connected within the same network. The MCP analysis shows the movements of 16 individuals (out of 157 individuals with at least 2 captures) between the two main study areas (Ligurian Sea and Campanian Archipelago), and of 1 individual between the Campanian Archipelago and the western Corsica, confirming that sperm whales are quite mobile on this spatial scale. The prevalence of one cluster colour (sky blue, number 6) in the Campanian Archipelago suggests some sort of site fidelity, to be confirmed by further analyses (Figures 22, 23).

In relation to the research campaign carried out in the Strait of Sicily, both the research units sighted the common bottlenose dolphin (*T. truncatus*) with good success, confirming this species as a dominant delphinid of the continental shelf macrohabitat, possibly distributed over the whole Mediterranean shelf, wherever a proper effort is implemented. However, the average group size was quite low (see Tables 10, 11) if compared with other areas of the Mediterranean Sea (Gnone *et al*., 2022), especially on the Sicilian side (average group size 3.22). The reasons for this should be investigated. The sightings of common dolphins (*D. delphis*) recorded by the CNR-IAS unit in the Sicilian waters, with a maximum group size of 100 individuals (see Table 10, Figure 25) is unexpected and of particular interest. As already mentioned, the common dolphin is poorly sighted in the western basin (except for the Alborán Sea) and in the Tyrrhenian Sea the sightings usually concern a few individuals, herded with striped dolphins. This interspecific behaviour may be due to the difficulty of forming large aggregations, typical of this highly social dolphin, with conspecifics. The sighting of large monospecific aggregation in the Strait of Sicily is therefore of special interest and suggests the need for a greater research effort to develop targeted conservation actions.

7. Summary of conclusions

Below is a summary of the main results of the TursioMed+InterMed projects.

- Eight species of cetaceans regularly live in the Mediterranean basin: the striped dolphin (*S. coeruleoalba*), the common bottlenose dolphin (*T. truncatus*), the common dolphin (*D. delphis*), the Risso's dolphin (*G. griseus*), the long-finned pilot whale (*G. melas*), the Cuvier's beaked whale (*Z. cavirostris*), the sperm whale (*P. macrocephalus*), and the fin whale (*B. physalus*). Four of these species (*T. truncatus*, *S. coeruleoalba*, *P. macrocephalus*, *B-physalus*) show a higher encounter rate and alone constitute 92 % of all sightings.
- In the study areas covered by the TursioMed+InterMed network the cetacean species show an uneven distribution, with some important diversity hot spots, such as the Alborán Sea and the SPAMI (Specially Protected Area of Mediterranean Interest) of the Pelagos Sanctuary (but possibly also some other areas where the data available are insufficient and that deserve more attention).
- The common bottlenose dolphin is confirmed as the dominant species of the continental shelf macro-habitat, where it forms discrete geographical units, with a high level of site fidelity. The degree of connectivity between these units seems to depend on the geographical and ecological distance of the areas of residence.
- The Risso's dolphin is poorly sighted on a Mediterranean level (374 sightings over 25,805), most probably because of the low and scattered occurrence of this species. The analysis of photo-identification data confirms some level of site fidelity, and this may be an additional cause for concern as this species appears to be declining in traditional sighting areas, such as the Pelagos Sanctuary.
- The Cuvier's beaked whale was sighted on 631 occasions but, considering its elusive behaviour and low "sightability", the presence of this deep and long diver in the Mediterranean Sea may be underestimated. The photographic data analysed (although relatively scarce) seem to confirm a certain level of site fidelity also for this species.
- The sperm whale, despite its low "sightability," has been sighted on 1376 occasions, confirming the dominant position of this odontocete among large cetaceans. Analysis of photo-identification data confirms sperm whales are quite mobile on the spatial scale of the Mediterranean Sea, but also suggests a kind of site fidelity, a hypothesis that deserves further analysis.
- The results of the research campaigns in the Strait of Sicily confirm the common bottlenose dolphin as the dominant species of the continental shelf macro-habitat, possibly distributed over the entire Mediterranean shelf, and reveal an unexpected presence of the common dolphin, one of the most threatened species in the Mediterranean Sea (Bearzi *et al*., 2022). In this regard, further investigations are urgently needed to improve the knowledge and develop targeted conservation actions.

8. Recommendations for the future

The results obtained in this collective research effort underline the importance of data sharing to better understand the distribution and ecology of cetaceans. As far as we know, the common dataset of the TursioMed+InterMed projects is the largest ever analysed in aggregate form in the context of the Mediterranean Sea, but there are still large portions of the basin for which no data were available (e.g., the eastern basin, in its southern portion and in the pelagic area) and this could lead to an underestimation of cetacean diversity and conservation needs. In fact, although it

is believed that the western basin hosts a greater diversity in terms of cetacean fauna (Coll *et al*., 2010), some species, such as the rough-toothed dolphin (*Steno bredanensis*), seem to find their main distribution range in the eastern basin (*Boisseau et al*., 2010). The gaps also include important biodiversity hotspots located in the eastern basin, such as the Hellenic Trench, which is considered an Important Marine Mammal Area (IMMA), especially for deep divers such as the sperm whale and Cuvier's beaked whale (IUCN-MMPATF, 2017). It is thus crucial to increase the sampling effort in poorly covered areas, to complete the picture and identify all possible biodiversity hotspots to be preserved.

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Authors

Guido Gnone[1], Michela Bellingeri[1], Alice Nebuloni[1], Miriam Paraboschi[2], Ilaria Campana[2], Jessica Alessi[3], Silvio Nuti[4], Francesca Salvioli, Paola Tepsich[5], Massimiliano Rosso[5], Aurelie Moulins[5], Barbara Mussi[6], Mario Letterio Tringali[7], Clara Monaco[7], Giuliana Pellegrino[2,7], Gabriella La Manna[8,9], Fabio Ronchetti[8], Luca Bittau[10], Sabina Airoldi[11], Caterina Lanfredi[11], Valentina De Santis[11], Arianna Fornaroli[11], Joan Gonzalvo[11], Nino Pierantonio[11], Carmen Andrés[11], Alberta Mandich[12], Alberto Castelli[13], Martina Gregorietti[13], Lara Carosso[13], Veronica Mazzucato[13], Marta Azzolin[14,15,26], Cristina Giacoma[14], Donatella Decandia[16], Roberta Pitzoi[16], Georges Azzinari[17], Caroline Azzinari[17], Léa David[18], Nathalie Di-Méglio[18], Julie Jourdan[19], Frank Dhermain[19], Marie-Catherine Santoni[20], Hélène Labach[21], Robert Nicolas[22], Ana Cañadas[23], Carla Chicote[24], Manel Gazo[24], Natalia Amigo[24], Bruno Diaz Lopez[25], Ayhan Dede[27], Aylin Akkaya[28], Tim Awbery[28], Tilen Genov[29], Yaly Mevorach[30], Aviad Scheinin[30,31], Ibrahem Ben Amer[32], Antonella Arcangeli[33], Lisa Stanzani[34], Oriol Giralt Paradell[35], Morgana Vighi[36], Maria Assunta Menniti[37], Davide Ascheri[38], Elena Fontanesi[38], Beatriu Tort[39], Elena Papale[40], Giuseppa Buscaino[40], Valentina Corrias[41], Fabio Giardina[41], Giulia Calogero[42], Biagio Violi[42], Lobna Ben Nakhla[43], Mehdi Aissi [43], Alessandro Verga[44].

[1]Fondazione Acquario di Genova Onlus; [2]Accademia del Leviatano Onlus; [3]MeRiS-Mediterraneo Ricerca e Sviluppo APS; [4]CE.TU.S. Research Center; [5]Centro Internazionale in Monitoraggio Ambientale – Fondazione CIMA; [6]Oceanomare Delphis Onlus; [7]Ketos; [8]MareTerra Onlus; [9]Area Marina Protetta Capo Caccia - Isola Piana; [10]SEA ME Sardinia onlus; [11]Tethys Research Institute; [12]Università di Genova; [13]Università di Pisa; [14]Università di Torino; [15]Gaia Research Institute Onlus; [16]Associazione CRAMA; [17]Associacion BREACH; [18]EcoOcéan Institut; [19]GECEM (MIRACETI); [20]Oec - Office de l'Environnement de la Corse; [21]MIRACETI; [22]Parc Naturel Régional de Corse; [23]Alnilam Research and Conservation; [24]SUBMON; [25]Bottlenose Dolphin Research Institute; [26]Thalassa Ricerca e Formazione; [27]Istanbul University and Turkish Marine Research Foundation; [28]Marine Mammals Research Association/Denìz Memelileri Araştirma Derneği; [29]Morigenos - Slovenian Marine Mammal Society; [30]Morris Kahn Marine Research Station, Department of Marine Biology, Leon H. Charney School of Marine Sciences, University of Haifa; [31]Delphis, Non Governmental Organization (NGO); [32]the Tunisian Dolphin Project; [33]ISPRA; [34]APS Sotto al Mare; [35]Associació Cetàcea; [36]University of Barcelona; [37]Ce.S.R.A.M, Centro Studi e Ricerca Ambiente Marino; [38]Delfini del Ponente APS; [39]EDMAKTUB; [40]CNR-IAS; [41]MarEco, Osservatorio della natura; [42]MENKAB; [43]SPA/RAC; [44]Golfo Paradiso Whale Watching.

Annex 1: photo-identification standards

Each image should be evaluated for photographic quality and grade of distinctiveness of the individual (Whitehead et al. 1997, Urian et al. 1999, Wilson et al. 1999, Gowans & Whitehead 2001, Ingram et al. 2003, Read et al. 2003, Berrow et al. 2012, Nicholson et al. 2012, Coomber et al. 2016).

Tursiops truncatus

Image quality
All dolphin images should be graded from 1 to 3 following criteria published by Ingram (2000):

• *Photo Grade 1* – Well-lit and focused shots taken perpendicular to the dorsal fin at close range.
• *Photo Grade 2* – More distant, less well-lit, or slightly angled shots of dorsal fins.
• *Photo Grade 3* – Poorly lit or out of focus shots taken at acute angles to the dorsal fin.

Grade of distinctiveness of the fin
The images of dorsal fin should be graded from 1 to 3 following criteria published by Ingram (2000):

• *Severity Grade 1* – Marks consisting of significant fin damage or deep scarring that were considered permanent.
• *Severity Grade 2* – Marks consisting of deep tooth rakes and lesions with only minor cuts present.
• *Severity Grade 3* – Marks consisting of superficial rakes and lesions.

Images uploaded on Intercet must have a resulting score (quality + distinctiveness) ≤ 3.

Example score: 2


Fig. 1 Photo Grade 1 and Severity Grade 1

Example score: 3


Fig. 2 Photo Grade 2 (the photo is backlit), Severity Grade 1


Fig. 3 Photo Grade 1 and Severity Grade 2

Example Score: 4, 5, 6

Fig. 4 Photo Grade 1, Severity Grade 3

Fig. 5 Photo Grade 3, Severity Grade 1

Fig. 6 Photo Grade 2, Severity Grade 2

Fig. 7 Photo Grade 2, Severity Grade 3

Fig. 8 Photo Grade 3, Severity Grade 2

Fig. 9 Photo Grade 3, Severity Grade 3

Physeter macrocephalus

The photo identification of the sperm whale is made based on both the pictures of the flanks and the fluke. Several images are needed to identify each whale:

- the total exposed flank, from blowhole to caudal peduncle (including the body region extending from behind the dorsal fin to the base of the flukes), including the dorsal fin (two pictures for each side).
- the fluke when it was raised in the air vertically (the ventral side, 1 picture, and, if necessary, the dorsal side, which can be useful when the profile is serrated, and a good ventral side image isn't available).

For the sperm whale image quality and grade of distinctiveness are assessed independently.

Image quality
The images are graded according to 4 criteria:

- focus or sharpness,
- the relative angle of the animal in the image compare to the photographer, best is perpendicular,
- the exposure and the percentage of the animal visible in the frame of the image (Arnbom, 1987; Dufault & Whitehead, 1993,1995)
- and in addition, for the fluke, its inclination in relation to the surface of the water.

All images should be graded from 1 (poor) to 5 (best) following the criteria published by Arnborn (1987):

• *Photo Grade 1* – Poor quality photo: very blurry, animal barely visible (far or only a little part from its body is outside the water).
• *Photo Grade 2* – Mediocre quality photo: blurry or backlit, animal not perpendicular and far away.
• *Photo Grade 3* – Medium quality photo (in terms of sharpness / contrast), animal visible.
• *Photo Grade 4* – Good quality photo, animal a little far away.
• Photo Grade 2 – Very good quality photo: sharp and well exposed, the animal is clearly visible.

Images uploaded on Intercet must have a score of quality ≥ 3

Example Photo Grade:

Flank


Fig. 1 Flank. Photo Grade 1


Fig. 2 Flank. Photo Grade 2


Fig. 3 Flank. Photo Grade 3

Fig. 4 Flank. Photo Grade 4

Fig. 5 Flank. Photo Grade 5

Fluke

Fig. 6 Fluke. Photo Grade 1

Fig. 7 Fluke. Photo Grade 2

Fig. 8 Fluke. Photo Grade 3

Fig. 9 Fluke. Photo Grade 4

Fig. 10 Fluke. Photo Grade 5

Grade of distinctiveness of the individual

The images should be graded from 1 (poor) to 3 (high) following criteria published by Alessi et al. (2014):

- *Severity Grade 1* – Marks consisting of superficial rakes and lesions.
- *Severity Grade 2* – Marks consisting of deep tooth rakes and lesions with only minor cuts present.
- *Severity Grade 3* – Marks consisting of significant fin damage or deep scarring that were considered permanent.

Images uploaded on Intercet must have a score of distinctiveness ≥ 2.

Example Severity Grade:

Flank

Fig. 11 Flank. Severity Grade 1

Fig. 12 Flank. Severity Grade 2

Fig. 13 Flank. Severity Grade 3

Fluke

Fig. 14 Fluke. Severity Grade 2 (Fluke a little serrated, no white area)

Fig. 15 Fluke. Severity Grade 3 (Fluke serrated and white area)

OVERALL EXAMPLES:

Fig. 16 Photo Grade 5 and Severity Grade 2

Fig. 17 Photo Grade 4 and Severity Grade 3

Fig. 18 Photo Grade 3 and Severity Grade 3

Fig. 19 Photo Grade 2 and Severity Grade 1

Fig. 20 Photo Grade 1 and Severity Grade 3

Fig. 21 Photo Grade 4 and Severity Grade 3

Ziphius cavirostris

The photo identification of the Cuvier's beaked whale is based on flank pictures. Since a single photo cannot collect all the natural marking showed on the whale flank, very good photo-id is generally achieved taking photographic sequences of the flank (from the cape to the caudal peduncle, see Comber et al. 2016).

Flank Area

This characterization is needed in order to define the whale flank portion showed in the photo (this is not linked to photo quality). Images should be graded from 1 to 3:

- *1 Cape only* - when the area from the tip of the snout to the posterior part of the melon is visible (typically from the snout to the blowhole). If an extended part of the flank - posterior to the blowhole - is also visible, the photo should be classified as "anterior part" (see below).
- *2 Anterior part* - the photo covers better the area from the blowhole to the anterior insertion of the dorsal fin.
- *3 Posterior part* - the photo covers better the area posterior to the insertion of the dorsal fin.

Image quality

All whale images should be graded from 1 to 4 (modified from Ingram, 2000 and Rosso et al. 2011):

• *Photo Grade 1* – Well or moderately lit and focused shot. The shot was taken perpendicular or slightly angled to the flank. At least one of the three "Flank Area" is largely showed in the photo. The animal in the photo is > 50% of the picture width.

• *Photo Grade 2* – Like "*Photo Grade 1*", but the animal in the photo is between the 50% and the 10% of the picture width.

• *Photo Grade 3* – Like "*Photo Grade 1*" or "*Photo Grade 2*" but, *i*) the shot was taken angled or *ii*) none of the "Flank Area" were substantially captured or *iii*) poorly lit.

• *Photo Grade 4* – out of focus shots <u>or</u> the animal in the photo is < 10% of the picture width <u>or</u> strong backlight <u>or</u> totally angled picture (e.g. frontal picture).

Grade of distinctiveness of the individual

The images of the exposed whale flank should be graded from 1 to 4 following criteria (modified from Rosso et al. 2011). IMPORTANT: diatom films / pigmentation patterns should not be used for the assessment.

• *Severity Grade 1* – The photographed flank is well marked, more than 5 distinct / clearly visible marks (linear marks / pale dots / miscellaneous marks) are shown on the photographed flank <u>or</u> at least one notch / indentation is present on the dorsal fin / caudal peduncle.

• *Severity Grade 2* – from 3 to 5 distinct / clearly visible marks (linear marks / pale dots / miscellaneous marks) are shown on the photographed flank.

• *Severity Grade 3* – one or two distinct / clearly visible marks (linear marks / pale dots / miscellaneous marks) are shown on the photographed flank.

• *Severity Grade 4* – No marks <u>or</u> indistinct marks are visible (due to water spray or poor photographic resolution).

Images uploaded on Intercet must have a resulting score (quality + distinctiveness) ≤ 5.

Example score: 2

Fig. 1 Flank Area 2. Photo Grade 1 and Severity Grade 1 (>5 marks visible)

Fig. 2 Flank Area 2. Photo Grade 1 and Severity Grade 1 (>5 marks visible)

Example score: 3

Fig. 3 Flank Area 2. Photo Grade 1 (>50% of photo width) and Severity Grade 2 (4 marks visible)

Fig. 4 Flank Area 3. Photo Grade 2 (<50% of photo width) and Severity Grade 1 (> marks visible)

Example score: 4

Fig. 5 Flank Area 3. Photo Grade 3 (angled shot) and Severity Grade 1 (1 indentation on the peduncle trailing edge)

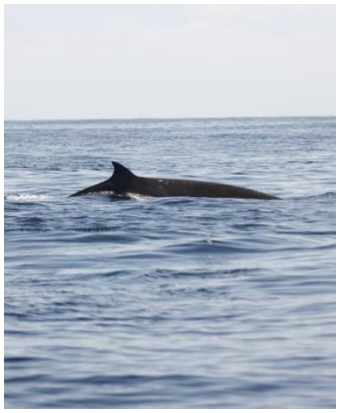

Fig. 6 Flank Area 2. Photo Grade 2 (<50% of photo width) and Severity Grade 2 (at least 3 distinct marks are visible)

Fig. 7 Flank Area 2. Photo Grade 3 (angled shot) and Severity Grade 1 (>5 marks visible)

Example score: 5

Fig. 8 Flank Area 2. Photo Grade 2 (<50% of photo width and slightly angled shot) and Severity Grade 3 (only 2 marks visible)

Fig. 9 Flank Area 2. Photo Grade 3 (only a small part of the anterior part of the animal is visible) and Severity Grade 2 (5 marks visible)

Fig. 10 Flank Area 3 (when both anterior and posterior areas are well shown, choose the area that provide more information on the animal identity, e.g. the most marked area). Photo Grade 4 (the animal is in severe backlight) and Severity Grade 2 (1 notch at the base of the dorsal fin)

Fig. 11 Flank Area 2. Photo Grade 2 (the cape area is fully visible at least) and Severity Grade 3 (2 dot marks visible)

Fig. 12 Flank Area 2. Photo Grade 4 (out of focus) and Severity Grade 1 (several marks visible)

Fig. 13 Flank Area 3. Photo Grade 4 (out of focus) and Severity Grade 1 (>5 marks visible)

Example score: >5

Fig. 14 Flank Area 2. Photo Grade 3 (only a small part of the anterior part of the animal is visible) and Severity Grade 3 (2 marks visible)

Fig. 15 Flank Area 3. Photo Grade 4 (out of focus) and Severity Grade 2 (<5 marks visible)

Fig. 16 Flank Area 2. Photo Grade 3 (angled shot) and Severity Grade 4 (no distinct marks visible)

Fig. 17 Flank Area 3. Photo Grade 4 (< 10% of the picture width) and Severity Grade 4 (no distinct marks visible)

Fig. 18 Animal in the background: **Flank Area 1. Photo Grade 4 (totally angled shot) and Severity Grade 4 (no defined marks visible).** Animal in the foreground: **Flank Area 2. Photo Grade 2 and Severity Grade 4 (no defined marks visible / possible water spray bias).**

Grampus griseus

Image quality

The images should be rated (Excellent, Moderate, Poor) according to 4 criteria following Airoldi *et al.* (2015):

- Focus/Clarity (FC): crispness or sharpness of the image,
- Contrast (CO): difference in coloration between the dorsal fin and the surrounding environment,
- Angle (AN): angle of the fin to the camera,
- Environmental interference (EI): obstruction to the view of the dorsal fin by environmental factors (waves, water splashes, other dolphins, etc..).

All images should be graded from 1 to 3 following the criteria published Airoldi *et al.* (2015):

• *Photo Grade 1* – Good quality: all criteria "Excellent" or at most 1 criterion "Moderate".
• *Photo Grade 2* – Moderate quality: two criteria "Excellent" and two "Moderate".
• *Photo Grade 3* – Poor quality: more than 3 criteria "Moderate" or even a single criterion "Poor".

Images uploaded on Intercet must have a Photo Grade 1 or 2.

Example Photo Grade: 1

Fig. 1 Photo Grade 1 (FC, CO, AN and EI Excellent)

Fig. 2 Photo Grade 1 (FC, CO, AN and EI Excellent)

Fig. 3 Photo Grade 1 (FC Moderate, CO, AN, EI Excellent)

Example Photo Grade: 2

Fig. 4 Photo Grade 2 (FC and EI Moderate, CO and AN Excellent)

Fig. 5 Photo Grade 2 (FC and AN Moderate, CO and EI Excellent)

Fig. 6 Photo Grade 2 (FC and CO Moderate, AN and EI Excellent)

Example Photo Grade: 3

Fig. 7 Photo Grade 3 (FC, CO and EI Moderate, AN Excellent)

Fig. 8 Photo Grade 3 (EI Poor)

Fig. 9 Photo Grade 3 (FC Poor)

Fig. 10 Photo Grade 3 (CO Poor)

Fig. 11 Photo Grade 3 (AN Poor)

Grade of distinctiveness of the individual

Overall individual distinctiveness is based on the amount of information present on the dorsal fin, namely:

- notches on the trailing and/or leading edge
- coloration and scarring
- fin shape

The images should be graded from 1 to 3 following criteria of Airoldi *et al.* (2015):

• *Severity Grade 1* – Very distinctive: three or more evident and well visible features.

• *Severity Grade 2* – Moderately distinctive: at least one evident and permanent and well visible feature.

• *Severity Grade 3* – Non distinctive: none or poor feature content.

Images uploaded on Intercet must have Severity grade 1 or 2.

Example Photo Grade: 1

Fig. 12 Severity Grade 1

Fig. 13 Severity Grade 1

Fig. 14 Severity Grade 1

Example Photo Grade: 1

Fig. 15 Severity Grade 2

Fig. 16 Severity Grade 2

Fig. 17 Severity Grade 2

Example Photo Grade: 1

Fig. 18 Severity Grade 3

Fig. 19 Severity Grade 2

Fig. 20 Severity Grade 2

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