Biological Conservation 178 (2014) 155–162

Contents lists available at ScienceDirect

Biological Conservation

journal homepage: www.elsevier.com/locate/biocon

Conserving Cuvier's beaked whales in the Alboran Sea (SW Mediterranean): Identification of high density areas to be avoided by intense man-made sound

A. Cañadas *, J.A. Vázquez

ALNILAM Research and Conservation, Cándamo 116, 28240 Hoyo de Manzanares, Madrid, Spain

ARTICLE INFO

Article history:
Received 13 January 2014
Received in revised form 13 June 2014
Accepted 31 July 2014

Keywords:
Spatial modeling
Abundance estimate
Marine protected area
Availability bias
Alboran Sea

ABSTRACT

Links between atypical mass strandings of beaked whales and military manoeuvres have been demonstrated in several parts of the Mediterranean, including the Alboran Sea. Herein, information on the distribution and abundance of Cuvier's beaked whales is presented for the Alboran Sea. Such information is of great importance to allow the impacts of mass strandings, entanglements, etc. to be put in a population context and to highlight the most important areas for this species which may be focus for conservation action. Data used for these analyses come from two sources: summers 2008–2009 on board the vessel Alliance; and 1992–2009 surveys under the umbrella of the NGO Alnitak. A detection function was obtained using distance sampling methods and density surface modeling was undertaken. Availability bias correction factors were estimated for different platforms and vessel speeds and applied during the spatial modeling exercise. The final estimate of density (in animals/km^2) corrected for the availability bias was 0.0054 (CV = 22%). Based on these results, and a comparison with estimates from elsewhere, it is clear that the Alboran Sea supports one of the highest densities of Cuvier's beaked whales in the world. This information and the proposed management measures are being used by the Spanish Ministry for Agriculture, Food and Environment to assess the possibility of increasing the level of protection of this species by either to promote a proposal for a Marine Protected Area designation or to include Cuvier's beaked whales in the Spanish catalogue of threatened species in the "Vulnerable" category.

1. Introduction

The Cuvier's beaked whale (*Ziphius cavirostris*) is a predominantly oceanic species, frequently associated with high slope habitats and a marked preference for submarine canyons and escarpments (D'Amico et al., 2003; Podesta et al., 2006; Azzellino et al., 2008). A direct relationship has been demonstrated between atypical mass strandings of beaked whales and high-intensity military sonar and seismic surveying activities (Frantzis, 1998; Jepson et al., 2003; Brownell et al., 2005; Fernández et al., 2004, 2012), which have caused the stranding of specimens with chronic and acute damage in their tissues due to the formation of air bubbles such as those caused in decompression sickness (Jepson et al., 2003; Fernandez et al., 2004, 2012).

Information on distribution of Cuvier's beaked whales in the Mediterranean is of fundamental importance for preventing the use of high intensity noise in potential high density or highly suitable areas for this species and therefore further events of injury and death. The inclusion of the Mediterranean Cuvier's beaked whale sub-population as Vulnerable in the IUCN Red List of Threatened Species has been proposed (currently under review). ACCOBAMS (Agreement for the Conservation of Cetaceans in the Black Sea, Mediterranean Sea and contiguous Atlantic waters, www.accobams.org) has proposed to include this species in Annex I of the CMS (ACCOBAMS MOP5/2013/Doc19). Currently the Spanish legal framework only considers Cuvier's beaked whale as one of the species included in the List of wildlife species under special protection regime but is not included in the National catalogue of endangered species (Law 42/2007).

Marine Protected Areas (MPAs) offer a potential solution to some challenges for management and conservation of the marine environment and for the most threatened species that inhabit them. They allow focusing specific targeting efforts or management actions at a geographical level. The recovery or maintenance of a favorable conservation status of endangered species under the management plans of MPAs or a broader conservation plan needs to be structured on solid scientific basis (Boersma and Parrish, 1999; Hooker and Gerber, 2004; Cañadas et al., 2005).

* Corresponding author. Tel.: +34 676481284.
E-mail address: anacanadas@alnilam.com.es (A. Cañadas).

http://dx.doi.org/10.1016/j.biocon.2014.07.018
0006-3207/

A habitat modeling analysis for Cuvier's beaked whale in the Mediterranean conducted under the auspices of ACCOBAMS and a collaborative effort of many organizations (Cañadas et al., 2013) incorporates survey effort and sightings data recorded from 1990 to 2010. The results identified three areas with higher relative densities of Cuvier's beaked whales, the Alboran Sea, the Ligurian Sea, and the Hellenic trench.

An abundance estimate of beaked whales has been obtained now for the Alboran Sea. But density estimates from line transect surveys are usually subject to "availability bias" due to animals not always being available for detection while within detectable range (Buckland et al., 2004), and to "perception bias" due to observers failing to detect animals even though they are available (Buckland et al., 1993), causing both a negative bias. Deep diving species such as beaked whales are even more subject to this negative bias. We tried to minimize this bias by estimating the availability bias specific for these surveys in the Alboran Sea.

Obtaining this abundance estimate is of great importance to (a) put potential threats into context (impact of a given amount of deaths on the population) and (b) highlight the most important areas for this species, susceptible for protection for its conservation.

The goals of this paper are to describe a novel method to get unbiased abundance estimates for Cuvier's beaked whale in the Alborán Sea, to identify high density areas, and to provide sound scientific information to the Spanish Ministry for Agriculture, Food and Environment to assess the possibility of changing the conservation status and protection of this species in the area.

2. Methods

2.1. Data sources

Data used for these analysis comes from two sources: (a) data collected during summers 2008–2009 onboard the vessel *Alliance* during the Sirena08 and Med09 surveys, and (b) data collected during surveys carried out by the NGOAlnitak, on board 3 vessels ("small vessels" hereafter): *Toftevaag* (1992–2010), *Thomas Donagh* (2009) and the Fisheries Patrol boat of the General Secretariat of Maritime Fisheries (2003–2009).

We collected data on radial distance and angle in all cases as described in Cañadas and Hammond (2006). Fig. 1 shows the tracks on effort and associated sightings of Cuvier's beaked whales.

2.2. Data organization

We divided the study area (the Alboran Sea) into grid cells of 2×2 min latitude–longitude of resolution, characterized according to several spatial and environmental variables (e.g. latitude, longitude, depth, standard deviation of depth, slope, distance from coast and from several isobaths, chlorophyll, sea surface temperature, primary productivity). We divided all on effort transects into small segments (average 2.8 km) with homogeneous type of effort along them and little variability in environmental features within them. Data was organized into two datasets (Fig. 1): (a) "Whole Alboran": whole Alboran sea (79,532 km^2); and (b) "Northern Alboran": northern part of the Alboran sea (25,589 km^2).

2.3. Analytical methods

For model-based abundance estimation based on spatial modeling, we followed a similar methodology as that described in Cañadas and Hammond (2006, 2008), in which five steps were taken, with some modifications adding two steps, as a novel approach, to incorporate the availability bias (points 1 and 4): (1) selection of cut points for expected maximum forward distances for the sightings; (2) estimation of the detection function from the distance data and covariates that could affect detection probability; (3) estimation of the *esw* (effective strip width) in each segment from the detection function equation and the covariates involved in it; (4) estimation of the availability bias correction factor using Laake's equation (1997), and applied to the estimated *esw* for each segment; (5) modeling of the count of groups as a function of spatial and environmental covariates using the corrected *esw* in the offset; (6) calculation of the mean group size; (7) combination of steps 5 and 6 and extrapolation to the whole study area to obtain the final abundance of animals.

2.3.1. Availability bias correction factor

If estimates are uncorrected for availability and perception bias, the two components of the $g(0)$, or probability of detecting the animals at distance zero from the transect line, are underestimated by an unknown magnitude (Buckland et al., 1993).

Laake et al. (1997) developed an equation to correct estimates for availability bias ($\hat{a}$ = correction factor), taking into account the average duration for each period of availability (surface) and of unavailability (immersion) and the time an animal is within a detectable range. The last factor is estimated as a function of the speed of the ship and the maximum forward distance at which animals are expected to be detected, for which a cut point had to be selected. CVs of the correction factors were also estimated following Laake et al. (1997).

Given that this distance depends largely on the height of the observation platform, we divided sightings into three major groups according to the platform height: (a) vessel *Alliance* with a platform height of 16.7 m; (b) small vessels using the crow's nest platform (10.5 and 11.2 m); and (c) small vessels not using the crow's nest platform (3–4.75 m). We used 90% of the data as a cut point for forward distance: 8000 m for the *Alliance*, 4400 m for small ships with a crow's nest platform, and 1600 m for small ships not using the crow's nest. The use or not of the crow's nest platform on the small ships was mainly dependent on the swell conditions, and it was always recorded during survey effort.

2.3.2. Detection function and esw

We fitted a detection function to all sightings pooled together to estimate the probability of detection, when surveying at speeds of $\leqslant$10 kts and sea state $\leqslant$2 Douglas (equivalent to Beaufort 3) to avoid bias. Sightings with forward distances larger than the selected cut points were discarded. Covariates considered for inclusion in the detection functions were effort related covariates (ship, observation platform height, position of observer, speed of vessel, sea state, swell height, sightability conditions) in order to be able to apply the availability bias correction factor to all effort segments.

Once a final detection function was selected, we obtained the *esw* for each observation applying the detection function equation to each observation according to their associated covariates.

2.3.3. Estimation of availability and unavailability for the availability bias correction factor

To estimate the average duration of availability and unavailability, we used data on focal follow of Cuvier's beaked whales during the 2008 and 2009 surveys on board the *Alliance* in the Alboran Sea. In total, 57 groups were followed (28 in 2008 and 29 in 2009), totaling 319 diving and surfacing events. Once a group of Cuvier's beaked whale was detected all observers covered 360° to start the focal follow. The use of BigEyes and 7×50 binoculars allowed identifying each group at every surface event according to their group composition and coloration of the animals. When identification of a group became uncertain, focal follow of such group ended.

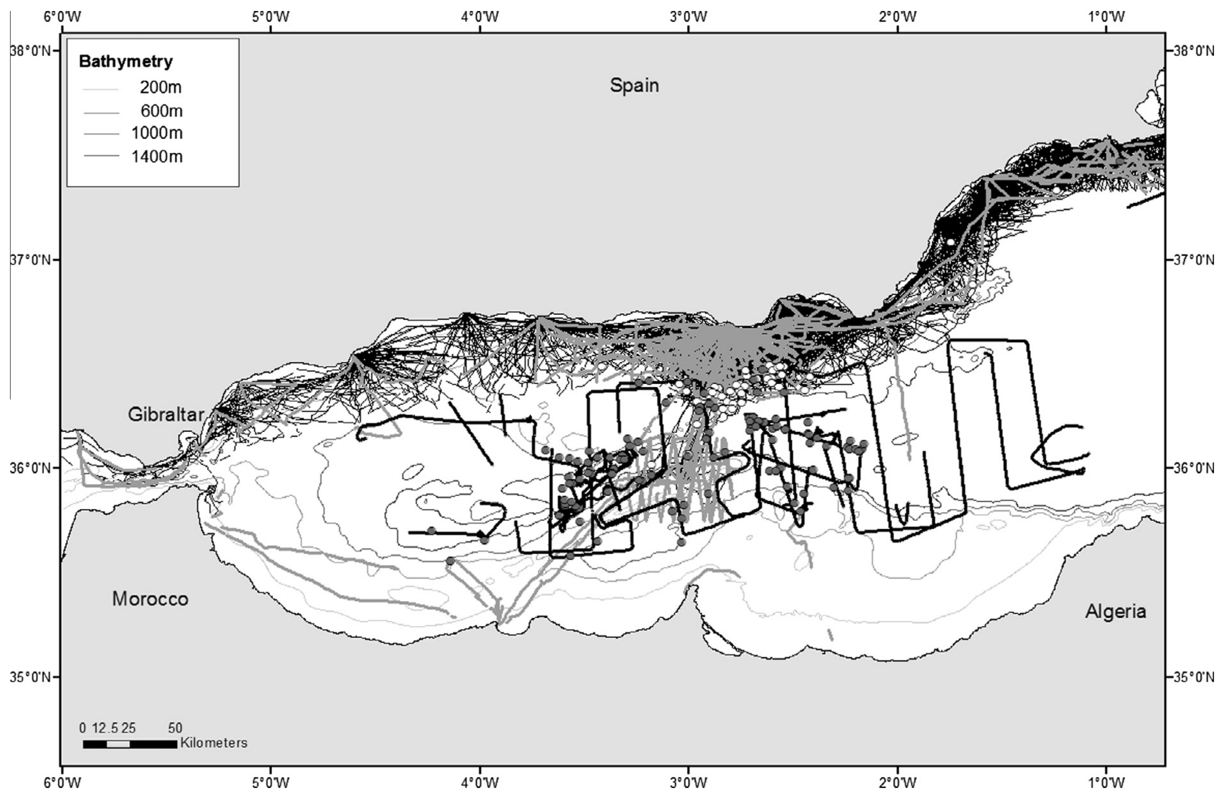

Fig. 1. Searching effort and sightings of Cuvier's beaked whales. Searching effort during 2008 and 2009 by the *Alliance* (thick black line) and by the small ships (thick gray line); searching effort from 1992 to 2007 by all ships in the northern Alboran Sea (thin black line); sightings of beaked whales in 2008 and 2009 by all ships (gray circles); and sightings of beaked whales from 1992 to 2007 by all ships in the northern Alboran Sea (white circles).

The time an animal is within a detectable range was estimated by dividing the expected maximum forward distance by the vessel's speed. Calculations were done for the three selected groups of maximum forward distances according to platform height, and within each group, this time was estimated for the whole range of speeds between 1 and 10 kts (at intervals of 0.1 kt). Therefore, we obtained a range of values for $\hat{a}$ for the different speeds for the three different platform height groups considered.

An *esw* was associated with each segment of effort according to the values of those covariates selected in the final model for the detection function in each segment. We calculated an offset (to be included in the spatial models) being the effective searched area for each segment, as L*2*esw where L is the length of the segment. The value of $\hat{a}$ was estimated for each segment according to which group of platform height it belonged to and the particular speed of the vessel in that segment. Finally, the previously calculated effective searched area for each segment was multiplied by $\hat{a}$ to obtain the corrected effective searched area for availability bias, used as final offset in the spatial models.

2.3.4. Perception bias

Experienced observers on Cuvier's beaked whale detection were onboard all surveys, so we assumed perception bias to be very close to 1.

2.3.5. Spatial models

The response variable used to formulate the spatial models of abundance of groups was the count of groups (N) in each segment (Hedley et al., 1999). We modeled the abundance of groups using a Generalized Additive Model (GAM) with a logarithmic link function, and a Tweedie error distribution, with a parameter p of 1.1, very close to a Poisson distribution but with some over-dispersion (see equation and its description in Cañadas and Hammond, 2008)

Models were fitted using package 'mgcv' version 1.7–22 for R (Wood, 2011). Model selection was done manually using three diagnostic indicators: (a) the GCV (Generalised Cross Validation score, an approximation to AIC Wood, 2000); (b) the percentage of deviance explained; and (c) the probability that each variable was included in the model by chance. Given that there was very little variation in group sizes and there was no evidence of spatial variation of group sizes, the mean group size was used, instead of modeling group sizes.

We produced predictions of abundance of groups, multiplied in each grid cell by the mean group size, over all the grid cells of the study area, according to the values of the covariate coefficients retained in the final models. We obtained the point estimate of total abundance by summing the abundance estimate of all grid cells over the study area. All datasets were modeled independently following the same procedure.

2.3.6. Uncertainty

We did 400 non-parametric bootstrap resamples of the whole modeling process, using day as the resampling unit, to obtain the coefficient of variation and percentile based 95% confidence intervals.

2.4. Identification of the high density areas for conservation

There are two possibilities under Law 42/2007 of December 13, Natural Heritage and Biodiversity, to improve the conservation status of Cuvier's beaked whale; (1) to create an MPA defined as "natural areas designated for the protection of ecosystems, communities or biological or geological elements of the marine environment, including intertidal and subtidal areas that because of its rarity, fragility, importance or uniqueness, deserve special protection"; or (2) to include it in the National Catalogue of

Endangered Species as "vulnerable". The latter would require the identification of "Critical Areas" and the development of a Conservation Plan.

We identified the critical areas for conservation of Cuvier's beaked whale in the Alboran Sea that could be considered according to the definitions and criteria established by the Spanish legislation: "*Critical area for a species*" as "*those sectors within the range that contain essential habitat for the conservation of the species or because their strategic location for the same requires a proper maintenance*".

To select the Critical Area boundary, we sorted all grid cells by their estimated abundance in decreasing order. We then assigned a relative index of abundance in terms of the percentage of the total estimated abundance in the study area to the grid cells in steps of 10%.

Potential threats were identified after literature review (see Introduction and item 3.2.4) and direct observations during surveys (e.g. animal entangled). An MPA without a management Plan is only paperwork (Cañadas et al., 2005; Hooker and Gerber, 2004; Hooker et al., 2011), therefore, based on the identified threats, some basis were proposed for a Management Plan to be developed by the administration taking into account this information.

3. Results

3.1. Estimation of abundance

3.1.1. Detection function

The best fitted model was a hazard-rate key function with no adjustment terms and right truncation at 3800 m and included 153 observations. Two covariates were selected; platform height and sea state. Average probability of detection was 0.343 (CV = 0.87). The *qq*-plot and the goodness of fit tests (*p* values between 0.35 and 0.8) showed a very good fit of the model to the data. The next best model had a delta AIC of 1.87 and the third one of 2.23.

3.1.2. Availability bias correction factor

The mean and CV of diving and surfacing times obtained from the focal follow and applied to Laake's (1997) equation, and the range and mean values for $\hat{a}$ obtained for the three groups considered are shown in Table 1.

3.1.3. Spatial modeling

Best models for both datasets retained the same covariates: latitude, longitude and depth, all highly significant, with deviances explained from 38.8% (whole Alboran) to 40.7% (north Alboran). The final selected predicted estimate of abundance for the Alboran Sea ("Whole Alboran") was 429 (CV = 0.22). This was selected because it was the model with most amount of data, in time and space, supporting it (Table 2).

Fig. 2 shows the prediction of abundance of beaked whales for 1992–2010 in the whole Alboran Sea, the selected model.

3.2. Implications for conservation

3.2.1. Identified Critical Area

The prediction used to define the Critical Area was from the most complete model: Whole Alboran. The proposed area boundaries were selected taking into account the results of the models and the distribution of sightings recorded (i.e. the support from the data). The areas comprising the highest 40% of abundance in the whole area of distribution (i.e. those grid cells classified with 10–40%; 0.036 animals/km^2 overall, CV = 0.25) was selected, making the borders coincide with the 1000 m isobaths (for ease of delimitation) and extending the northern part to cover the waters with stronger support from the data (Fig. 3). The choice of 40% was done after exploring also the choices from 20% to 60%, as the limit that best incorporated most sightings but still not being too large for a feasible and cost-efficient monitoring.

3.2.2. Zoning

Three zones were differentiated within the Critical Area according to their importance for conservation (see Fig. 3): (a) Zone A: the

Table 1
Diving and surfacing times and correction factor for availability bias from Focal Follow data.

Mean diving and surfacing times (min)		Mean	CV
Dives		26.3 n = 166	CV = 0.05
Surfacings		2.0 n = 153	CV = 0.05
Correction factor		Mean	Range
Alliance	Correction factor	0.79	(0.635–1.000)
	Effective searched area (total sum km^2)	19,409	
Small vessels (high platform)	Correction factor	0.70	(0.447–1.000)
	Effective searched area (total sum km^2)	74,050	
Small vessels (low platform)	Correction factor	0.38	(0.231–0.999)
	Effective searched area (total sum km^2)	10,162	
Total	Correction factor (mean)	0.58	
	Effective searched area (total sum km^2)	103,628	

Table 2
Corrected (for availability bias) estimates of abundance and measures of uncertainty for beaked whales in the Alboran Sea from spatial modeling. The all-seasons model results for northern Alboran are also shown as means of comparison.

Study area	Dataset	Surface area (km^2)	Corrected density (animals/km^2)	Corrected estimate of abundance (95% CI)	Coefficient of variation
Whole Alboran Sea	Whole Alboran	79,532	0.0054	429[a](334–557)	0.22
Northern Alboran Sea	Northern Alboran	25,589	0.0051	121(100–144)	0.15

[a] The partial point estimate for the sub-area corresponding to the northern Alboran Sea was 116.

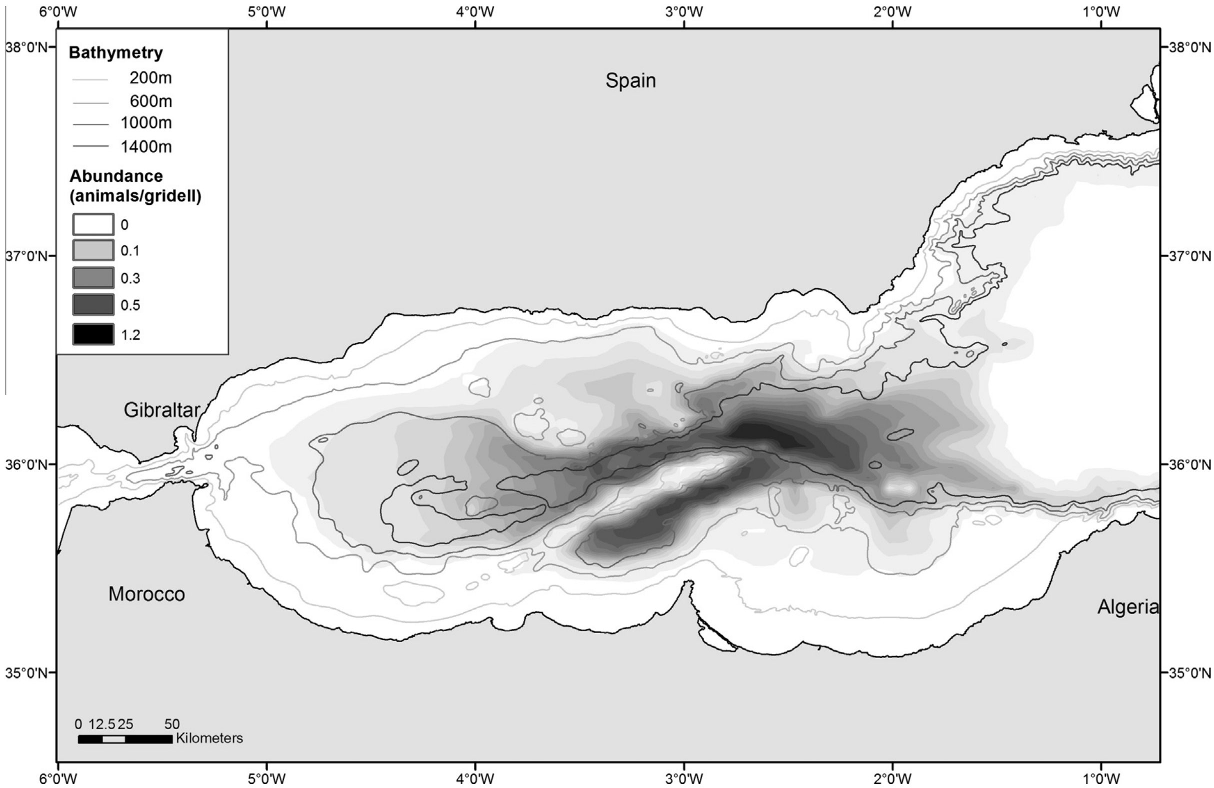

Fig. 2. Prediction of abundance of beaked whales for all year round 1992–2009 in the whole Alboran Sea.

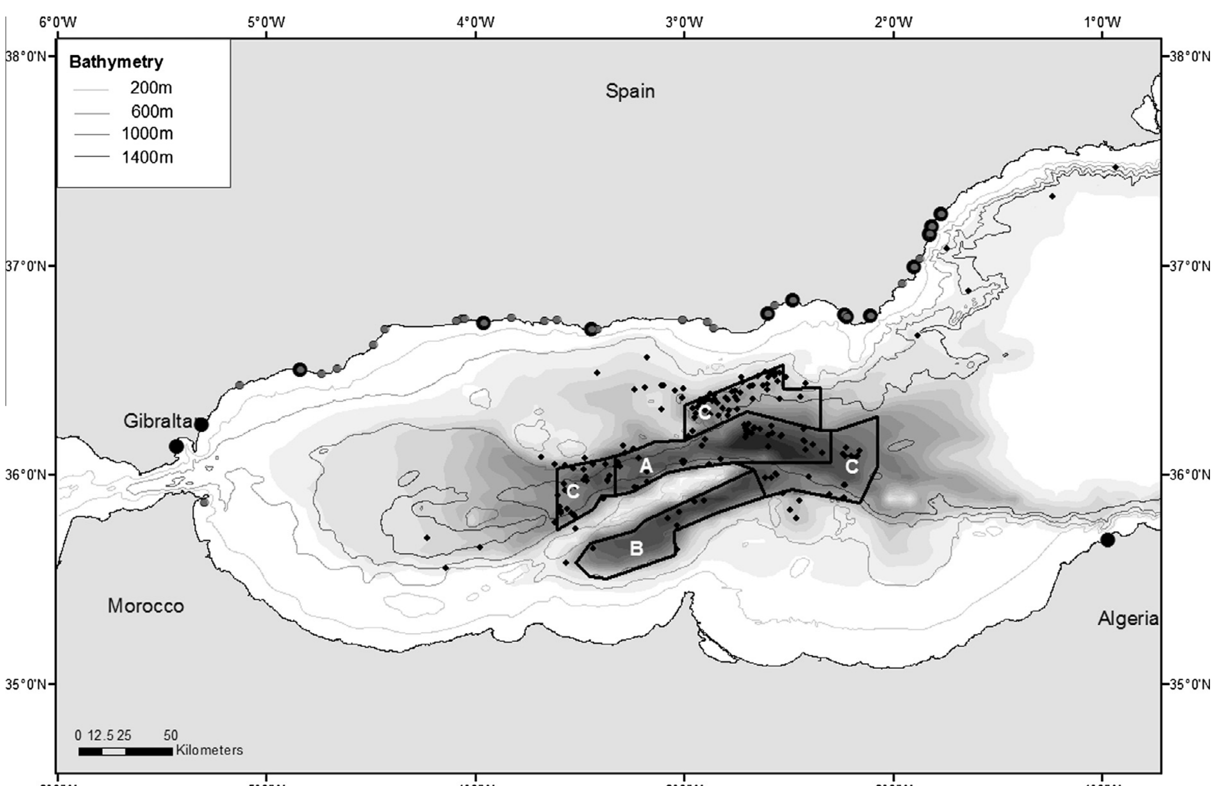

Fig. 3. Proposed Critical Area and zoning. Small black dots represent sightings of beaked whales from 1992 to 2010. Small gray dots represent strandings of Cuvier's beaked whales in the Spanish coasts from 1997 to 2011. Large black dots represent mass strandings (2 or more individuals) in the Spanish coast in the same period.

most important area with relative high density (0.044 animals/km^2); (b) Zone B: area to be sampled in future surveys, because despite containing high values of predicted density, it contained little survey effort and few sightings; and (c) Zone C: the rest of the priority area that is not included in areas A and B.

3.2.3. Buffer zone

A buffer zone was also recommended in which, when military maneuvers and gas/oil exploration and extraction activities are planned, the responsible entity should do a specific environmental impact assessment to determine, according to the source level and the environmental factors in the area, the minimum distance to keep away from the limits of the Critical Area so that within those limits the level of SPL 140 dB re 1 μPa @ 1 m is not exceeded (following the recommendation of the 7th meeting of the Scientific Committee of ACCOBAMS (2011)). This buffer would allow that inside the Critical Area the aforementioned limits is not exceeded, given the propagation nature of the sound.

Furthermore, the latest Recommendation of ACCOBAMS Scientific Committee (ACCOBAMS, 2013) recalls that an example of the effectiveness of spatial mitigation is the moratorium on the use of military sonar within 50 nmi of the Canary Islands that was established in 2004. Since then, no atypical mass strandings of beaked whales have been recorded in the archipelago, after a long series of mortality events linked to military sonars (Aguilar de Soto and Martin, 2007; Fernández et al., 2012), and recommends its implementation in the Mediterranean around the high-use areas and mass strandings. The issue was discussed later at the 2013 ACCOBAMS Meeting of the Parties, where a resolution was approved (Resolution 5.13, Conservation of beaked whales in the Mediterranean; www.accobams.org/images/stories/MOP/MOP5/Documents/mop5%20final%20report.pdf)

This recommendation of a "fixed" buffer would probably be more effective from the governance and management standpoint, although in cases of expected high level of noise the specific environmental impact assessment should also be done to make sure that such a pre-established buffer zone is enough in such case.

3.2.4. Potential threats and proposed basis for a Management Plan

The threats identified were:

3.2.4.1. Military maneuvers and other underwater anthropogenic high intensity noise. There are at least 10 mortality events that closely coincided with naval exercises in the Mediterranean (Arbelo et al., 2008; Blanco and Raga, 2000; D'Amico et al., 2009; Filadelfo et al., 2009; Frantzis 1998; https://lists.uvic.ca/pipermail/marmam/2011-December/003963.html): Gulf of Genoa, Italy (1963, Naval exercise, 15 animals), Corsica, France (1974, Naval exercise, 3 animals), Valencia, Spain (1996, Naval exercise, 2 animals), Kyparissiakos Gulf, Greece (1997, SACLANTCEN experimental testing of low and mid-frequency sonar, 21 animals), Ionian Sea, Greece (1997, NATO Naval exercise, 9 animals; and 2000, NATO Naval exercise, 1 animal alive),Oran, Algeria (2001, Naval exercise, 2 animals), Almería, Spain (2006, NATO Naval exercise, 4 animals), Fintane Bianche, Sicily, Italy (2011, NATO Naval exercise, 2 animals), Ionian Sea, Greece and Italy (2011, Italian naval exercises and seismic surveys, 12 animals). A total of 34 strandings of this species have been recorded in the Spanish coast of the Alboran Sea from 1997 to 2011 (Fig. 3).

The Navy and seismic survey companies should be informed of the existence of this Area and the risks for this species. There should be total prohibition to make any military or seismic or any other activity that produce underwater noise of high intensity (emission above 140 dB re 1 μPa @ 1 m) within the Critical Area, and if carried out in the vicinity, it should be mandatory to follow the procedure mentioned above for the identification and respect of the buffer zone.

3.2.4.2. Driftnets. Beaked whales are occasionally found entangled in driftnets in the Alboran Sea (pers. obs). The management measures should urge national governments, and European and international, mainly North African countries, for enhanced surveillance in critical areas and "buffer" areas for Cuvier's beaked whale, and to enforce the law (the European Community countries and some North African countries have laws that prohibit entirely the use of driftnets, although they are still used illegally in the Alboran Sea; Tudela et al., 2005).

3.2.4.3. Drifting plastics. Cuvier's beaked whales and other teutophagic species sometimes accidentally swallow drifting plastics that remain in the digestive systems producing important feeding problems and eventually death (Simmonds, 2012; de Stephanis et al., 2013). In the Alboran Sea, Almeria (SW Spain) is one of the areas with more greenhouses in Europe and many of the plastics discarded or flown away from them end up on the sea (Cañadas et al., 2005). The proposed management measure was to establish a more comprehensive control over the disposal of this plastic material.

4. Discussion

4.1. Abundance of beaked whales in the Alboran Sea

4.1.1. Availability bias

The correction factor for the availability bias used in this study is a novel way of addressing this problem for cetaceans, and especially deep divers, in abundance estimates through habitat modeling, and could be applied to analysis of surveys for any cetacean species in any area where surveys could not follow a double platform procedure (Hammond et al., 2013).

However, the correction factor is most probably slightly underestimated by a small percentage considering the availability bias. This is because in the calculation of the diving time there is proportionally more representation of the "shallow dives" (of around 20 min) than the "deep dives" (of around one hour), because during long deep dives the animals were often lost, and the dive duration could not be recorded. Additionally, the issue of the perception bias has not been addressed in this study, because there is no available data to do so, and not considering the perception bias could lead to an even higher underestimation of the total abundance, but of an unknown level. We suspect the perception bias may be very small in the case of the *Alliance* as they were surveys targeting beaked whales and the observers were very experienced. But it may be larger in the case of the smaller ships. It would be advisable to carry out a more systematic survey in the whole Alboran Sea using methods able to deal with both availability and perception bias (e.g. double platform, Hammond et al., 2013).

4.1.2. Abundance estimates in the Alboran Sea

Effort in the area during 2008 and 2009 (outside the "Northern Alboran") was very heterogeneous and there were two big areas to the west and the east that were not surveyed at all. Hence, all predictions produced by the models in these areas should be considered only as an exploratory exercise. Nevertheless, the central part of the Alboran Sea, where the area was identified, has good coverage and sightings information.

The density estimates obtained through the modeling of these data are very consistent when comparing similar areas between the two datasets. The densities for the northern Alboran Sea extracted from the predictions from the whole area models are very similar to those from the models for the northern part (Table 1). Comparing the encounter rate of groups during the summer months (June to September, 1.16 animals/1000 km of survey), with the non-summer months (1.11 animals/1000 km), we conclude that there are no real differences in density between summer and non-summer months, so season is not affecting these estimates.

Based on the modeling of these data, the Alboran Sea presents one of the highest densities of Cuvier's beaked whales in the world, together with Hawaii and the California current (see a review in Barlow et al., 2006). An abundance of Cuvier's beaked whales has also been estimated for the offshore waters of the European Atlantic (2005–2009, Cañadas et al., 2011) yielding a density of 0.0017 animals/km^2, and for some submarine canyons in the Bay of Biscay (2006–2008; Macleod et al., 2011) with densities of 0.009–0.029 animals/km^2 (CV = 0.37–0.52), both uncorrected.

4.2. Implications for conservation

The knowledge of precise distribution patterns and abundance estimates for *Z. cavirostris* in the Alboran Sea is the key factor to understanding the magnitude of the pressure of different threats that are actually affecting it. This study is the first attempt to deeply address this crucial issue for the conservation of this species in the Alboran Sea, and the whole Mediterranean Sea.

Resightings of individuals in several areas of the world have occurred over multiple seasons and years (as many as 15), suggesting long-term site fidelity in these areas, with increasing evidence that small resident or year-round populations exist in various locations (e.g., Falcone et al., 2009; McSweeney et al., 2007; Revelli et al., 2008; Allen et al., 2011). Therefore, any conservation measure for these animals should be at a small scale at management unit level.

4.2.1. Improvement for Cuvier's beaked whale conservation status

These results have been included in the Marine Strategy document developed in 2012 by the Spanish Ministry of Agriculture, Food and Environment in the framework of the Spanish law on the Protection of the Marine Environment (41/2010 of 29 December 2010) which constitutes the transposition of the Marine Strategy Framework Directive (http://ec.europa.eu/environment/water/marine/directive_en.htm; Directive 2008/56/EC, of 17 June 2008) in the Spanish regulatory system. The establishment of either an MPA for Cuvier's beaked whale in the Alboran Sea, or a Critical Area and a Management Plan derived from the inclusion of Cuvier's beaked whale into the National catalogue of endangered species as "vulnerable" is a decision that has to be taken by the Spanish Government based on the information provided here. Such political decision would provide the legal protection that this species deserves considering the nature and intensity of the threats described above. Furthermore, this area is heavily used also by loggerhead turtles (*Caretta caretta)* and other cetacean species such as *Globicephala melas*, *Stenella coeruleoalba* and *Delphinus delphis*, and less frequently also by *Grampus griseus* and *Physeter macrocepahlus* (Cañadas et al., 2002, 2005; Cañadas and Hammond, 2008). All these species will benefit from the protection of this area.

4.2.2. Monitoring

The first step is to establish the baseline information, such as abundance and habitat preferences, as a scientific reference to guide future conservation actions. Once this is achieved, monitoring needs to become the spine of the management to provide information on the conservation status of the species, and to determine the effectiveness of the Management Plan in achieving its conservation objectives. This achievement needs to be reviewed periodically to adjust the actions to the diverse changes that can occur, in response either to the conservation plan actions themselves or to external factors (Sutherland et al., 2004). This is done through monitoring, in which the suitable indicators for the follow up are established, as well as the tools to obtain them. In this way, the plan has a feedback mechanism which ensures its correct functioning and allows it to adapt to changes in the target species or its environment, or in the face of threats (Margules and Pressey, 2000; Hooker et al., 2011).

Therefore, it is necessary that monitoring cover not only population parameters, to detect trends in its conservation status, but also human activities so that reliable and long-term information on their development is available. This recommendation has also been included in the proposed basis for a Management Plan for the MPA or Critical Area for this species.

It is of fundamental importance that these proposals are taken into account by Governments and interested parties (NATO, Navies, seismic companies, etc.) to avoid further events of mortality caused by intense man-made underwater noise, especially that caused by naval exercises and seismic operations. The enforcement of these kind of regulations has proven very effective in the Canary Islands (Fernandez et al., 2004, 2012), and we hope it will follow suit in the Alboran Sea.

The zoning into 3 areas was created to allow for stratified or even restricted monitoring according to the potential available resources. In the case of small availability of resources, priority should be given to monitor area A, if more is allowed, also area B, etc. The most feasible monitoring actions will be assessed through a power analysis.

4.3. Conclusions

In comparison with the available information, the Alboran Sea is clearly a very important area for Cuvier's beaked whales in the whole Atlantic and Mediterranean, with one of the highest densities recorded (mean density of 0.0054 animals/km^2, CV = 22%). The results of the habitat modeling have been the key tool to design a proposal for a Critical Area or MPA for the Spanish Administration, and the basis for a Management Plan. In this study, it is the first time an availability correction factor specific for distinct survey circumstances has been applied, being a very novel method to improve the estimates. This is a very important issue to be considered, especially for deep divers for which the availability bias may be considerable, and in surveys where a double platform cannot be applied due to logistical reasons. To be effective, enforcement of all resolutions and recommendations made by the different intergovernmental organizations on Cuvier's beaked whale conservation issues must be necessarily based on sound and precise data as we have provided in this paper. Therefore, this whole process is an exportable tool for any species and area in the world, to propose potential conservation areas based on sound science.

Acknowledgements

This analysis was part of the project "Beaked whales and pilot whales in the Alboran Sea (SW Mediterranean): research towards improved science-based mitigation strategies for risks from manmade sound": Grants Number N000140910536 (ALNITAK Marine Research Center) and N000141010709 (ALNILAM Research and Conservation Ltd) funded by ONR (Office for Naval Research) and in collaboration with Woods Hole Oceanographic institution. The conservation implications was part of the project "Identification of the critical areas for ziphiids in the Alboran Sea, delimitation of the Priority Area for Conservation and basis for the development of a management plan", funded by the Secretary for Climate Change, General Directorate of the Natural Environment and Forestry Politics, of the Spanish Ministry of the Environment and Rural and Marine Affairs through the minor contract Number 110910621. Data collected on the *Alliance* in 2008 during SIRENA08 was funded by Strategic Environmental Research and Development Program (SERDP), contract SI-1539. Research was conducted under NMFS permit 981-1707. Data collected on the *Alliance* in 2009 during MED09 was funded by the US Office of Naval Research (ONR), contract N00014-09-10528. Research was conducted under NMFS permit 14241. Data from the Fisheries Patrol Boat was provided by the General Secretariat of Maritime Fisheries. The vessel *Thomas Donagh* (2009) was used during the project "Train the Trainers" funded by ACCOBAMS. Data collected onboard the vessel *Toftevaag*, was possible through several projects under the umbrella of Alnitak, funded by Fundación Biodiversidad, the General Secretariat of Maritime Fisheries, the Ministry of Environment, the Spanish Cetacean Society, Earthwatch, and individual volunteers. Special thanks are due to D. Borchers for his very valuable suggestions and input on how to deal with the availability bias with this data. Thanks also to M. Fitzer for the review and correction of the English writing.

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