Winter abundance of striped dolphins (*Stenella coeruleoalba*) in the Pelagos Sanctuary (north-western Mediterranean Sea) assessed through aerial survey

SIMONE PANIGADA[1], LOUISE BURT[2], GIANCARLO LAURIANO[3], NINO PIERANTONIO[1], GREG DONOVAN[4]

[1] *Tethys Research Institute, Viale G.B. Gadio 2, 20121 Milano, Italy*

[2] *RUWPA, University of St. Andrews, U.K.*

[3] *ISPRA, Via di Casalotti, 300, Roma, Italy*

[4] *International Whaling Commission, Cambridge, U.K.*

Abstract

This paper presents data on an aerial survey conducted throughout the Pelagos Sanctuary (north-western Mediterranean Sea) in January-February 2009; this project is part of a series of research programmes, funded by the Italian Ministry of the Environment and aimed at establishing systematic monitoring campaigns in the Pelagos Sanctuary and assessing the presence of critical habitats for cetaceans in the area. The main aim was to assess cetacean abundance and densities in the Pelagos waters in winter and to generate baseline data to investigate potential trends in future years. An area of 88,267 km^2 was surveyed. Tracklines were designed using *Distance 5.0* to allow for homogeneous coverage probability over the selected area (parallel line transects, covering 8144.40 km of tracks). The study area was subdivided into three strata, taking into account bathymetry and previous knowledge of cetaceans' presence and distribution. Total effort consisted of 82 transects, with 10 km between each transect. Transects were oriented north-south and east-west to abut the coast line perpendicularly. A total of 131 cetacean sightings of were made: striped dolphins (n=114), common bottlenose dolphins (7), fin whales (1), sperm whales (1), Cuvier's beaked whales (1) and unidentified small dolphins (7). Abundance estimates were then obtained for striped dolphins only using both conventional distance sampling (CDS) methods and multiple covariate (MCDS) methods. The best detection function models were selected with the lowest Akaike's Information Criteria (AIC) values and both had a half normal form. The results from both analysis were very similar; using the MCDS method, the uncorrected striped dolphin population size was estimated to be 19,578 (%CV=19.2; 95% C.I.=12,318 – 27,039), with a density of 0.2218 individuals km^{-1} (%CV=19.23; 95% C.I.=0.1395-0.3063). Estimates were not corrected for g(0) since methods to estimate this parameter were not applied during data collection during this 'feasibility' study. However, an identical survey (same transects, same plane, same observers) is planned for this coming summer (July-August 2009) and methods for assessing g(0) will be applied, thus allowing these current estimates to be adjusted *a posteriori*. These results provide the first estimate of cetaceans' abundance and density for the whole Pelagos Sanctuary during the winter, when information on cetaceans' presence and distribution are difficult to obtain, primarily due to poor weather conditions. The use of aerial surveys increases the chance to cover a wide area when conditions are good, thus obtaining more robust estimates with lower CVs and CIs, when compared to more traditional ship based surveys. These results represent baseline data for striped dolphins within the Pelagos Sanctuary – a SPAMI, specifically designated to protect cetaceans – that will be of crucial importance to assess eventual population trends over the next few years. Considering that the recent Red List assessment for Mediterranean striped dolphins is *Vulnerable*, the need for further systematic monitoring is stressed to inform conservation measures throughout the Basin.

Introduction

Information on presence, distribution and abundance of cetaceans during the winter months is scattered and incomplete in the Mediterranean Sea, as it often is elsewhere due to poor conditions for surveys. The winter months in this region, particularly in the Ligurian Sea and in the Gulf of Lions, are characterized by strong north-westerly winds, which render data collection at sea particularly difficult. There is inadequate knowledge of whether cetacean species migrate during the winter, e.g. if and when they migrate in and out of the Mediterranean Sea, and also, whether there are areas devoid of cetaceans (Zimmer, 2002), and little is known about seasonal patterns of the most common species in the Mediterranean Sea (Laran and Drouout-Dulau, 2002).

The striped dolphin is believed to be the most abundant cetacean in the Mediterranean (Reeves and Notarbartolo di Sciara, 2006). The population in the western Mediterranean, excluding the Tyrrhenian Sea, has been estimated at: n=117,880 (95%CI=68,379-214,800) in 1991 (Forcada et al., 1994). Other estimates are available from different Mediterranean regions, such as the Balearic Sea n=5,826 (95%CI=2,193-15,476) in 1991, the Gulf of Lions n=30,774 (95%CI=17,433-54,323) in 1991, the South Balearic area n=18,810 (95%CI=8,825-35,940) in 1991, and the Alboran Sea n=17,728 (95%CI=9,507-33,059) in 1992 (Forcada and Hammond, 1998), the Central coast of Spain n=15,778 (95%CI=10,940-22,756) in 2001-2003 (Gómez de Segura et al., 2006), the south Tyrrhenian Sea n=4030 (95% CI=2239–7253) in 2002-2003 (Fortuna et al., 2007), the Ligurian Sea n=14,003 (95%CI=6,305-31,101) in 1991 (Forcada and Hammond, 1998) and the western Ligurian Sea and the offshore waters of western Corsica n=25,614 (95%CI=17,377-42,658) (Forcada et al., 1995) (Fig. 1). However, at present, there are no estimates for the whole Pelagos Area, nor for the eastern Mediterranean Sea.

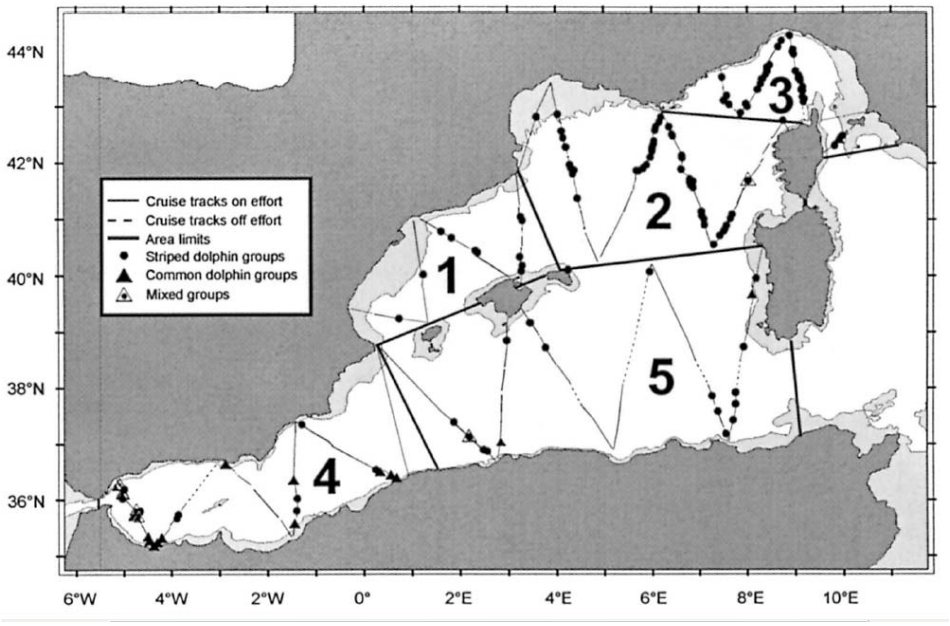

Fig. 1 - Cruise tracks surveyed on effort with groups of common and striped dolphin schools sighted during the 1991 survey in the western Mediterranean. 1=Balearic Sea; 2=Provençal basin; 3=Ligurian Sea; 4=Alboran Sea; 5=south Balearic area (From Forcada and Hammond, 1998).

Relative abundance estimates for this species in the winter, and comparison with summer abundance and distribution in the north-western Mediterranean Sea (Corso-Ligurian- Provençal Basin), have been provided by Gannier and Gannier (1997), Laran and colleagues (2002) and Laran and Drouout-Dulau (2002). In particular, Laran and Drouout-Dulau (2002) highlighted how, using visual observation (standard line-transect methodology) and passive acoustic sampling, seasonal changes in striped dolphin relative abundance occur, with a peak in dolphins abundance in May and September ($>1.3\times10^{-2}$ ind.km^{-1}), and a consistent minimum ($<0.6\times10^{-2}$ ind.km^{-1}) from December to April.

Striped dolphins face several threats in the Mediterranean Sea, with the main cause of death being incidental mortality in fishing gear, namely pelagic driftnets (Di Natale and Notarbartolo di Sciara, 1994; Tudela et al. 2005), along with overfishing (Aguilar, 2000). Moreover, a large-scale die-off caused by an epizootic, spreading eastward from the Catalonian coast to the Aegean Sea, caused by a morbillivirus infection in 1990-92, probably had severe impacts on the population (Domingo et al., 1990; Van Bressem et al., 1991; Bortolotto et al., 1992; Aguilar and Raga, 1993; Aznar et al., 1994). Mass die-off deserves special concern for this species (Di Guardo et al., 2007), considering that additional episodes have recently occurred in the Mediterranean Sea basin, affecting the striped dolphin population especially along the Spanish coast (Di Guardo, 2008; Raga et al., 2008). In addition, high levels of PCBs and other organochlorine pollutants with potential for immunosuppressive effects also threaten Mediterranean striped dolphins (Aguilar, 2000; Fossi et al., 2003).

Mediterranean striped dolphins appear to be morphologically and genetically isolated from North Atlantic populations, with limited gene flow across the Straits of Gibraltar (Calzada and Aguilar, 1995; Archer, 1997; Calzada et al., 1996; Calzada et al., 1997; Garcia-Martinez et al., 1999; Valsecchi et al., 2006; Gaspari et al., 2007). Moreover, population genetic structure within the Mediterranean basin has been found, including small

but significant differentiation between the Adriatic and Tyrrhenian Seas, and between putative 'inshore' and 'offshore' populations in the Tyrrhenian Sea (Gaspari et al., 2007).

The Pelagos Sanctuary is a Marine Protected Area established to preserve the conservation status of the cetaceans and manage the human activities in the area; these aims concern a wide international environment, since the 96.000 km^2 extension of the Pelagos area cover both national and international waters of France, Italy and Monaco Principality. Since several local coastal MPAs are present in the Pelagos region, some of the overall management objectives such as systematic monitoring could be easily achieved throughout combined actions.

Aim of this survey was to provide robust estimates on the striped dolphins' abundance and density within the Pelagos Sanctuary area during the winter months, in order to provide tools for the management and conservation objectives of this international MPA.

Materials and methods

Survey design

This survey was conducted over two periods of time: 11-31 January 2009 and 18-22 February 2009; the interval between the two periods was due to bad weather and extraordinary aeroplane maintenance. The platform used was a *Partenavia P-68*, with two observers seated in the rear seats, equipped with bubble windows. A third observer, recording the data in a laptop computer, was seated in the co-pilot seat. Rotation between the three observers occurred at each plane landing. GPS positions, environmental variables and sightings were recorded following the same protocol and software used for SCANS II aerial surveys (SCANS-II, 2008). Declination angle to sightings was measured with hand-held *Suunto* clinometers that, together with the aircraft altitude, provided an estimate of the perpendicular distance to the animal or group of animals, and stored in the computer by the co-pilot. Flight altitude and speed were kept constant, at 750 feet (229 m) and 100kts (185 km/hr), respectively.

The survey was conducted in passing mode (Dawson et al., 2008) but large groups were assessed in closing mode, by leaving the track-line and circling over the school, lowering the altitude if needed for counting animals and/or for species identification. The track was then resumed where it had been left for circling. Any other dolphins or groups of dolphins, sighted during the off-effort circling patterns were not taken into account. Environmental conditions, reported by the observers, were recorded at the beginning of each transect and whenever a change in Beaufort sea state, glare, cloud cover, turbidity or subjective overall conditions occurred (Gòmez-de Segura et al., 2006). Sighting information included species, group size, initial cue, swim direction and observer. The survey was designed with *Distance 5.0* using parallel line transects with a random start point to allow for homogeneous coverage probability over the selected area (Buckland et al, 2001).

The study area was subdivided into three strata (Fig. 2), following a bathymetric criteria and previous knowledge on cetaceans' presence and distribution. Total effort consisted of 82 transects, line spacing between each transect was 10km. Transects were oriented north-south in stratum C and east-west in strata A and B to abut the coast line perpendicularly.

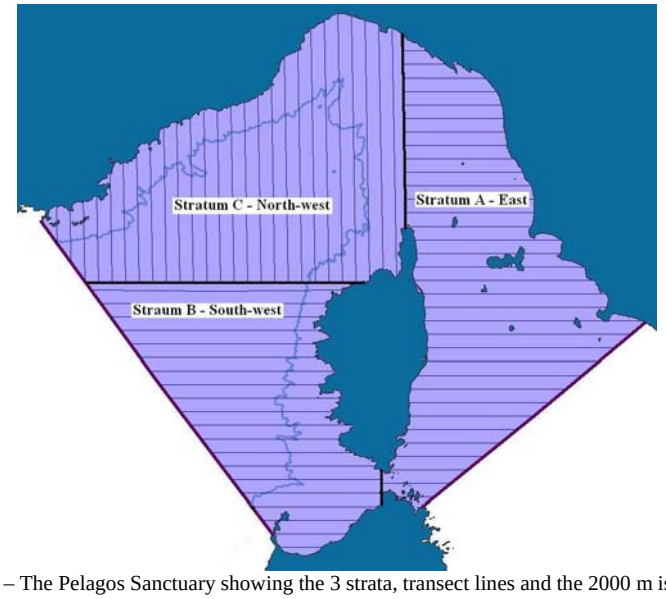

Fig. 2 – The Pelagos Sanctuary showing the 3 strata, transect lines and the 2000 m isobath.

Data analysis

Abundance was estimated using both conventional distance sampling (CDS) (Buckland et al., 2001), and multiple covariate distance sampling (MCDS) (Marques and Buckland, 2004). In CDS, animal abundance in each stratum was estimated by

$$\hat{N} = A\frac{n}{2L\hat{\mu}}\hat{E}[s]$$

where for each stratum, A is the area, L is the total search effort, n is the number of sightings, $\hat{\mu}$ is the estimated effective strip half-width (esw) and $\hat{E}[s]$ is some estimate of mean group size (see later).

In MCDS, covariates other than perpendicular distance are included in the detection function and hence the esw becomes a function of the covariates, *z*. Abundance is estimated using a Horvitz-Thompson-like estimator:

$$\hat{N} = A\frac{n}{2L}\hat{E}[s]\sum_{i=1}^{n}\frac{1}{\hat{\mu}(z_i)}$$

Results

A total of 131 sightings of cetaceans were made: striped dolphins (*n*=114), common bottlenose dolphin (7), fin whales (1), sperm whales (1), Cuvier's beaked whales (1) and unidentified small dolphins (7). This paper only presents the results for striped dolphins and no inference has been made on the other species sighted because of their low sample size. An area of 88,267km^2 was surveyed, covering 8,144 km of tracks. Four of the planned tracks in the north west corner of Stratum C could not be surveyed because of a French military "no fly zone" area. Three sightings of striped dolphins had a missing declination angle thus leaving 111 sightings to effectively estimate abundance and density; a summary of sightings per strata is presented in Table 1 and shown in Fig. 3.

Table 1 - Summary statistics per strata (*k*=# of transects, *n*=# of sightings)

Stratum	Size (km^2)	*k*	*L* (km)	*n*
A	30 907	34	2 932.6	31
B	23 208	20	2 273.5	33
C	34 153	22	2 938.3	47
Total	88 267	76	8 144.4	111

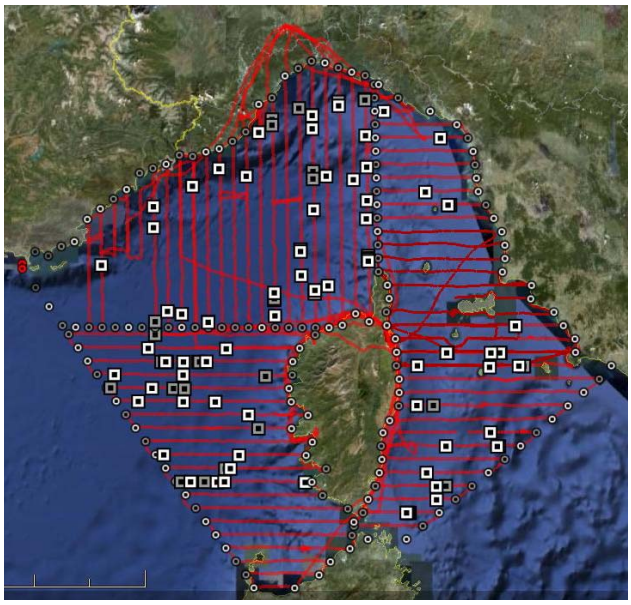

Fig. 3 – The tracks surveyed and the striped dolphin sightings.

Cluster size of striped dolphin schools ranged between 1 and 57 animals (mean=7.96, SD=9.54; the frequency distribution of all the striped dolphin sightings is shown in Fig. 4).

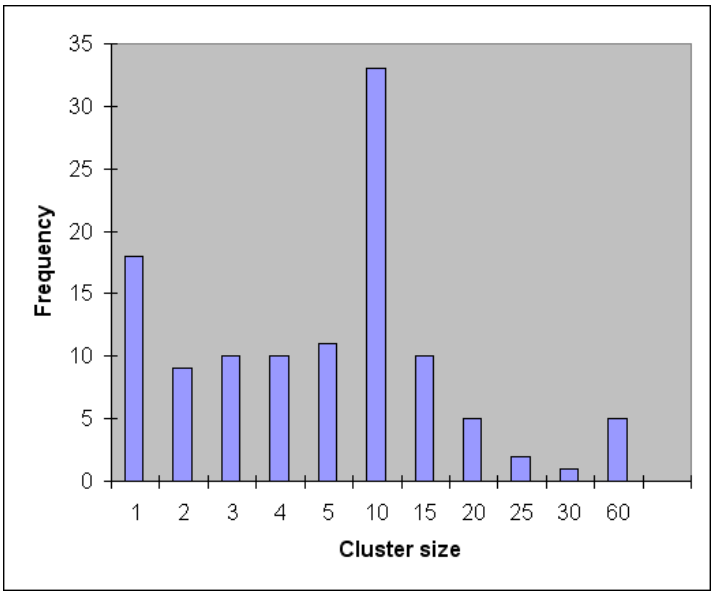

Fig. 4 – Frequency distribution of striped dolphins' cluster size.

To fit the detection function, sightings were truncated at a perpendicular distance of 380m leaving 108 sightings. AIC was used to choose between models and for the CDS, this suggested that a single detection function should be calculated rather than estimating detections functions in each strata. A half normal form was used (Fig. 5). In general, small groups are not detected at long perpendicular distances, therefore the sample of groups sighted contains too many large groups compared to the overall population. To account for this, expected group size is assessed using a regression of log group size against estimated detection probability. However, in this case, the size-bias regression estimate was larger than the simple mean, therefore, the mean of groups within 300m of the trackline was used. It was felt that the whole range of group sizes would be seen within this range. The calculated abundance was 18,526 animals (CV=21.1; 95% CI 12,261 – 27,992) (Table 2).

Table 2 – CDS summary statistics per strata and overall.

Stratum	n/L	%CV(n/L)	esw(km)	CV(esw)	D	%CV(D)	N	%CV(N)	95% CI(N)
A	0.0102	28.31	0.252	8.86	0.14744	39.65	4557	39.65	2124-9776
B	0.0136	29.21	0.252	8.86	0.18085	34.27	4197	34.27	2132-8261
C	0.0160	19.72	0.252	8.86	0.28613	29.59	9772	29.59	5482-17418
Overall	0.0133	14.18			0.20989	21.14	18526	21.14	12261-27992

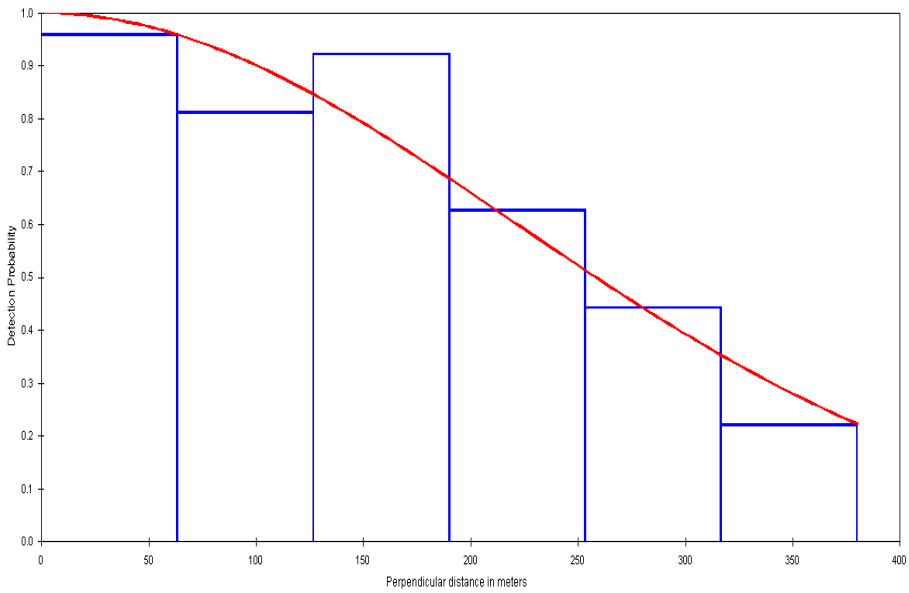

Fig. 5 – Detection function for CDS with 380 m right truncation.

The additional covariates considered for inclusion in the MCDS model were stratum, observer, cue, cloud cover, glare (all as factor variables with 3 levels), Beaufort sea state (4 levels) and group size (as a non factor). AIC suggested that observer, in addition to perpendicular distance, should be included in the detection function (Table 3; Figure 6). Although the parameters of the detection function were estimated using data from all strata, estimates of the esw were obtained for each stratum. This resulted in an abundance estimate of 19,578 animals (CV=19.2; 95% CI 12,318 – 27,039) (Table 4).

The abundance estimates from the CDS and MCDS analyses are very similar and not significantly different, however, AIC suggested that the MCDS estimate was to be preferred.

Table 3 - AIC values for half normal detection functions including covariates (half normal form always chosen). All covariates fitted as factors (number of levels indicated by subscript). PD=perpendicular distance.

Model	AIC
PD	1268.13
PD + Sea State$_4$	1269.68
PD + Cloud cover$_3$	1277.20
PD + Cue$_3$	1270.01
PD + Observer$_3$	1262.96
PD + Glare$_3$	1267.41
PD + Cluster Size	1269.48
PD + Observer$_3$ + Glare$_3$	1264.8

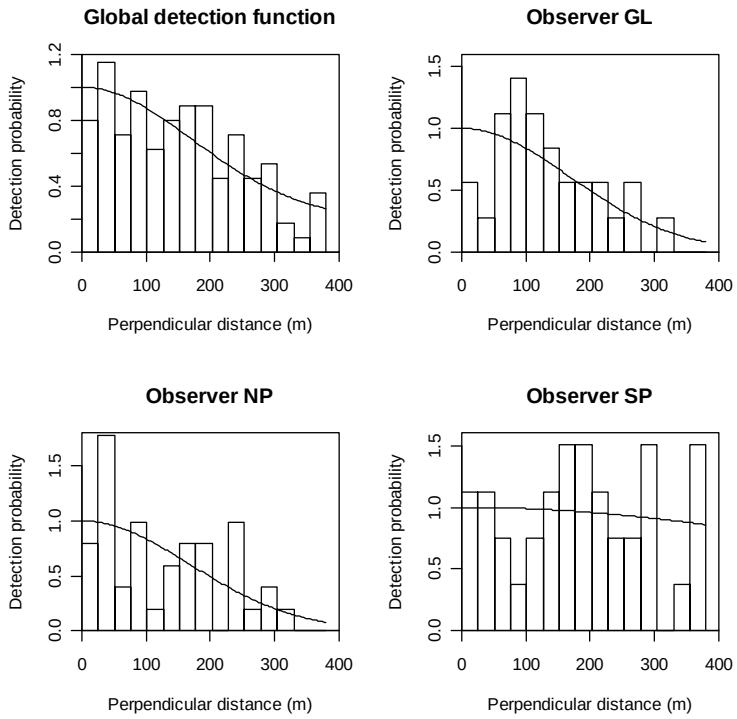

Fig. 6 - MCDS detection functions with observer as covariate.

Table 4 – MCDS summary statistics per strata and overall.

Stratum	n/L	%CV(n/L)	esw(km)	CV(esw)	D	%CV(D)	N	%CV(N)	95% CI(N)
A	0.0102	28.31	0.236	12.33	0.1575	40.57	4867	40.57	2234-10602
B	0.0136	29.21	0.285	10.79	0.1601	34.81	3716	34.81	1871-7380
C	0.0160	19.72	0.224	10.00	0.3219	29.96	10995	29.96	61297-19724
Overall	0.0133	14.18			0.2218	19.23	19578	19.23	12318-27039

Discussion

This study provide the first estimate of abundance and density of striped dolphins for the Pelagos Sanctuary during the winter months, when information on cetaceans' presence and distribution are difficult to obtain, because of poor weather conditions. Although the distribution of striped dolphin populations has been described in different regions of the world (Perrin et al., 1994) and in some regions, such as the North Atlantic, they tend to be present all year round, regions exist where their distribution is associated with warm fronts, characterized by seasonal movements (Perrin et al., 1994).

The western Ligurian Sea is associated with a permanent frontal system (Stocchino and Testoni, 1977), with high levels of primary productivity (Goffart et al., 1995). These processes are enhanced by seasonal upwellng currents, supported by the prevailing winter wind from the north-west (Gonella et al., 1977; Arnau et al., 2004). As a consequence, the area has high concentrations of Chl-a during the spring, with values of more than 10 mg/m3 (Jacques, 1989), supporting a rich biomass of zooplankton and their predators, such as large pelagic fish and cetaceans (Forcada et al., 1995, 1996; Gordon et al., 2000; Notarbartolo di Sciara et al., 2008). Winter abundance of striped dolphins and other cetaceans in the area may therefore be lower if compared with summer months, as suggested by Gannier and Gannier (1997) and Gannier (1998). The overall uncorrected reported density values here for area C (i.e. the north-western part of the Sanctuary), while not strictly comparable, are lower than those observed from previous studies in a similar area from uncorrected shipboard surveys (D=0.56, Gannier, 1998), supporting the hypothesis that striped dolphin abundance during the winter months is lower than in other seasons of the year.

The estimates provided here, however, were not corrected for g(0) since methods to estimate this parameter were not applied during data collection. Nevertheless, considering that an identical survey (same transects, same plane, same observers) is planned for this coming summer (July-August 2009) and methods for assessing g(0) will be applied, the current estimates will be corrected *a posteriori*. While it is not appropriate to directly use correction factors from other aerial surveys, it should be noted that following an approach used by Gomez de Segura *et al.* (2006), the correction factor may be of the order of around 0.7.

This research provides evidence that the use of aerial surveys increases the chance to cover a wide area in great detail, allowing higher coverage of the area (total transect length x width observed on both sides of the plane / total area) thus obtaining more robust estimates with lower CVs and CIs, when compared to more traditional ship based surveys.

These results represent baseline data for striped dolphins within the Pelagos Sanctuary – a SPAMI, specifically designated to protect cetaceans – that will be of crucial importance to assess eventual population trends over the next few years. Interpretation of trends at the population level (necessary to inform views of status and conservation needs) also requires an understanding of stock structure and movements (e.g. see Donovan *et al.*, 2008) and this must be addressed as part of any overall conservation plan – the boundaries of the Sanctuary do not coincide with biological boundaries of striped dolphins (or other cetaceans).

The effects of the direct (by-catch) and indirect threats (related to the habitat degradation) affecting the striped dolphin sub-population in the Pelagos area since the first summer abundance estimate provided in '92, have not been thoroughly assessed . By-catch in pelagic driftnets was indicated as unsustainable for the Mediterranean populations (IWC, 1994) and the die off was responsible for the deaths of at least 1,000 animals (Aguilar, 2000), even though it was not possible to assess the true numbers. The abundance estimates resulting from this study will be particularly useful to quantify the impact of the threats on the Pelagos Sanctuary striped dolphin population.

Systematic monitoring of density and abundance of the most common cetacean species of the Pelagos Sanctuary is one of the current priorities of the Italian Ministry of the Environment; further monitoring actions will be funded during summer 2009, with an identical aerial survey aimed at providing density and abundance estimates in the same area in different part of the year (winter and summer). These monitoring programmes are among the priority actions mentioned in the Sanctuary Management Plan, and those listed by ACCOBAMS and by the Specially Protected Areas and Biodiversity Protocol under the Barcelona Convention.

Moreover, considering that recent Red List assessments for Mediterranean striped dolphins has been suggested as *Vulnerable* (Reeves and Notarbartolo di Sciara, 2006), the need for further systematic monitoring and conservation measures throughout the Basin appears particularly evident.

Acknowledgements

This research was funded by the Italian Ministry of the Environment within a project aiming to "Assess the presence of critical habitats for cetaceans within the Pelagos Sanctuary". We are particularly grateful to Phil Hammond for his valuable inputs and for sharing his previous experience in cetaceans' populations monitoring.

Reference

Arnau, P., Liquete, C. and Canals, M. 2004. River mouth plume events and their dispersal in the Northwestern Mediterranean Sea. *Oceanography* 17: 23-31.

Aznar, F.J., Balbuena, J.A. and Raga J.A. 1994. Are epizoites biological indicators of a western Mediterranean striped dolphin die-off? *Diseases of Aquatic Organisms* 18:159-163.

Aguilar, A. 2000. Population biology, conservation threats and status of Mediterranean striped dolphins (*Stenella coeruleoalba*). *J. Cetacean Res. Manage.* 2(1):17-26.

Bortolotto, A., Casini, L. and Stanzani L.A. 1992. Dolphins mortality along southern Italian coasts. *In*: X. Pastor, and M. Simmonds (eds.) Proceedings of the Mediterranean striped dolphin mortality International Workshop, Palma de Mallorca, 4-5 November 1991 Greenpeace Medlterranean Sea Project, Palma de Mallorca, p.33-37.

Buckland, S.T., Anderson, D.R., Burnham, K.P., Laake, J.L., Borchers, D.L. and Thomas, T. 2001. *Introduction to distance sampling: estimating abundance of biological populations.* Oxford University Press, Oxford. 448pp.

Calzada, N. and Aguiar A. 1995. Geographical variation of body size in western Mediterranean striped dolphins (*Stenella coeruleoalba*). *Zeitschrift fuer Saeugetierkunde* 60(5):257-264.

Calzada, N., Aguilar, A., Sorensen, T.B. and Lockyer C. 1996. Reproductive biology of female striped dolphin (*Stenella coeruleoalba*) from the western Mediterranean. *Journal of Zoology* 240(3):581-591.

Calzada N., Aguilar A., Lockyer C. and Grau E. 1997. Patterns of growth and physical maturity in the western Mediterranean striped dolphin (*Stenella coeruleoalba*) (Cetacea: Odontoceti). *Canadian Journal of Zoology* 75:632-637.

Dawson S., Wade, P., Slooten, E. and Barlow J. 2008. Design and field methods for sighting surveys of cetaceans in coastal and riverine habitats. *Mammal Rev.* 38(1), 19-49.

Di Guardo, G., Proietto, U., di Francesco, C.E., Marsilio, F., Baffoni, M., Zaccaroni, A., Scaravelli, D., Mignone, W., Caroggio, P., Garibaldi, F., Ballardini, M., Kennedy, S., Forster, F., Podestá, M., Bozzetta, E., Julini, B. and Casalone, C. 2007. Exposure occurred, but morbillivirus was not the likely cause of striped dolphin deaths in the Ligurian Sea during 2007. Paper SC/60/E10 presented to the IWC Scientific Committee, Santiago, Chile, 1-13 June, 2008 (unpublished). 4pp. [Available from the Office of this Journal].

Di Guardo, G. 2008. Dolphin Morbillivirus in the Mediterranean Sea. *Aquatic Mammal* 34(4):514-515.

Di Natale, A. and Notarbartolo di Sciara, G. 1994. A review of the passive fishing nets and trap fisheries in the Mediterranean Sea and of the cetacean bycatch. *Rep. Int. What. Commn.* (special issue) 15:189-202.

Domingo, M., Ferrer, L., Pumarola, M., Marco, A., Plana, J., Kennedy, S., McAlistey, M. and Rima B.K. 1990. Morbillivirus in dolphins. *Nature* 348: 21.

Forcada, J., Aguilar, A., Hammond, P.S., Pastor, X. and Aguilar, R. 1994. Distribution and numbers of striped dolphins in the western Mediterranean Sea after the 1990 epizootic outbreak. *Marine Mammal Science* 10:137-150.

Forcada, J., Notarbartolo di Sciara, G. and Fabbri F. 1995. Abundance of fin whales and striped dolphins summering in the Corso-Ligurian Basin. *Mammalia* 59(1):127-140.

Forcada, J., Aguilar, A., Hammond, P., Pastor, X. and Aguilar R. 1996. Distribution and abundance of fin whales in the Western Mediterranean Sea during the summer. *Journal of Zoology* 238: 23-34.

Fortuna, C., Canese, S., Giusti, M., Revelli, E., Consoli, P., Florio, G., Greco, S., Romeo, T., Andaloro, F., Fossi M.C. and Lauriano G. 2007. An insight into the status of striped dolphins (*Stenella coeureoalba*) of the southern-Tyrrhenian sea. *J. Mar. Biol. Ass. U.K.* 87:1321-1326.

Fossi, M.C., Marsili, L., Neri, G., Natoli, A., Politi, E and, Panigada, S. 2003. The use of a non-lethal tool for evaluating toxicological hazard of organochlorine contaminants in Mediterranean cetaceans: new data 10 years after the first paper published in MPB. *Marine Pollution Bulletin* 46(8):972-982.

Gannier, A. 1998. Une estimation de l'abondance estivale du dauphin bleu et blanc *Stenella coeruleoalba* (Meyen, 1833) dans le future sanctuaire marin international de Méditerranée Nord-occidentale. *Re.v Ecol.* 53:255–271.

Gannier, A. and Gannier, O. 1997. New results on the seasonal variation of cetaceans in the Liguro-Provençal basin. *Eur. Res. Cetaceans* [Abstracts] 11:91-4.

Garcia-Martinez, J., Moya, A., Raga, J.A. and Latorre, A. 1999. Genetic differentiation in striped dolphin *Stenella coeruleoalba* from European waters according to mitochondrial DNA (mtDNA) restriction analysis. *Molecular Ecology* 8(6):1069-1073.

Gaspari, S., Azzellino, A., Airoldi, S and, Hoelzel, A.R. 2007. Social kin associations and genetic structuring of striped dolphin populations (*Stenella coeruleoalba*) in the Mediterranean Sea. *Molecular Ecology* 16:2922-2933.

Goffart, A., Hecq, J.H. and Prieur L. 1995. Contrôle du phytoplankton du bassin ligure par le front liguro-provençal (secteur corse). *Oceanol Acta* 18:329-342. [in French with English abstract]

Gomez de Segura, A., Crespo, E.A., Pedraza, S.N., Hammond, P.S. and Raga, J.A. 2006. Abundance of small cetaceans in the waters of the central Spanish Mediterranean. *Marine Biology* 150:149-160.

Gonella, J., Lamy, A. and Millot, C. 1977. Upwellings d'été sur la côte méditerranéenne française. *Annales Hydrographiques* 5:87-94.

Gordon, J.C.D., Matthews, J.N., Panigada, S., Gannier, A., Borsani, J.F. and Notarbartolo di Sciara G. 2000. Distribution and relative abundance of striped dolphins, and distribution of sperm whales in the Ligurian Sea cetacean sanctuary: results from a collaboration using acoustic monitoring techniques. J. Cetacean Res. Manage. 2(1):27-36.

International Whaling Commission. 1994. A review of the passive fishing nets and trap fisheries in the Mediterranean sea and of the cetacean bycatch. Gillnets and cetaceans. *In: W.F* Perrin, G.P. Donovan and Barlow, J (eds.) Rep. Int. Whal. Commn. (special issue) 15:189-202.

Jacques, G. 1989. L'oligotrophie du milieu pélagique de Méditerranée occidentale: un paradigme qui s'estompe? *Bulletin de la Société Zoologique de France* 114:17-29.

Laran, A., Gannier, A. and Bourreau S. 2002. Preliminary results on seasonal variation of cetacean population in the Mediterranean sanctuary. *European Research on Cetaceans* 14:115.

Laran, S. and Drouout-Dulau, V. 2002. Seasonal variation of striped dolphins, fin- and sperm whales' abundance in the Ligurian Sea (Mediterranean sea). *J. Mar. Biol. Ass. UK*. 87:345-352.

Marques, F.F.C. and Buckland, S.T. 2004. Covariate models for the detection function. In: Buckland, S.T., Anderson, D.R., Burnham, K.P, Laake, J.L., Borchers, D.L. and Thomas, L. (eds) *Advanced distance sampling: estimating abundance of biological populations*. Oxford University Press, Oxford. 434pp.

Notarbartolo di Sciara, G., Agardy, T., Hyrenbach, D., Scovazzi, T. and Van Klaveren P. 2008. The Pelagos sanctuary for Mediterranean marine mammals. *Aquatic Conservation: Marine and Freshwater Ecosystems* 18:367-391.

Perrin, W.F., Wilson, C.E. and Archer, F.I., II. 1994. Striped dolphin - *Stenella coeruleoalba* (Meyen, 1833). *In*: S.H. Ridgway and S.R. Harrison (eds). *Handbook of Marine Mammals*. Vol. 5: *The first book of dolphins*. Academic Press, London, pp. 129-160.

Raga, J.A., Banyard, A., Domingo, M., Corteyn, M., Van Bressem, M.F., Fernández, M., Aznar, F.J. and Barrett, T. 2008. Dolphin morbillivirus epizootic resurgence, Mediterranean Sea. *Emerg. Infect. Dis.* 14:471-3

Reeves, R. and Notarbartolo di Sciara, G. (compilers and editors). 2006. The status and distribution of cetaceans in the Black Sea and Mediterranean Sea. IUCN Centre for Mediterranean Cooperation, Malaga, Spain. 137 pp.

SCANS-II. (2008). Small Cetaceans in the European Atlantic and North Sea. Final Report to the European Commission under project LIFE04NAT/GB/000245. Available from SMRU, Scottish Oceans Institute, University of St Andrews, St Andrews, Fife KY16 8LB, UK.

Stocchino, C. and Testoni, A. 1977. Nuove osservazioni sulla circolazione delle correnti nel Mar Ligure. *Istituto Idrografico della Marina*, F.C. 1076, Genova: 13pp.

Valsecchi, E., Amos, W., Raga, J.A., Podestà, M. and Sherwin, W. 2006. The effects of inbreeding on mortality during a morbillivirus outbreak in the Mediterranean striped dolphin (*Stenella coeruleoalba*). *Animal Conservation* 7(2):139-146.

Zimmer, W.M.X. 2002. Underwater acoustics and ahales in the Mediterranean Sea. *Polarforschung* 72(2/3), 115-118.

Van Bressem M.F., Visser I.K.G., Van de Bildt M.W.G., Pettema J.S., Raga J.A.., Osterhaus A.D.M.E. 1991. Confirmation of morbillivirus infection in Mediterranean striped dolphins (*Stenella coeruleoalba*). *Vet. Rec.* 129: 471-472.