COMPARING TWO MONITORING TECHNIQUES FOR THE SUMMER POPULATIONS OF CETACEANS IN THE MEDITERRANEAN SANCTUARY

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INTRODUCTION Populations of cetaceans in the International Marine Mammals Sanctuary Mediterranean need to be monitored on a long term basis. This is particularly the case for striped dolphins and fin whales whose population have been estimated in various areas of the Western Mediterranean in the past (Forcada *et al.* 1996; Gannier, 1998). As new limits have been agreed for the Sanctuary by Italy, France and Monaco on 29 November 2001 (Fig.1), a first important step was to determine the summer distribution of these populations and to quantify their abundance within the new area. During summer 2001, two simultaneous surveys took place in the Sanctuary: one carried out by the C.R.C./G.RE.C. and the other by the WWF-France. They were run independently and used two different sampling strategies, but were both to deliver relative or absolute abundance estimates on striped dolphins and fin whales populations. The distribution results obtained by each survey, and relative abundances for three regions of the Sanctuary could be compared. The discussion rose methodological points on both monitoring techniques, as well as practical consequences for future similar surveys.

MATERIAL AND METHODES

C.R.C./G.RE.C. survey

A standard line transect method was implemented from 25th July to the 3rd August, with a motor boat cruising at 10 knots average speed, in four regions of the Sanctuary. Four observers were seating on a 4.5 meter deck: three of them shared the 180° frontal sector, searching with naked eyes, one supplementary observer was also a sighting secretary. Observers rotated on a one-hour basis, two resting positions being available during the survey. Every 20 minutes, the boat was stopped during 3 minutes to carry out a passive acoustics monitoring session, and various environmental parameters recorded. Two reticuled binoculars were used for measuring the sighting relative position.
Sampling consisted in pre-determined zig-zag lines in four stratified areas of the Sanctuary: the Central (CE), Northeast (NE), Southwest (SW) and Tyrrhenian regions. A passage mode was used (Hiby and Hammond, 1989) whenever cetaceans were sighted, the cruising speed being decreased to 7 knots for 30 sec-2 min to enable a more efficient school size estimate. The survey was designed to deliver absolute abundance estimate (Gannier *et al.*, 2001), however distribution variables and relative abundance estimates obtained with Distance 2.2 will be presented here.

Cap Ligures survey

The Cap Ligures survey (WWF-France) took place from the 20th July to the 3d August : two motorised sailboats applied the LTM at 5.5 knots average speed. Three permanent observers cover the 180° frontal sector, with their eyes situated at 2,75 m above the sea surface. A

fourth one recorded the sightings parameters. Two resting positions enable a rotation of the observers. We applied mainly (81%) a passage mode, and otherwise the boat moves briefly closer to the animals to precise the group size estimation. The sighting relative positions were measured with reticuled binoculars. Estimation of school size were rounded to the nearest 5 multiple (when the group encompassed 30 individuals).
The positions of the boat given by a GPS, connected with the pilot automatic, were automatically recorded into a computer each half an hour. We noted at the same time the meteorological conditions. Based on a previous work named POSEIDON (Roussel *et al.*, 2001), the Sanctuary was split into 20' latitude/longitude squares. To ensure a sufficient and homogeneous prospection effort, 37 km to 74 km were to be cruised on-effort in each square in predefined straight segments. The aim of the survey was to obtain an extensive distribution of striped dolphins and fin whales and their relative abundance. Sampling was designed to avoid double counting between both boats, in principle.

Calculation of the indices of relative abundances per sector

Relative abundance Indices R were computed with *Distance* 2.2 software (Laake *et al.* 1994). for both species and each survey in the three regions. Our relative abundance was obtained from the density estimator of Buckland *et al.* (1993) : $\underline{D} = (n / L) . \underline{E(s)} / 2\,esw$
where n= the number of primary sightings, L= the transect length, E(s) the mean school size and esw effective detection half-width, which was considered constant for each survey team across all regions. Then $R = (n/L)*E(s)$ as in Gannier (1999). This assumption holds if meteorological conditions were good or very good during all sampling period and E(s) was similar in all three regions. Only effort covered with sea state and wind conditions ≤ 3 Beaufort were retained for this study.

RESULTS Wind rarely exceeded Beaufort 3 during the period of study. E(S) were estimated for every region and tested to be not significantly different, hence they were latter calculated for the whole Sanctuary. Possible correlation between E(S) and perpendicular detection distance was also looked for (Buckland *et al.*, 1993) but found to be not significant. Hence, the assumptions for using relative abundance R were met for both surveys.

Sampling effort

Effective effort amounted to 1182km (CRC/GREC) and 2095km (WWF) (Fig.2). It was verified that all three regions were homogeneously covered with a specific effort of about 20 m/km² for the CRC/GREC and 36 m/km² for the WWF (although in the latter case, effort in the NE region was slightly less intense). The sampling homogeneities were compared for both surveys at three scales: mean sampling effort and associated variances were calculated on grids of 60x60, 30x30 and 15x15milles. Effort was more homogeneous at large scale for CRC/GREC (CV=0.40 against 0.52) and more homogeneous at small scale for WWF (CV=0.46 against 0.50), thus illustrating sampling strategies adapted to each survey specific goals.

Sightings and Mean group sizes

For fin whales, 21 on-effort sightings were obtained by CRC/GREC during the period of study and 35 by WWF (Fig.3). A mean school size of 1.18 (CV=10.4%) was estimated by CRC/GREC against 1.66 (CV=14.1%) for WWF. Estimates of E(S) were significantly different between both surveys (test T p>99%).

For striped dolphins, 42 on-effort sightings were obtained by CRC/GREC during the period of study and 53 by WWF. A mean school size of 18.8 (CV=12.6%) was estimated by CRC/GREC against 25.7 (CV=18.9%) for WWF. Estimates of E(S) were significantly different between both surveys (test T $p<0.01$).

Abundance indices

For fin whales, CRC/GREC obtained abundance indices of 0.46, 3.40 and 1.26 ind./km^2 in SW, Central and NE regions respectively (Table 1) when WWF estimated 2.68, 3.33 and 1.45 respectively. Hence, if both surveys agreed on relative abundances in NE and Central regions, their estimates were different for the SW region, found to be much higher by WWF than by CRC/GREC. Within each survey, statistically significant differences (95%CL) were found between all regions (CRC/GREC) and NE/Centre regions (WWF). For striped dolphins, CRC/GREC obtained abundance indices of 44.3, 88.3 and 50.3 ind./km^2 in SW, Central and NE regions respectively (Table 2) when WWF estimated 52.1, 83.2 and 33.7 respectively. Both surveys agreed on relative abundances in NE, Central and SW regions, their estimates being in the same order of magnitude, with the possible exception of NE area. The differences were found significant between all sectors for the WWF survey ($p<0.05$), and not significant at the 95%CL for CRC/GREC survey.

DISCUSSION Since significant differences arose between both survey results, discussion focused first on the influence of methodological points on relative abundance results and then on cetacean distribution aspects, in the perspective of efficient monitoring of the protected area.

Concerning WWF Cap Ligures ‘s data, the risk of double counting for one boat was verified by considering archive data on cetacean movements and existed in 5 cases only. Double counting between boats was similarly estimated to be possible in 8% of the cases. We assumed that double counting could not seriously affect our results and both the data sets.
Group sizes, E(s), was similar between boats data sets for fin whales, and significantly different for striped dolphin with : boat 1 E(S)=24,5 ; boat 2 E(S)=19,2 (T=2,52 et p=0.017).
The R values for each boats were found to be significantly different for both species between the three sectors (test T, $p<0.01$ for fin whales, and $p= 0.01$ for striped dolphins). This is due to sampling covering distinct areas for each boat (within one region), the strategy being to obtain global and representative result by grouping both data sets together.

The differences of the E(s) values obtained by the C.R.C./G.RE.C. and the Cap Ligures surveys, could arise from bias or rounding effect in estimates. Possible correlation between number of individuals and date, time or sighting distance were tested unsuccessfully. The possible influence of remote (over 2500m in radial distance) and short duration (less than 30sec) sightings was observed in the GREC data set : after removing those cases, the school size estimate rose to 1.29 instead of 1.18. Also, due to insufficient sample size, differences might be the consequence of spatial heterogeneity in distribution. The fact that variable school sizes were also estimated for striped dolphins indicates that increased attention should be given on this delicate methodological point.

The differences of R values between surveys was not important for striped dolphins and significant for fin whales, mainly affecting the SW region (NE being less covered by WWF). Although, inter-survey difference may be caused by respective sampling design within study areas, they could also highlight movements of animals during the summer period. In the SW,

Cap Ligures survey, which took place on 23, 24 and 25th of July, numerous sightings of both species were made near the western and northern borders of this region (Figs 1-2). Moreover, Cap Ligures survey sampled the Central sector mainly on 21, 22 and 26th of July, and the C.R.C./G.RE.C. 8 to 10 days later. Westwards distribution shifts could be possible for fin whale during this time lapse, as northwards movement of striped dolphins are plausible. These results would confirm and precise phenomena of movements in the Mediterranean sea (David *et al. 2001 ;* Roussel *et al.* 2001).

Teaching about both type of surveys

An "absolute abundance" survey like the C.R.C./G.RE.C. one, allow an homogeneous sampling effort over vast sectors. It is realised in a short period of time, so that the hypothesis of non transfer of animals between sectors is accepted, and with a design avoiding double counting inside sectors. But the sampling is not exhaustive on a smaller scale. The "hazard" of sampling can lead to differences between estimated and real abundance, although this is normally covered by variances estimate.

A « small squares » survey like the Cap Ligures one, benefits of exhaustive sampling over the sectors covered. The duration of field sampling cannot *a priori* avoid transfer of animals. According to the cruise speed and distance between transects, double counting between different boats may be excluded within sectors, enabling to get relative abundance results on large scale in these sectors.

The comparison of both surveys allowed to compare indices of abundances R between regions, and to highlight distribution results given by the « small squares » survey.

CONCLUSION For the first time an exhaustive distribution survey was coupled with a survey designed to deliver absolute abundance estimate on large scale, complementary approaches leading to additional results. The "time" factor which arises from our findings highlights probable summer movements of cetaceans within the Sanctuary and from/to adjacent waters, potentially important points for the monitoring of cetaceans population in the Sanctuary.

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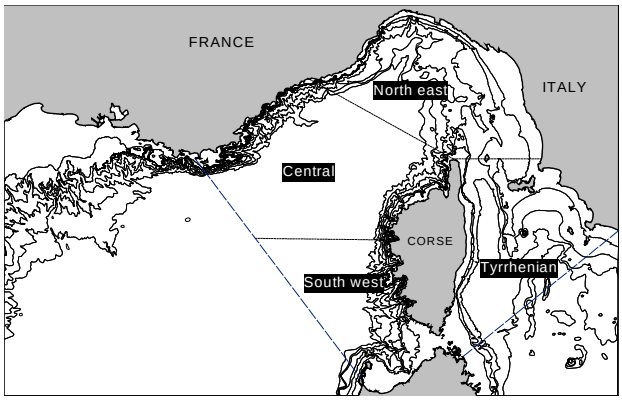

Figure 1 : Limits of the International Marine Mammals Sanctuary Mediterranean, and of the fourth regions of study, Central, South-west, North-East and Tyrrhenian.

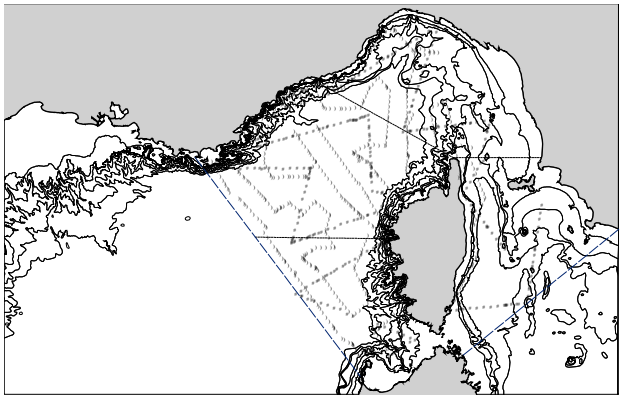

Figure 2 : Sampling effort in wind conditions ≤ 3 Beaufort for the C.R.C./G.RE.C. survey (black) and Cap Ligures survey (grey).

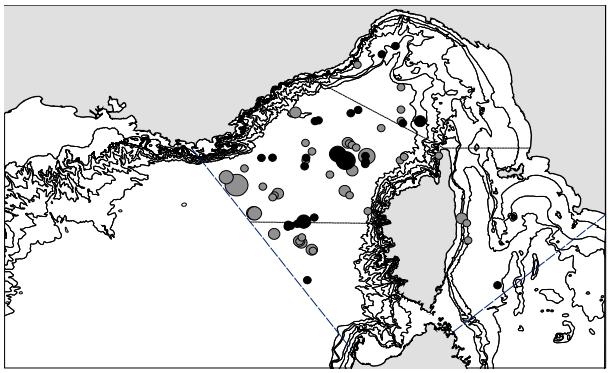

Figure 3 : Sightings of fin whale during the C.R.C./G.RE.C. survey (black) and Cap

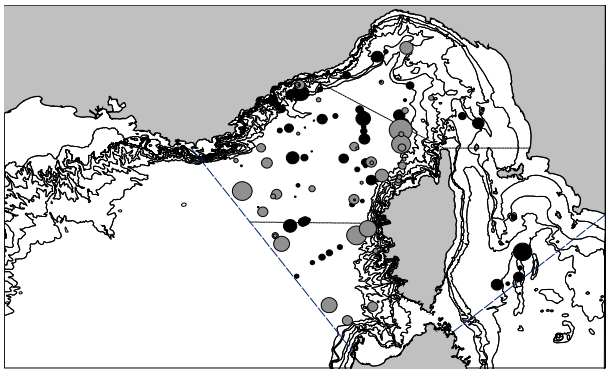

Figure 4 : Sightings of striped dolphin during the C.R.C./G.RE.C. survey (black)