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Using opportunistic sightings to assess the suitability of Important Marine Mammal Areas (IMMAs) for cetacean conservation in the Western Mediterranean Sea

Uso de avistamientos oportunistas para evaluar la idoneidad de las IMMAs (Áreas Importantes para Mamiferos Marinos) para la conservación los Cetáceos en el Mar Mediterráneo occidental

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Abstract

The Western Mediterranean Sea connects the Atlantic Ocean with the rest of the Mediterranean Sea through the Strait of Gibraltar. The Western Mediterranean Sea is important area for cetaceans and it contains highly productive feeding areas, such as the Pelagos Sanctuary and the South Balearic eddy. The main aim of this study was to assess the suitability of a group of Important Marine Mammal Areas (IMMAs) for the conservation of cetaceans inhabiting this area. There were 398 (46.44%) opportunistic sightings (OS) within a number of IMMAs and 459 (53.56%) sightings outside of IMMAs in this area. Trend surface analysis was used to select the OSs (GPOSs hereafter) most likely to be observed within IMMAs as a function of their geographical position. Significant differences were found between the observed GPOS rate and the expected GPOS rate weighted by the surface area of each IMMA. Specifically, there were more sightings than expected in the Alboran Sea IMMA than in the North West Mediterranean Sea, Slope, and Canyon System IMMA. In the latter area, there were fewer sightings than expected.
Key words: cetacean, collaborative science, distribution, highly migratory animals, Key Biodiversity Areas (KBAs)

Resumen

El Mar Mediterráneo occidental conecta, a través del Estrecho de Gibraltar, el Océano Atlántico con el resto del Mediterráneo, siendo un área importante para los cetáceos. Además, en el Mediterráneo occidental existen importantes áreas de alimentación como el Santuario de Pelagos y el giro Sur de Baleares. El objetivo principal del presente estudio es evaluar la idoneidad de la delimitación de las diferentes IMMAs (Áreas Importantes para Mamíferos Marinos) descritas en el Mediterráneo occidental, para la conservación de los cetáceos que habitan en el área de estudio, a través del análisis de avistamientos oportunistas. Se recogieron 398 avistamientos oportunistas (OS) dentro de algunas IMMAs (46,44%), frente a 459 (53,56%) avistamientos fuera de las IMMAs. Usando un análisis de superficie de tendencia espacial se seleccionaron los OS más probables (GPOS desde ahora) que aparecen dentro de una IMMA en función a su posición geográfica. Se encontraron diferencias significativas entre la frecuencia de GPOS y las esperadas ponderada para la superficie de cada área IMMA. Concretamente el IMMA del Mar de Alborán mostró un número mayor de GPOS de lo esperado, en comparación con el IMMA del Mar Mediterráneo, Pendiente y Cañón del noroeste mediterráneo que mostró un número menor de GPOS de lo esperado.
Palabras clave: Áreas Claves de Biodiversidad (ACB), cetáceos, ciencia colaborativa, distribución, grandes migradores

Introduction

The Western Mediterranean Sea is the most productive subregion of the Mediterranean Sea and is an important area for many cetacean species (Mannocci *et al*. 2018). It forms a transition zone between the Atlantic Ocean and the central Mediterranean Sea, and connects cetacean populations with their origins in the Mediterranean and the Atlantic (Notarbartolo-Di-Sciara 2002). It contains highly productive feeding areas such as the Pelagos Sanctuary within the North Western Mediterranean (Notarbartolo-Di-Sciara *et al*. 2008) and the South Balearic eddy (Font *et al*. 2004).

The International Union for Conservation of Nature (IUCN) defines Key Biodiversity Areas (KBAs) as sites that significantly contribute to the global persistence of biodiversity (IUCN 2016). Such sites include marine ecosystems, some of which have been identified in the Western Mediterranean Sea. The IUCN expert group for Marine Mammals has identified a set of KBAs called Important Marine Mammals Areas (IMMAs), which are defined as "discrete portions of habitat, important to marine mammal species, that have the potential to be delineated and managed for conservation" (Corrigan *et al*. 2014, Hoyt 2015). Table 1 shows the name, surface area (km^2), and main species present in each IMMA in the Western Mediterranean Sea.

The main aim of this study was to use opportunistic sightings (OS) to assess the suitability of the different IMMAs for the conservation of cetaceans inhabiting the Western Mediterranean Sea.

Material and Methods

Since 1997, the Spanish Institute of Oceanography (IEO), under the coordination of J. A. Camiñas, has collected opportunistic sightings of marine turtles, mammals, birds, and other marine species. These data have a heterogeneous origin. The observers can be divided into two groups: (i) scientific personnel on board fishing boats and oceanographic research vessels; and (ii) volunteers with professions or activities related with the sea, such as sailors, scuba divers, and professionals (e.g. skippers and fishermen). The scientific personnel on board had received previous training in the identification of cetaceans, whereas the volunteers had not been trained. Opportunistic sightings provided by the volunteers were included within the unidentified cetacean group unless the OSs were accompanied by photographs or good descriptions. Both groups filled in a purpose-built form that included the coordinates of sightings, species identification (we provided pictures and distinguishing characteristics), group size, cetacean behaviour, boat distance, visibility, wind direction

Table 1. Surface Area (km^2) and Main Species Present in Each IMMA in the Western Mediterranean Sea.

IMMA name	Surface area (km^2)	Main species present (Marine Mammal Habitat 2019)
Alboran Corridor IMMA	20208	Sperm whale (*Physeter macrocephalus*), fin whale (*Balaenoptera physalus*)
Alboran Deep IMMA	22638	Long-finned pilot whales (*Globicephala melas*), sperm whale (*Physeter macrocephalus*), Risso´s dolphin (*Grampus griseus*), Cuvier's beaked whale (*Ziphius cavirostris*)
Alboran Sea IMMA	55906	Common dolphin (*Delphinus delphis*), bottlenose dolphin (*Tursiops truncatus*)
Balearic Islands Shelf and Slope IMMA	22845	Sperm whale (*Physeter macrocephalus*)
North West Mediterranean Sea, Slope and Canyon System IMMA	146170	Sperm whale (*Physeter macrocephalus*), Risso´s dolphin (*Grampus griseus*), fin whale (*Balaenoptera physalus*)

and force, sea surface temperature, and boat characteristics.

We assumed that the OS records were collected using a non-systematic design and that they were mainly collected along vessel routes. Thus, due to the (a) possible lack of randomization in the OSs and (b) the size of the study area (geographical background [GB]), we delimited the appropriate GB by selecting the most probable OSs. Thus, from the total OSs of cetaceans, we selected the most probable set of OSs based on their geographic position. In line with Acevedo *et al.* (2012), we used Trend Surface Analysis (TSA) to assess the probability of each OS according its geographical position. Also in line with these authors, we performed binary stepwise logistic regressions between the occurrence or otherwise of OSs within IMMAs as the target variable. We used different spatial polynomials as independent variables, such as latitude (LAT), longitude (LONG), latitude by longitude (LATLONG), latitude squared (LAT^2), longitude squared ($LONG^2$), latitude squared by longitude squared (LAT^2LONG^2), latitude cubed (LAT^3), and longitude cubed ($LONG^3$). The discrimination capacity of the stepwise logistic regression model was assessed using the area under the receiver operating characteristic curve (ROC), otherwise known as the AUC (Lobo *et al.* 2008).

Based on the results of the binary logistic regression, we selected the most likely OSs (i.e. P> 0.6) independently of the species observed. Secondly, we used a chi-squared test to determine differences between the observed OS rate (GPOSs hereafter) and the expected GPOS rate within IMMAs weighted by the surface area of each IMMA (Table 1).

Results

We recorded a total of 857 OSs, which included eight different cetacean species. Of the total, 398 (46.44%) were recorded inside some of the IMMAs and 459 (53.56%) were recorded outside the IMMAs (Table 2). Figure 1 shows the spatial distribution of all the OSs.

A significant difference was found between geographical distribution and OSs within IMMAs (Omnibus test= 680.972; df= 3; P< 0.0001) according to the model logit (y) function:

$$y=-2.441-0.877*LONG-0.213*LONG^3+0.001*LAT^2LONG^2$$

The model had a very high AUC value (0.952).

We obtained 345 OSs (P> 0.6) according to their geographical position. Of these GPOS, 311 were within an IMMA (i.e. approximately 75% of the OSs were correctly classified by the model).

A significant difference (P< 0.0001) was found between the observed GPOS rate and the expected GPOS rate within IMMAs weighted by the surface area of each IMMA. There were more sightings than expected in the Alboran Sea IMMA than in the North West Mediterranean Sea IMMA.

Discussion

The results of this study suggest that the distribution of cetaceans differs between IMMAs. We found that the Alboran Sea, which lies within the Western Mediterranean Sea, is an important area for cetaceans. This finding is in line with those of previous studies (ACCOBAMS 2019). In contrast, we found an unexpectedly low presence of cetaceans

Table 2. Number of Cetacean Species Observed Inside and Outside the IMMAs.

Species name	Inside IMMA	Outside IMMA
Striped dolphin (*Stenella coeruleoalba*)	109	219
Common dolphin (*Delphinus delphis*)	91	36
Long-finned pilot whales (*Globicephala melas*)	57	38
Sperm whale (*Physeter macrocephalus*)	38	32
Fin whale (*Balaenoptera physalus*)	25	27
Risso´s dolphin (*Grampus griseus*)	21	27
Bottlenose dolphin (*Tursiops truncatus*)	13	29
Killer whale (*Orcinus orca*)	1	1
Unidentified beaked whale	1	1
Unidentified	42	49

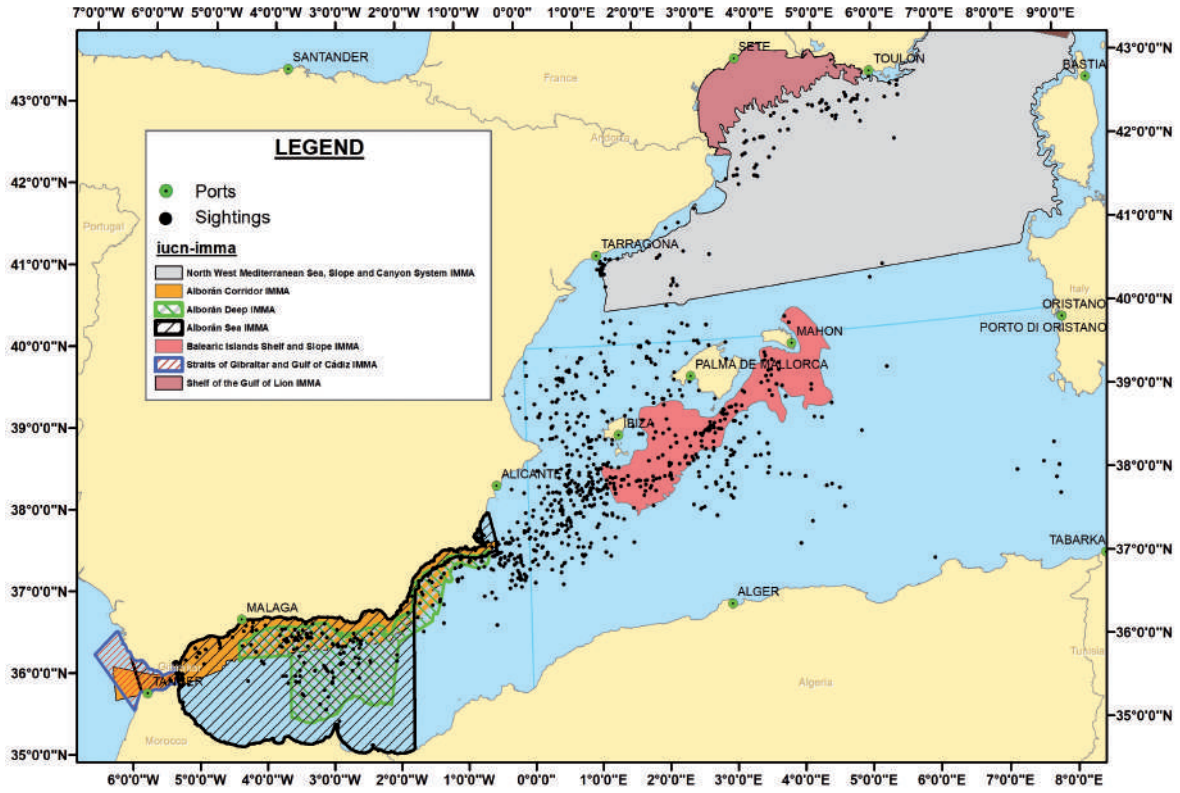

Figure 1. Spatial distribution of IEO opportunistic sightings (1997-2014) by IMMA.

in the North West Mediterranean Sea, Slope, and Canyon System IMMA. However, the present study addressed the presence of cetaceans independently of the species observed. Nevertheless, some IMMAs were delimited according to the presence of vulnerable species, such as in the case of the North Western Mediterranean IMMA and Fin whale *Balaenoptera physalus* OSs. This species is especially important in the North Western Mediterranean Sea (Torreblanca *et al.* 2019). Although the Alboran Deep IMMA has a high presence of Cuvier's beaked whale (*Ziphius cavirostris*), only one beaked whale was sighted in this area but was not identified. Three Mediterranean subpopulations of dolphins (*Delphinus delphis*, *Stenella coeruleoalba* and *Tursiops truncatus*) are listed in the IUCN Redlist (IUCN 2019). Our results showed that there were more OSs of these species in the Alboran Sea than in the rest of the Western Mediterranean. These differences suggest that the Alboran Sea IMMA is well suited to its objective. Thus, based on the diversity of cetaceans sighted, we suggest that some IMMAs are well suited to their conservation, whereas other IMMAs are less well suited to this objective and should have their limits redefined.

Recently, the Spanish Government has established a new Marine Protected Area (MPA) in the "migration corridor for cetaceans" that runs between the north Balearic Islands and the Port of Alicante (BOE 2018). This decision was based on the abundance and distribution of marine mammals, among other environmental factors. This new MPA has been included in the List of Specially Protected Areas of Importance for the Mediterranean (ZEPIM List) within the framework of the Barcelona Convention. However, the present results suggest that the area between the Balearic Islands, the Eastern Iberian Peninsula coast, and the Alboran Sea is also of importance, because a large number of OSs (approximately 49%) of different species were recorded in this area.

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