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# 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*

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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).

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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 $2 \times 2$ 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 $7 \times 50$ 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.