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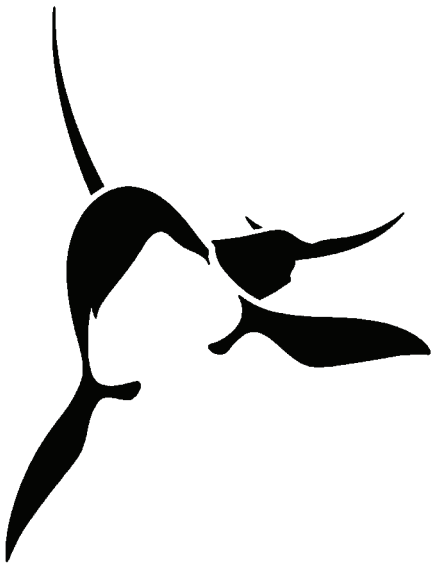

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LARGE SCALE MONITORING IN THE NORTH WESTERN MEDITERRANEAN SEA - RESULTS OF TWO YEARS OF RESEARCH USING FIXED TRANSECT SURVEYS

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INTRODUCTION

The use of ferries as research platform to survey fixed transects started in Mediterranean Sea in 1989 (Marini et al. 1997; Arcangeli et al. 2008). Nowadays a large scale surveys along different transects allows synoptic monitoring of cetacean distribution in the North western Mediterranean Sea. In particular, the four fixed transects monitored in this research fall inside and just off the southern boundaries of the Pelagos Sanctuary. Cetaceans are known to concentrate in this area during summer, which is also the season when nautical traffic increases. Thus the presence of Marine Mammal Observers on board of ferries allows not only to collect data on cetacean distribution but also to prevent ship strikes. Ferries provide the opportunity to undertake repetitive surveys along a fixed line transect which can be conducted regularly throughout different years, providing, consequently, information on long-term populations pattern (MacLeod et al., 2007) and spatio-temporal relations with oceanographic features (Cottè et al., 2009); in addition repeated surveys along fixed transects reduces spatial heterogeneity. The use of scheduled ferry runs does not add a new disturb to the animals and allows to survey areas difficult to reach using standard research vessels.

MATERIALS AND METHODS

From June to September 2008 and 2009, ferries hosted dedicated Marine Mammal Observers (MMO) once a week on four fixed transects: Civitavecchia-Golfo Aranci (CIV), Livorno-Bastia (LIV), Savona-Bastia (SAV) and Nizza-Calvi (NIZ). The last has been surveyed only on 2009. MMO collected data on cetacean presence in "passing mode" (continuous search effort, with schools or animals not being approached) following the distance sampling protocol and warned ferries crew about cetacean presence in order to avoid ship strikes. Data were collected under good weather condition (Beaufort ≤ 3). For each sighting, species, number of individuals, presence of juveniles, behaviour and boat traffic were noted.

Data on relative abundance where analysed using a single transect as a statistical unit. The encounter rate (ER) was measured as the number of sightings per hour spent in observation. Distribution was analysed first considering the ER of different species on different tracks and then using GIS program. Hotspots for species distribution have been identified considering areas with higher concentration of sightings. A preliminary analysis of environmental parameters on these hotspots has then been made in order to understand possible correlations with animal's presence.

Potential relationship between naval traffic and cetacean presence were also investigated: systematic scan samplings of the horizon, in concurrence of cetacean sightings, were undertaken in order to quantify the number of vessels, bigger than 5 metres (sailing boats, fishing boat, ferries, cargo etc), detectable from the observation platform. In absence of cetacean, scans were undertaken randomly at a minimum of 45 minutes or 10 NM. All records from all the routes were grouped together and values of naval traffic gained from scans in presence (N=596) and in absence (N=601) of cetacean sightings were compared with non-parametric statistical tests, assessing the probability (P) of the two median and of the two distribution frequency to be equal. Moreover, possible episodes of "ferry-whale" collisions were recorded.

RESULTS

General results from two years monitoring are presented in Table 1. In total, 207 runs were analyzed resulting in 752 hours of observation under good weather condition ("on effort"). All 8 cetacean species inhabiting regularly the Pelagos Sanctuary have been sighted: striped dolphin (*Stenella coeruleoalba*), fin whale (*Balaenoptera physalus*), bottlenose dolphin (*Tursiops truncatus*), sperm whale (*Physeter macrocephalus*), Cuvier's beaked whale (*Ziphius cavirostris*), Risso's dolphin (*Grampus griseus*), common dolphin (*Delphinus delphis*) and long finned pilot whale (*Globicephala melas*) (Tab.2). ER for the 4 fixed transects pooled together was 0.874 sightings/h. Highest ER was recorded along NIZ (1.597), followed by CIV (1.036), SAV (0.769) and LIV (0.357).

Table 1 General results

Fixed transects	Period	Tot # of run	Tot # hours in good weather condition	Tot Nautical Miles in good weather condition	Tot # of sightings	Sighted species	General ER	
							#sight/h	#sight/NM
CIV	June-Sept. 2008-2009	63	253.94	6678.3	263	7	1.036	0.039
LIV	June-Sept. 2008-2009	56	170.73	3.752	61	5	0.357	0.016
SAV	June-Sept. 2008-2009	60	228.94	5725	176	7	0.769	0.031
NIZ	June-Sept. 2009	28	98.3	2.940	157	5	1.597	0.053
TOT.	**01/06 – 30/09 2008-2009**	**207**	**752**	**19.095.30**	**657**	**8**	**0.874**	**0.034**

Table 2 Sighted species

	CIV	LIV	SAV	NIZ
S. coeruleoalba	√	√	√	√
B. physalus	√	√	√	√
T. truncatus	√	√	√	√
P. macrocephalus	√	√	√	√
Z. cavirostris	√	-	√	-
G. griseus	√	-	√	-
D. delphis	√	√	-	√
G. melas	-	-	√	-

Species presence

The most observed species was striped dolphin (ER=0.43±0.04), followed by fin whale (ER=0.18±0.02), bottlenose dolphin (ER=0.08±0.02) sperm whale (ER=0.02±0.01), Cuvier's beaked whale (ER=0.01±0.00), common dolphin (ER=0.01±0.01), Risso's dolphin (ER=0.004±0.001) and long finned pilot whale (ER=0.002±0.001). (Fig.1).

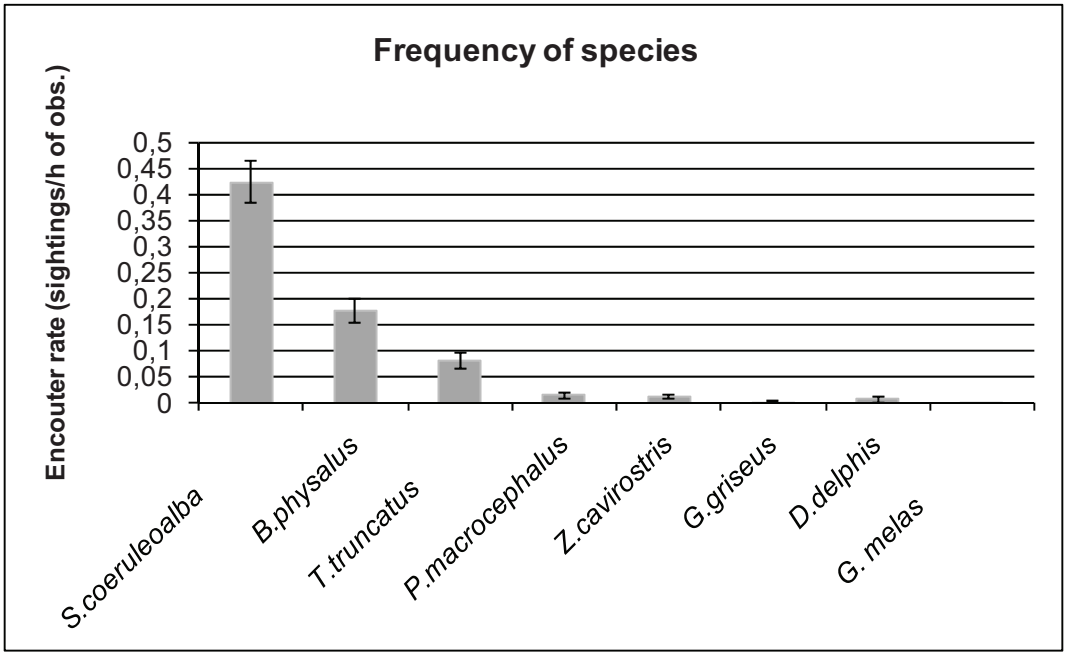


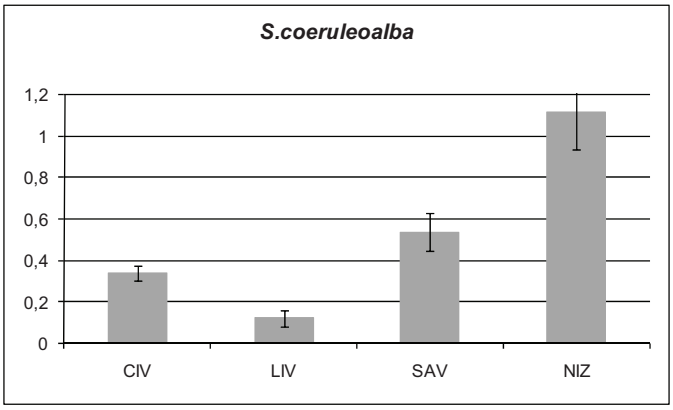
Fig. 1 Frequency of sighted species

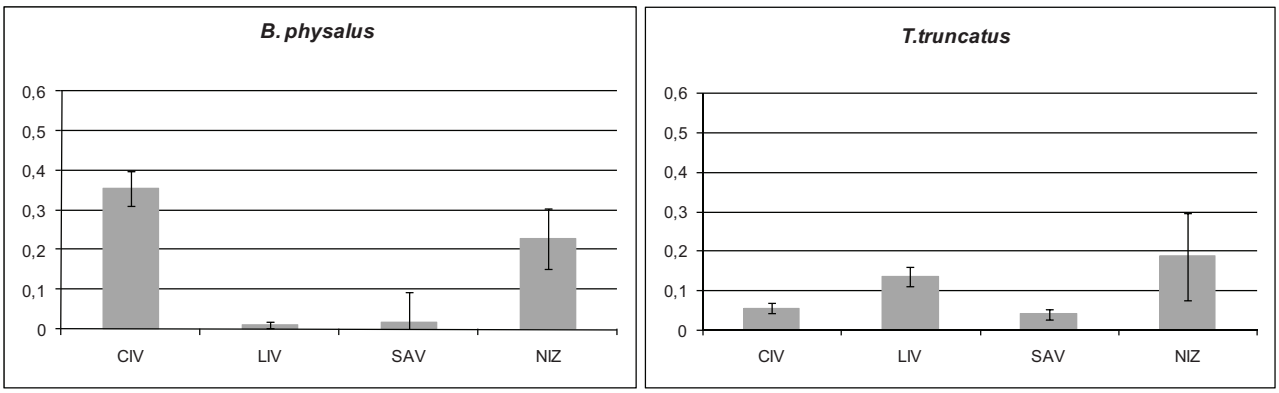
Distribution

Striped dolphin showed significant differences among the four transects, with NIZ being the area in which the species was far more abundant (ER=1.112±0.18; P<0.0001).

Fin whale showed no significant difference between CIV and NIZ (ER=0.35±0.04 and 0.23±0.08), both having a significant higher ER than LIV and SAV (ER=0.01±0.01 and 0.02±0.07).

Bottlenose dolphin showed no significant difference between LIV and NIZ (ER=0.13±0.02 and 0.18±0.12), both having a significant higher ER than CIV and SAV (ER=0.06±0.01 and 0.04±0.01) (Fig. 2).





Figs. 2 ER of the three most sighted species

Other species, which however had sporadic sightings, did not show statistical significant difference between the 4 areas, even if sperm whale appeared to be more abundant in the northern (NIZ and SAV ER=0.04 and 0.03) than in the southern transects (CIV and LIV ER=0.005 and 0.006).
Species distribution and relative hotspots are shown in Fig. 3. Three different maps have been generated: the first one refers to dolphin species, the second one to teuthophagous species and the latter to baleen whales.
Striped dolphin showed a homogeneous distribution for all transects, confirming cosmopolitan habits of the species. Bottlenose dolphin distribution was confined in areas not deeper than 500m, although the species occurred in offshore waters in the NIZ and CIV transects, where it was sighted even at 40 NM from Sardinia coast. Common dolphin sightings were rare and the species should be considered as occasional.
Squid-eating species distribution did not highlights remarkable differences amongst species. Areas where sightings appear to be more concentrated (circles in Fig. 3) are distinguished by an articulate topography (seamounts and canyons) where usually large bathypelagic squids are known to occur.
Fin whale distribution showed differences amongst the four transect: in CIV most of the sightings occurred in the area from 20 to 50 NM from Sardinian coast, as for the toothed cetacean distribution of sightings. In NIZ fin whale is much more abundant in offshore waters (>2500m depth).

Figs. 3 Species distribution and main hot spots

Nautical traffic
Regular scan sampling of the horizon (N=601), showed a mean of 5.12±0.21 vessels while in presence of cetaceans (N=596), there was a mean of 1.34±0.06 detected vessels; for both "treatments" the median was 1. During cetacean sightings the total number of detected vessels was smaller by approximately 280% compared to the case in the absence of sightings.
Both statistical tests lead us to reject the null hypotheses that the two groups have the same median ($P<0.001$) and the same distribution frequency respectively ($P<0.001$). Overall, only one ferry-whale near collision was recorded in a total of 23,000 NM travelled.

CONCLUSIONS
This monitoring offers new insight into summer distribution of cetacean species within and off the southern boundary of the Pelagos Sanctuary and provides useful indications for further conservation needs. The French part of the Pelagos Sanctuary (NIZ) confirms the importance in terms of high frequency and relative abundance of species. In general, northern areas (NIZ and SAV) seem to be more important for striped dolphin while fin whale sightings are concentrated mainly in two specific areas which are at the extreme boundaries of the Pelagos Sanctuary (NIZ and CIV). The most remarkable fact is that the highest ER for fin whale has been recorded in central-western Tyrrhenian Sea (CIV), outside the border of the Protected Area. As expected, bottlenose dolphin sightings are concentrated mainly in the long part of LIV transect lying on the continental shelf,

while in NIZ and CIV transects, sightings occurred also in deeper waters: this is probably due to the steep topography in the NIZ area, while in CIV these sightings occurred in coincidence with the high density area showed by fin whale and the squid eating species distribution. Even if not statistically significant, sperm whale sightings appear to be more abundant in the heart of the Ligurian Sea.
Data agree with the presence of the hot spot area in north-western Ligurian Sea and confirm (Arcangeli et al., 2009) the urgent need of conservation measures in the hot spot of cetacean in central Tyrrhenian Sea, in an area that lacks of any protection.
According to our results, cetaceans seem to avoid vessels. However, due to the restricted number of observation and the stochastic effect of pooling together species and routes, no cause-effect conclusion can be drawn at this stage and we should be very cautious in interpreting the findings.
In the short future, this cost effective and large scale monitoring network will allow the creation of dynamic maps of cetacean presence that can be useful for conservation program, also to mitigate the effect of impacts such as nautical traffic. Meanwhile, such long term and large scale program will help in the understanding of dynamic processes that drive marine ecosystem and influence presence and relative abundance of cetacean species.

However, due to the restricted number of observation, to the fact that records of all species and routes were grouped together and to the stochastic nature of the scans no cause-effect conclusion can be drawn at this stage and we should be very cautious in interpreting the findings.

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