

# Mark-recapture analysis of sperm whale (*Physeter macrocephalus*, Linnaeus 1758) movements in the Ligurian Sea, Tyrrhenian Sea and Gulf of Taranto through photo-identification analysis

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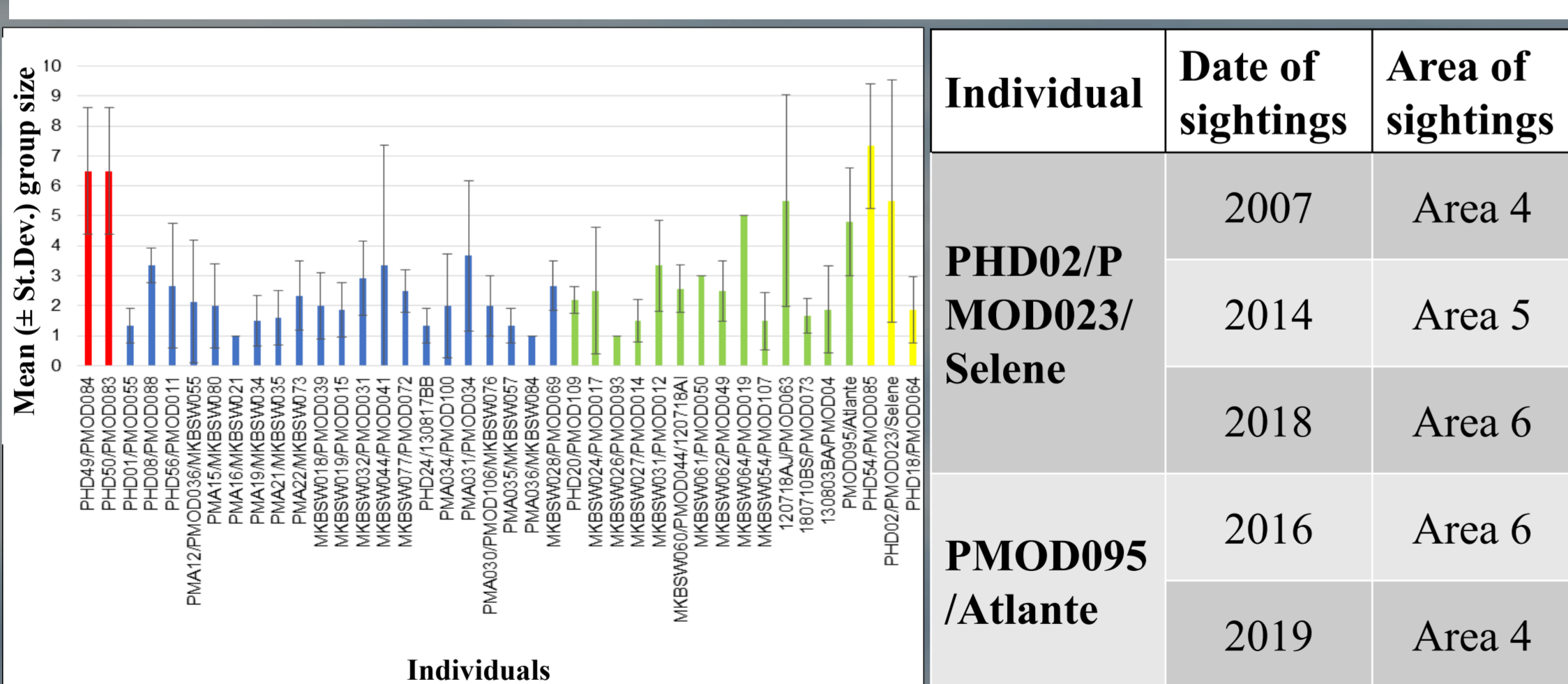
## INTRODUCTION

Sperm whale Mediterranean population is considered isolated from Atlantic one and assessed as Endangered by International Union of Conservation. Generally, social units of females and calves in the Mediterranean Sea are thought to inhabit the water below 41° parallel. Photo-identification studies revealed movements of specimens within the western Mediterranean basin, such as between Strait of Gibraltar, Alboran Sea, Ligurian Sea, Gulf of Lyon and Balearic Sea, and few evidence were recorded between western and eastern Mediterranean basins. Here sperm whale movements are investigated in the area of the Central Mediterranean Sea through matching of photo-identification catalogues.

Contributors	FWC	DDP	ODO	MKB-UniGe	SMS	JDC
<b>FWC</b>	<b>51</b>	0 (0)	9 (0.062)	0 (0)	1 (0.010)*	1 (0.016)
<b>DDP</b>	-	<b>39</b>	4 (0.029)	9 (0.077)	0 (0)	0 (0)
<b>IDP</b>	15 (300)	9 (598)	<b>104</b>	17 (0.098)	4 (0.027)*	2 (0.017)
<b>MKB</b>	-	15 (110)	16 (643)	<b>87</b>	1 (0.007)*	0 (0)
<b>SMS</b>	7 (546)	-	12 (340)	1 (573)	<b>47*</b>	0 (0)
<b>JDC</b>	7 (840/1240)	-	11 (760/1240)	-	-	<b>12</b>

**Table 1.** Numbers in bold represent the total number of sperm whales captured in the respective study area. Number of individuals shared between different study areas and related simple ratio index in brackets are shown in the above diagonals. Maximum years' span between recaptures and maximum displacement (km) in brackets between each pair of study areas in the below diagonals.

\*the quality analysis of images was not performed thus, the number of animals captured (in bold) could be overestimated.

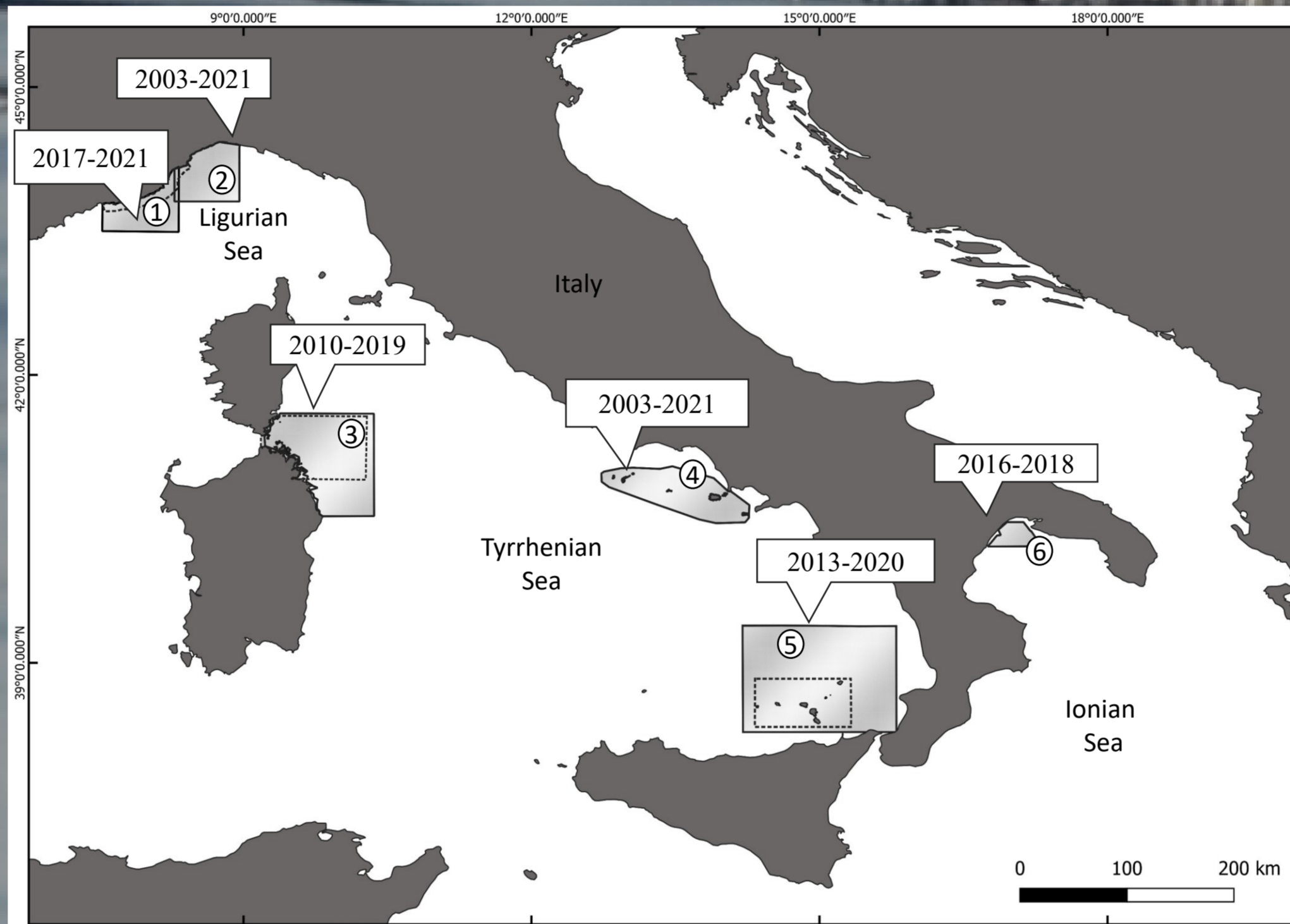


**Figure 2.** Mean (± St. Dev.) group size of all recaptures per each individual. In red females, in blue males, in green estimated males, in yellow individuals of unknown sex.

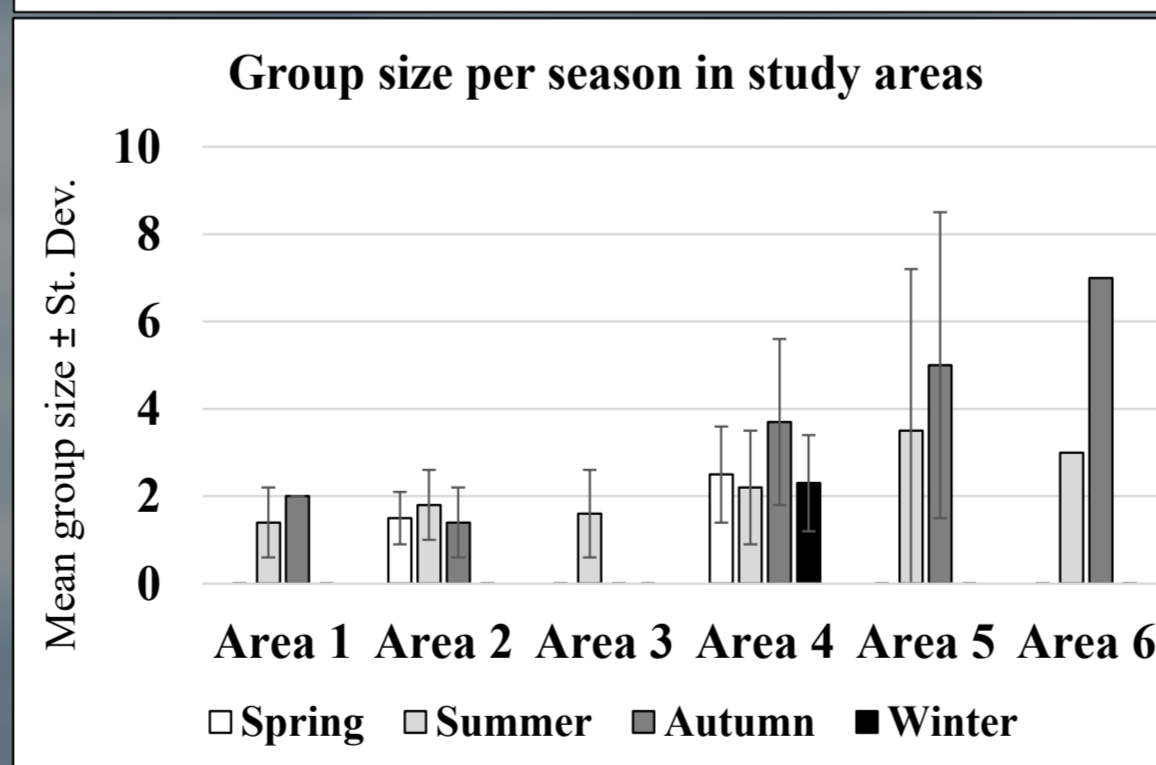
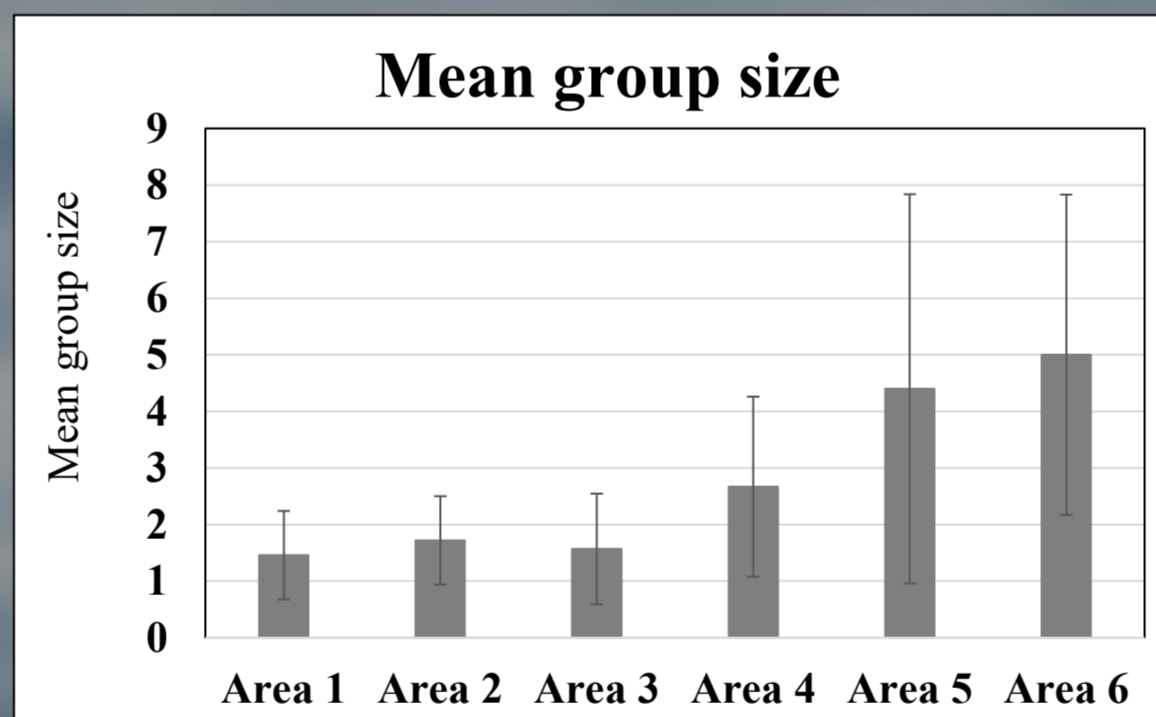
**Table 2.** Inter-year recaptures of two individuals between Tyrrhenian Sea and Ionian Sea.

## RESULTS AND CONCLUSIONS

On the total of 349 captured sperm whales, 40 were recaptured in more than one study area. Every area counted shared animals, with maximum displacement between 840/1240 km and 16 years of maximum time span (**Table 1**). Thirty-seven of the shared animals were sexed (5%, n = 2, females; 52.5%, n = 21, males and 35%, n = 14, classified as “estimated males”) (**Figure 2**). Group size of recaptures was higher at the lower latitudes (**Figure 3**), where the only two recaptures of females occurred, supporting the designation of a breeding ground in the area. Seasonality of displacements (**Figures 4**) showed sperm whales likely move from Ligurian Sea to Central Tyrrhenian Sea regularly, in every season. Two records of sperm whales that moved between Tyrrhenian Sea and Ionian Sea, first sighted as calf/juveniles in a social unit and then in male aggregations, suggest the hypothesis of dispersal movements between eastern and western Mediterranean Sea (**Table 2**).



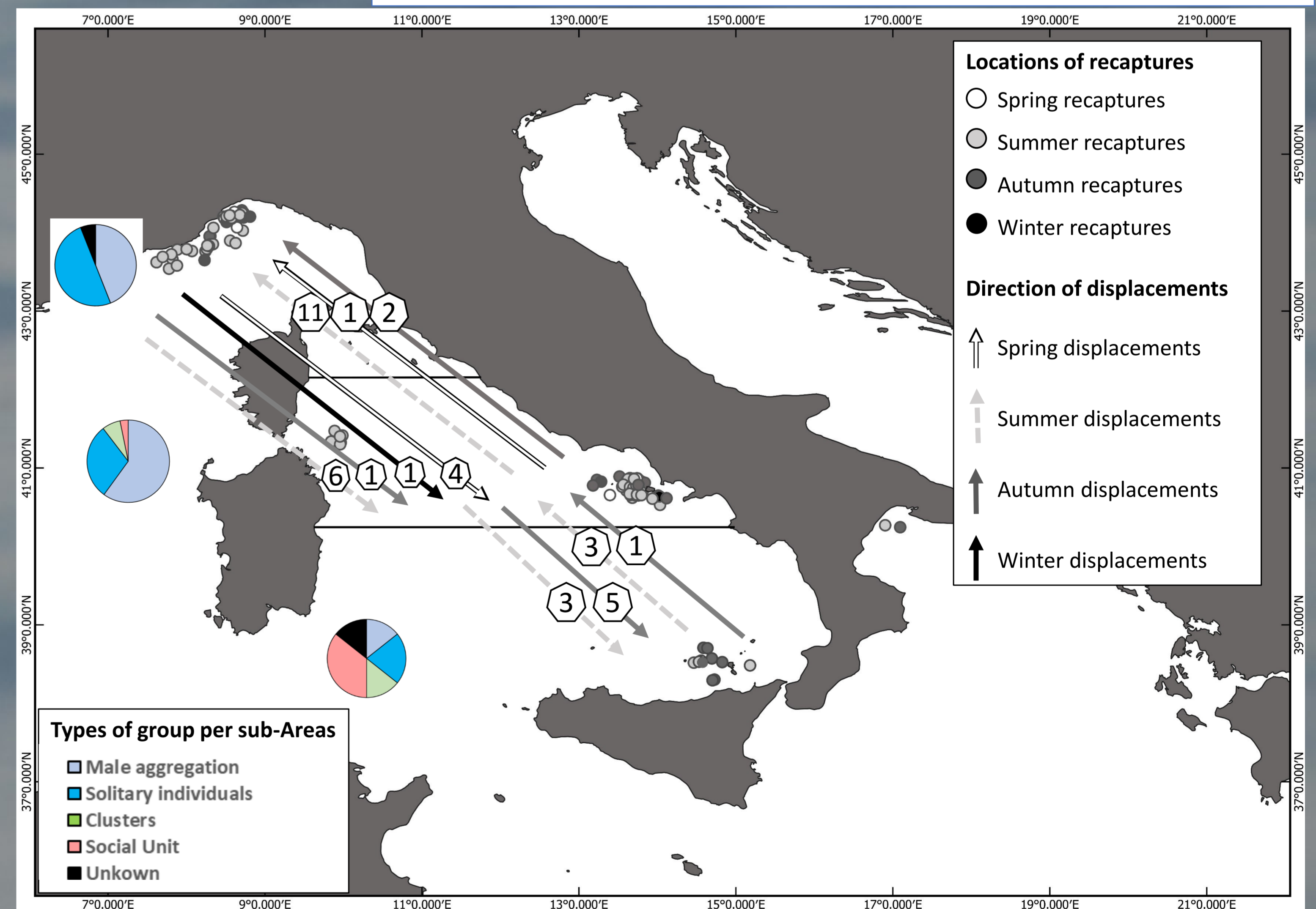
**Figure 1.** Study areas of contributors: (1) Delfini del Ponente (DDP) and (2) Menkab-UniGe (MKB) in Ligurian Sea; (3) Sea Me Sardinia (SMS) in Caprera canyon and adjacent waters - Central-West Tyrrhenian Sea; (4) Oceanomare Delphis Onlus (ODO) in Cuma canyon - Central-East Tyrrhenian Sea; (5) Filicudi Wildlife Conservation (FWC) in Aeolian Sea - Southern Tyrrhenian Sea; (6) Jonian Dolphin Conservation (JDC) in Gulf of Taranto - Ionian Sea.



**Figure 3.** Above, mean (± St. Dev.) group size per study area. Below mean group size per season in the different study areas

## MATERIALS AND METHODS

Photo-identification data, collected by six contributors in different study areas in the Mediterranean Sea and in different study periods (**Figure 1**), were matched by naked eyes to found shared animals. Sex, age class, group size and type of encounters (i.e. solitary individual, male aggregation, social unit and clusters) were studied *per* every sighting of the shared animals. Mean group size of recaptures (± St. Dev.) was calculated per shared animals, per study area and per seasons in the study areas. GPS locations of the encounters were plotted through QGIS 3.4 and maximum displacements were calculated per individual. The degree of isolation between study areas was analyzed through the Symple Ratio Index as  $SRI = X / (a + b - X)$ , where a and b = numbers of identified individuals in area A and B, and x = number of shared animals between A and B. The degree of isolation between the study areas defined three sub-Areas: the Northern and the Southern ones, isolated from each other, and the Central one linked to both the others. The seasonality of displacements between these sub-areas was studied.



**Figure 4.** Location of recaptures in the sub-areas per season. The arrows indicate the direction of displacements of two consecutive recaptures (also inter-years) between sub-areas. The colour of the arrows heading a sub-area refers to the season of sightings in that sub-area. The numbers on the arrows indicate the number of recaptures in that season in the sub-area indicated by the arrow. The pie patterns show the percentage of type of encounters *per* sub-area.



Data of Area 2 are partially deduced from LIFE WHALESAFE (LIFE13/NAT/IT/001061) and within Menkab - UniGe convention.

Figure 1: ODO/IUCN-MMPATF (2017) Campanian and Pontino Archipelago IMMA, The IUCN Global Dataset of Important Marine Mammal Areas (IUCN-IMMA), December 2017. Made available under agreement on terms of use by the IUCN Joint SSC/WCPA Marine Mammal Protected Areas Task Force and made available at [www.marinemammalhabitat.org/imma-atlas](http://www.marinemammalhabitat.org/imma-atlas)