Strandings of cetaceans and sea turtles in the Alboran Sea and Strait of Gibraltar: a long–term glimpse at the north coast (Spain) and the south coast (Morocco)

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Abstract

Strandings of cetaceans and sea turtles in the Alboran Sea and Strait of Gibraltar: a long–term glimpse at the north coast (Spain) and the south coast (Morocco).— A total of 13 species of cetaceans and three species of marine turtles were found in this study. Data were collected by eight independent and self–regulated stranding networks, providing information about 1,198 marine mammal (10 odontocetii, three mysticetii and one phocidae) and 574 sea turtle stranding events between 1991 and 2008. Trends in the strandings were analysed in relation to species composition and abundance, and their geographic and seasonal distribution. The most abundant species recorded were the striped dolphin and the loggerhead turtle. Some of the strandings, such as the humpback whale, harbour porpoise, hooded seal and olive ridley turtle, were considered 'rare' because their distribution did not match the pattern of the study. When the north and south coasts in the study area were compared, pilot whales stranded more frequently in the north, while delphinid species stranded more in the south coast, and loggerhead turtles stranded more frequently in the north while leatherback turtles stranded more in south coast.

Key words: Strandings, South–western Mediterranean, Distribution, Marine turtle, Cetacean, Conservation.

Resumen

Varamientos de cetáceos y tortugas marinas en el mar de Alborán y el Estrecho de Gibraltar: un vistazo a largo plazo de la costa norte (España) y la costa sur (Marruecos).— En este estudio se registraron un total de 13 especies de cetáceos y tres especies de tortugas marinas, proviniendo los datos de redes de voluntarios que prestan asistencia en los varamientos. Se recogió información de 1.198 mamiferos marinos (10 odontocetos, tres misticetos y un fócido) y 574 tortugas marinas entre los años 1991 y 2008. Se analizaron las tendencias de los varamientos en relación a la composición de especies, su abundancia y su distribución geográfica y estacional. Las especies más comunes fueron el delfín común y la tortuga boba. Algunos de los varamientos, como la ballena jorobada, la marsopa común, la foca de casco o la tortuga olivácea, pueden considerarse "anómalos" puesto que su distribución se escapa a los patrones del estudio. Comparando la costa norte del área de estudio con la sur, los calderones y tortugas bobas vararon con mayor frecuencia en la costa norte, mientras que las especies de delfines y las tortugas laúd vararon con mayor frecuencia en la costa sur.

Palabras clave: Varamientos, Sudoeste mediterráneo, Distribución, Tortuga marina, Cetáceo, Conservación.

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Introduction

Andalucía is a region in the south of Spain where two geographic systems meet: the Gulf of Cádiz (Atlantic Ocean) and the Alboran Sea (Mediterranean Sea). Andalucian coastal waters (south of Spain) are characterized by high biodiversity and productive habitats for commercial species; the area is characterized by nutrient inputs due to upwelling processes in the Gulf of Cadiz (García Lafuente & Ruiz, 2007), the Alboran Sea (Reul et al., 2005), and the water bodies mixing processes at the Strait of Gibraltar (Echevarria et al., 2002). In the Mediterranean Sea, 20 species of cetaceans (Notarbartolo di Sciara, 2002), and three species of marine turtles (Jerez et al., 2010) have been recorded.

Small and large species of cetaceans are distributed in this area not only as migrators (fin whale, *Balaenoptera physalus*, L. 1758; Jonsgård, 1966), but also as resident populations (short–beaked common dolphin, *Delphinus delphis*, L. 1758; Cañadas et al., 2002). Cetaceans are particularly vulnerable to threats deriving from human activities. The Mediterranean Sea supports a high human density in the coastal zone. Chemical pollution, marine debris, climate change, land–based changes (agriculture, industry, tourism, etc.), depletion of marine resources and acoustic contamination may all contribute to the degradation and loss of cetacean habitat. As a result, the natural factors causing cetacean mortality have intensified, such as the morbillivirus epizootic that affected the striped dolphin (*Stenella coeruleoalba*, M. 1833) in 1990 (Aguilar & Borrell, 1994). In addition, collisions with ships and incidental captures by fisheries are sources of direct mortality (Notarbartolo di Sciara, 2002). Cetaceans may also be affected by oil spills by causes such as contamination of their prey items (Moore & Clarke, 2002).

Three of the seven species of marine turtles can still be found in the Mediterranean Sea: the loggerhead sea turtle (*Caretta caretta*, L. 1758), the green turtle (*Chelonia mydas*, L. 1758) and the leatherback turtle (*Dermochelys coriacea*, V. 1761). All of them are currently classified as 'endangered' species (IUCN, 2007). Bycatch in drifting longlines has often been considered to be the main threat for immature loggerhead sea turtles, *C. caretta,* throughout the Mediterranean (Aguilar et al., 1995; Margaritoulis et al., 2003; Lewison et al., 2004; Deflorio et al., 2005; Camiñas et al., 2006).

To be effective, conservation actions require basic biological information about the species. Obtaining abundant estimates is a priority to assess the status of the cetacean species in the Mediterranean Sea and to evaluate the impact that human threats may have on the populations (Gómez de Segura et al., 2006). The information collected could contribute to the development of conservation plans by identifying coastal areas of high importance to cetaceans (Pierce et al., 2010).

To promote the maintenance of biodiversity, most species of cetaceans and marine turtles are protected under the European Union Habitats and Species Directive (92/43/EEC). The Spanish Law on Conservation of Wild areas and Species (4/1989) recognizes the need to protect cetaceans and marine turtles, and establishes the legal basis for their conservation, providing a national catalogue of threatened species. The Law on Conservation of Nature (9/2001) sets out rules for protection, and the Law on Natural Heritage and Biodiversity (42/2007) includes the incorporation of the Habitats Directive into Spanish Law. Royal decree 1727/2007 completes this legislation, establishing measures for the protection of cetacean species in Spanish waters (Pierce et al., 2010).

The monitoring of cetacean strandings in the south of Spain and north of Morocco has been undertaken since 1990 by several non–governmental volunteer organizations through the Marine Animal Stranding Network. Stranding networks are made up of volunteers based at local environmental NGOs, academic associations, and veterinary clinics and also by independent people who respond to or provide professional advice on handling stranding events. Data gathered from stranding events can facilitate management in several ways. It provides an overview of distribution and stranding trends usually observed in the region, it helps monitor stranding patterns (spatial and temporal) by identifying unusual mortality events, and it adds to existing knowledge on distribution of cetaceans already obtained from terrestrial sightings and aerial and shipboard surveys. Furthermore, stranded animals provide information on population movement patterns or residency of a given species (Norman et al., 2004). It may also be possible to draw correlations between beached species and their parent populations in the region (Woodhouse, 1991).

This work links data from eight independent and self–regulated stranding networks in Spain and Morocco, providing information about 1198 cetacean and 574 sea turtle stranding events from both sides of the Gibraltar Strait and the Alboran Sea. Trends in stranding reports are analysed in relation to species composition and abundance, geographic and seasonal distribution and size of stranded animals and gender. No attempts have been made to explain the cause of strandings except in general terms.

Material and methods

Records of marine mammals and turtles stranded on beaches in the study area were collected from several sources; mainly comprised by volunteers from universities and from the NGO Ecologistas en Acción. Data of this study were recorded from 1991 to 2008. Only some punctual data were recorded before that period. The volunteer network is distributed along the coast forming a marine mammal and turtle stranding network, and allowing performance of an effective stranding time–response in the whole area (fig. 1).

The stranding network receives alerts from diverse sources such as state agencies like the police corps and coast guards, an emergency phone number, and also from local residents and tourists who may encounter a dead or injured marine mammal (or turtle).

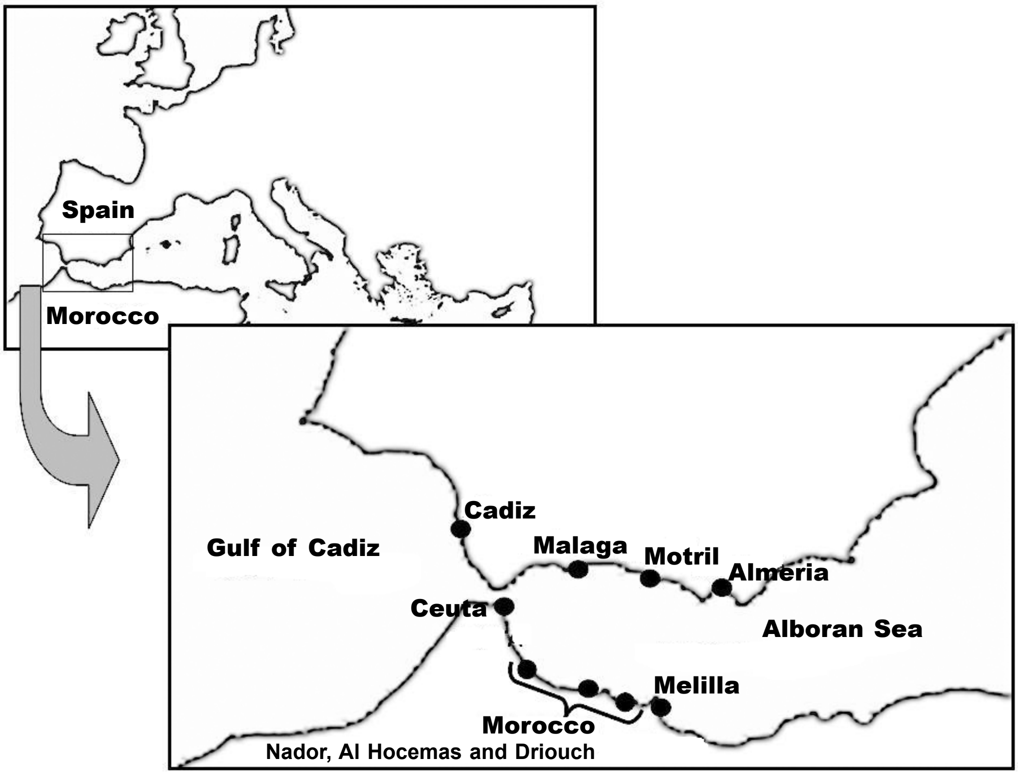

Fig. 1. Study area indicating the location of volunteer groups.

Fig. 1. Área de studio donde aparecen indicadas las localizaciones de los diferentes grupos de voluntarios.

In case of a stranding event, the network immediately sends the closest volunteer (team) out to confirm the report, investigate the animal, collect data about location, beach morphology, weather conditions, sea conditions and physical condition of the animal (alive or dead), to decide the suitable response.

If the animal is still alive, qualified personnel such as veterinarians and staff members from the rescue centres go to the site to assist the animal with medical care and, if necessary, to transport it to the nearest rehabilitation centre. Some of the work teams do not have qualified personnel at all times. However, all the volunteers are trained in marine mammal health assessment and supportive care, so they are able to proceed with keeping the animal in situ, checking vital signs, informing general public about the situation and waiting for the authorised personnel to arrive (DELPHIS, 2005).

When the stranded animal is dead on the beach (the most frequent case), data are collected according to established protocols (Geraci & Lounsbury, 1993): species identification, general measurements (standard length, head height, body width), body state and body condition. If the body is still in a fresh stage, the authorised team personnel proceed to do a necropsy and collect the samples (tissues, teeth, etc.). Samples are stored and/or delivered to university research groups who are carrying out studies on cetacean and marine turtles (*i.e.* teeth for age studies, muscle for isotope analyses for trophic research, etc.).

Species

This paper contains data from thirteen cetacean species, one phocid species, and four marine turtle species: D.d. *Delphinus delphis,* common dolphin; S.c. *Stenella coeruleoalba,* striped dolphin; T.t. *Tursiops truncatus,* bottlenose dolphin; G.m. *Globicephala melas,* pilot whale; G.g. *Grampus griseus,* risso's dolphin; Z.c. *Ziphius cavirostris* Cuvier's beaked whale; B.a. *Balaenoptera acutorostrata,* minke whale; B.p. *Balaenoptera physalus,* fin whale; P.p. *Phocaena phocaena,* harbour porpoise; M.b. *Mesoplodon bidens* Sowerby's beaked whale; P.m. *Physeter macrocephalus* sperm whale; M.n. *Megaptera novaeangliae,* humpback whale; P.c. *Pseudorca crassidens,* false killer whale; C.c. *Cystophora cristata,* hooded seal; D.s.i. Unidentified dolphin (usually D.d. or S.c.); Ca.ca. *Caretta caretta,* loggerhead sea turtle; D.c. *Dermochelys coriacea,* leatherback turtle; C.m. *Chelonia mydas,* green turtle; L.o. *Lepidochelys olivacea,* olive ridley sea turtle.

Table 1. Strandings of cetaceans recorded in the study area: C. Cadiz; A. Almeria; G. Granada; Ce. Ceuta; Me. Melilla; M. Morocco; other cases ([a] *M. novaeangliae*; [b] *P. crassidens*; [c] *P. macrocephalus*; [d] *C. cristata*; [e] *P. phocoena*; [f] *M. bidens*). (* The year is shown between brackets.)

	T. truncatus						*S. coeruleoalba*					
	C	A	G	Ce	Me	M	C	A	G	Ce	Me	M
Other year*					1			7(1990)				1(1967)
1991												
1992												
1993												
1994												
1995										1		
1996												
1997		1						2				
1998								1				
1999		1				1		9		1		
2000						1		7		5		
2001		1	1	2		2		9	1	3		
2002								23	2	4		4
2003			1					24	1	4		115
2004	1	1					1	20		3		
2005	6	1	1		2		13	13	1	13	1	
2006	2	3	2					17	7	6	1	2
2007	1	2					1	38	1	7		
2008	2						1	34		7		

	G. melas						*G. griseus*					
	C	A	G	Ce	Me	M	C	A	G	Ce	Me	M
Other year*				1(1962)						1(1974)		
1991												
1992												
1993												
1994												
1995						1						
1996						1						
1997								1				
1998		2						1				
1999		1		1								
2000		3				3						
2001		2	1					1	1			
2002		4				2		1				
2003		3	1			2		3	2			
2004		2				1		1				
2005	1	3	3			2		1				
2006		2	1	1		1		3	1			
2007	3	9						3				
2008	1	1		1				2				

Tabla 1. Varamientos de cetáceos registrados en el área de estudio: C. Cádiz; A. Almería; G. Granada; Ce. Ceuta; Me. Melilla; M. Marruecos; otros casos ([a] M. novaeangliae; [b] P. crassidens; [c] P. macrocephalus; [d] C. cristata; [e] P. phocoena; [f] M. bidens). (El año se especifica entre paréntesis.)*

D. delphis						Unidentified dolphin						*Z. cavirostris*					
C	A	G	Ce	Me	M	C	A	G	Ce	Me	M	C	A	G	Ce	Me	M
							12(1990)				1(1967)			1(1974)			
							2										
							1										
													1				
					2												
	12		1				2										
	3						6				1						
	3		2		2		6				3						
	6		1				3				4		1				
	7	2					14	4			2			1			
	19	7	2		7		8	2			1		1				
	25	6	3		115		22	2			1						
1	16		4		2	2	20										
6	6	6	8		3	24	21	6		1	7		5				1
	2	11	1		1	1	14	13			9		4				
2	8	1	1			6	27	3	2				5		1		
3	6		1			13	13										

B. physalus						*B. acustorata*						Other cases					
C	A	G	Ce	Me	M	C	A	G	Ce	Me	M	C	A	G	Ce	Me	M
			1(1960)						1(1986)								
															1[c]		
					2								1[c]				
									1								
					1												
					1												
											1						
	2								1								
			1						1								
	1																
			1										1[c]	2[d]	1[c]		1[c]
					1												
	1																
	2					1			1			1[e]	1[c]		1[a]		
1				1	4	1					1		2[c]				
													1[c]	1[d]			
1	1						1		1			1[a],1[b],1[f]	1[c]				
1	2		1									1[e]					1[a]

Table 2. Strandings of turtles recorded in the study area: C. Cadiz; A. Almeria; G. Granada; Ce. Ceuta; Me. Melilla; M. Marruecos; [a] *L. olivacea*; [b] *C. mydas*; [c] Undefined.

Tabla 2. Varamientos de tortugas registrados en el area de studio. (Para las abreviaturas, ver arriba.)

	Caretta caretta						*Dermochelis coriacea*						Other cases		
	C	A	G	Ce	Me	M	C	A	G	Ce	Me	M	[a]C	[b]C	[c]C
1990		3													
1997		2													
1998		13													
1999		5				1		1							
2000		25													
2001		103	21												
2002		21	3			5									
2003		22	3			45									
2004	26	28					7	1							
2005	52	7	3		1	1	1					2	1	1	2
2006	10	10	3	1		2	4	1	1	2	1	3			
2007	16	23	1	26			1			5					2
2008	29	5		8			7	1		6					

Study area

The Alboran Sea is the most western area in the Mediterranean Sea. The western boundary is the Strait of Gibraltar, and the Eastern end is a line drawn from the Gata Cape (Almería) to the African coastline. In the Alboran Sea, upwellings take place, providing nutrient enrichment of the surface waters (Reul et al., 2005), and thus making this area one of the most productive regions in the Mediterranean Sea (Cañadas et al., 2002). Furthermore, it is an important route for migratory species (such as cetaceans and marine turtles) between the Atlantic Ocean and the Mediterranean Sea (DELPHIS, 2009). This makes the Alboran Sea region rich in cetacean and turtle diversity, with stable (Gómez de Segura et al., 2006) and migratory populations (Castellote et al., 2010). The study area is shown in figure 1.

Statistical analysis

Principal component analysis and cluster multivariate analysis were performed using the software Statistica 6.0 (StatSoft®). Principal component analysis (PCA) enabled ascertainment of associations between variables, thus reducing the dimensionality of the data table. This reduction is accomplished by diagonalisation of the correlation matrix data, which transforms the 'n' standardised original variables into 'n' uncorrelated (orthogonal) ones (weighed linear combinations of the original variables) called principal components (PCs). The eigenvalues of the PCs are the measure of their associated variance; the participation of the original variables in the PCs is given by loadings, and the individual transformed observations are called scores. A varimax rotation (VF) allows to 'clean up' the PCs by increasing the participation of the variables with higher contribution, while simultaneously reducing the variables with less contribution. Therefore, the number of original variables contributing to each VF is reduced at the cost of a loss of orthogonality.

Cluster analysis is an unsupervised pattern recognition technique that uncovers intrinsic structure or underlying behaviour of a data set without making prior assumptions about the data. The objective is to classify the variables, or cases (sampling stations) of the system into categories or clusters based on their proximity or similarity. Hierarchical agglomerative cluster analysis was carried out on the standardised data by means of the Wards method of linkage, using Euclidean distances as a measure of similarity (Massart & Kaufman, 1983).

Results and discussion

Cetacea

Table 1 and 2 show the data of strandings obtained from 1991 to 2008 (with some punctual data of strandings occurring before this period) in six areas on the coast of the Alboran Sea and Strait of Gibraltar. A total

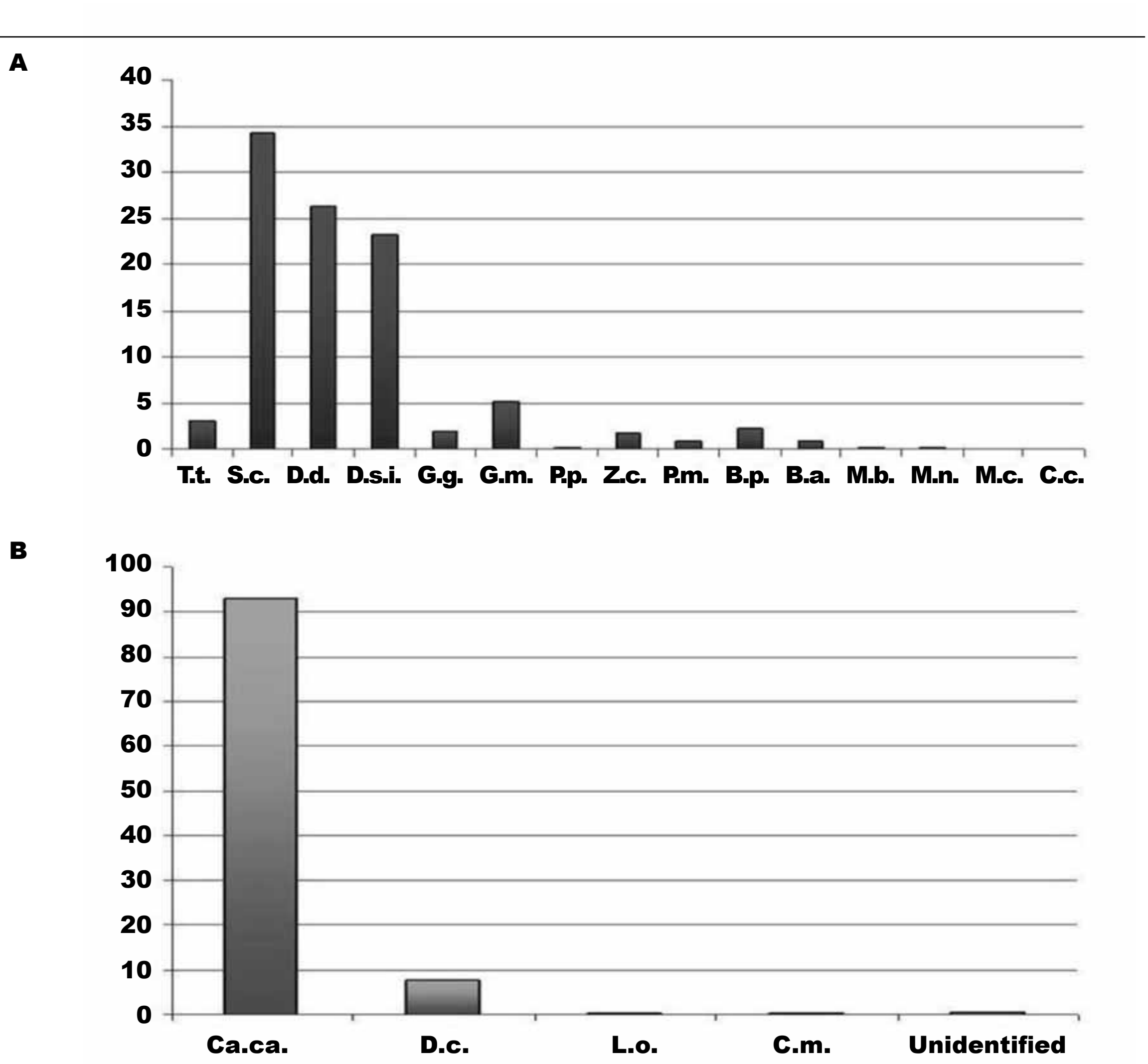

Fig. 2. Percent of strandings for each species: A. Cetaceans; B. Turtles. (Species codes are indicated in Material and methods section.)

Fig. 2. Porcentaje de varamientos por especies: A. Cetáceos; B. Tortugas. (Los códigos de las especies se encuentran indicados en la sección Material and methods.)

of 1,198 cases were recorded for 14 species in the study area (10 odontocetii, three mysticetii and one phocidae). This is the widest compilation of stranding data to date in the study area.

These data may also be used as an approximation to which species are present in the study area, but never as an approximation to a size of population, because the number of beached animals depends on several factors, such as habitat (more or less close to the platform), feeding behaviour, impact factors, etc., and they are not only linked to number of members.

Spatial distribution

Figure 2A shows the percentages of stranding of each species. The data have been standardised with respect to the total number of strandings to avoid errors in comparisons. The species that stranded most frequently were dolphins (striped and common), followed by the pilot whales (Risso's dolphin and long–finned pilot whale).

The striped dolphin was the most abundantly stranded (34.3%) cetacean species in the western Mediterranean. Common dolphins were common two decades ago, but the continuous incidental killings of common dolphins in some areas such as the Alboran Sea and the Strait of Gibraltar may have caused a significant decline even when the population was still abundant (Forcada & Hammond, 1998). In the Andalucian coast, the striped dolphin is catalogued as a 'vulnerable' species, and the common dolphin is catalogued to be at 'critical risk' (Libro Rojo de los Vertebrados Amenazados de Andalucía, 2001); this

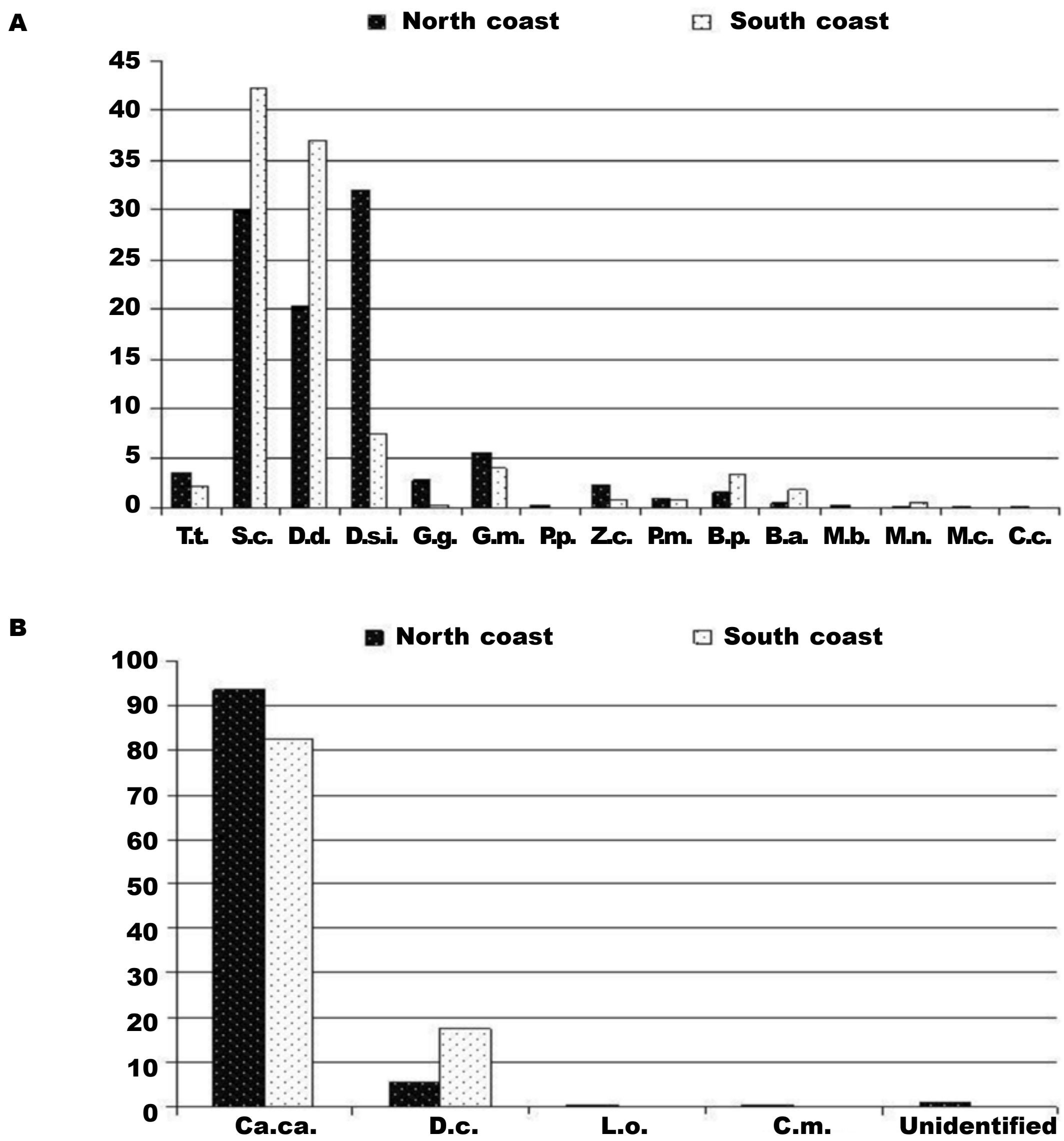

Fig. 3. Comparison between strandings recorded on the north and south coasts. (Species codes are indicated in Material and methods section.)

Fig. 3. Comparación entre varamientos registrados en la costa norte y en la costa sur de la zona de estudio. (Los códigos de las especies se encuentran indicados en la sección Material and methods.)

indicates that the high number of deaths may be important for the conservation of the species.

Other species are uncommonly stranded; however, some strandings were maintained over the years (*e.g. Balaenoptera physalus)*. A significant point to highlight in this study is the first stranding record of the species Sowerby's beaked whale in the Gulf of Cadiz, according to the authors' knowledge and bibliography.

There was a remarkably high occurrence of stranding of pilot whales in Almeria in 2007 (seven cases). According to Fernández et al. (2008) this was due to a morbillivirus epizootic. The increase in strandings of Cuvier's beaked whales in Almeria since 2005 is also interesting.

In 2003, in Morocco, a program was carried out to monitor the dolphins captured in fishing nets. These data are accounted together with the normal data of strandings for that year.

Figures 3a shows a comparison between the strandings that occurred in the north coast, Alboran Sea and Strait of Gibraltar (Andalucian coast), and the south coast (Ceuta and Melilla). The data have been standardized with respect to the total number

Table 3. Factorial analysis with cetacean data. Factor loadings (Varimax norm.); * Marked loadings > 0.700000.

*Tabla 3. Análisis factorial con los datos de cetáceos según las localizaciones. Cargas factoriales (Varimax normalizada); * Cargas marcadas > 0,700000.*

	Principal Components	
Variable	Factor 1	Factor 2
Almeria	0.841953*	0.450509
Granada	0.966429*	0.080902
Cadiz	0.907535*	0.055762
Ceuta	0.439687	0.818370*
Melilla	–0.106394	0.822135*
Morocco	0.697791	0.593599
Eigenvalue	3.882011	1.186645
% Total variance	64.70018	19.77741
Cumulative eigenvalue	3.882011	5.068656

Table 4. Factorial analysis with cetacean data. Factor loadings (Varimax norm.); * Marked loadings > 0.700000.

*Tabla 4. Análisis factorial con los datos de cetáceos según las especies. Cargas factoriales (Varimax normalizada); * Cargas marcadas > 0,700000.*

	Principal Components	
Variable	Factor 1	Factor 2
Tursiops truncatus	0.827994*	0.152275
Stenella coeruleoalba	0.186432	0.960231*
Delphinus delphis	0.012270	0.935003*
Unidentified dolphin	0.891106*	0.410057
Ziphius cavirostris	0.891778*	0.108618
Globicephala melas	0.743288*	0.463590
Grampus griseus	0.275200	0.859294*
Balaenoptera physalus	0.719895*	0.022054
Balaenoptera acustorata	0.685323	–0.198398
Eigenvalue	4.783991	2.134516
% Total variance	53.15546	23.71684
Cumulative eigenvalue	4.783931	6.918507

of strandings on each coast (where total stranding cases on each coast were equal to 100). It was found that for the species with a high number of strandings (dolphins and pilot whales) there was a difference in frequency on the beached animals; dolphins stranded more on the south coast (although the difference was not significant, 89% *vs.* 86%), and pilot whales stranded more on the north coast (8.2% *vs.* 4.3%). This could be due to the distribution patterns in the study area and/or the oceanographic water circulation.

Table 3 shows the results of the factorial analysis (PCA) to establish the determinant factors for location and species variables of the strandings. In the case of locations, there were two principal factors that were related with the north and south coasts. In the case of species, there were two principal factors: one of them related with the two species that stranded more frequently (common and striped dolphin), and the other related to the remaining species.

Figure 4A shows cluster analysis results for the associations between the strandings of the different species. For this analysis, the results of factorial analysis by species (table 4) were taken into consideration. The most important factor in this analysis was the delphinid species, possibly due to their representative number of cases. Two well–differentiated groups were found in the cluster analysis: one of them with the common dolphin, striped dolphin and unidentified dolphin (because it is one of the precedent species), and the other group included the rest of the delphinid species. These two groups were representative of the stranding frequency.

Figure 4B shows the zoning of the study area according to the strandings that occurred. Cluster analysis was carried out using the components of the two factors by species. Figure 4 shows that south zones were highly related and constituted a group. Northern areas did not make a differentiated group, but certain trend in strandings may be noticed. Further studies would be necessary to corroborate that trend.

Temporal trends

Figure 5 shows the temporal trends of strandings of different species (the data have been standardized with respect to the total strandings of each species). These temporal trends were only made for those species with more than 10 recorded animals.

During the study period, most of the strandings occurred in spring; however, data were not analysed by season. Future analysis would be necessary to show whether different seasonal trend patterns exist.

Turtles

Table 2 shows the data obtained for the period from 1991 to 2008 (with some punctual data recorded before this period) in six locations on the coasts of the Alboran Sea and the Strait of Gibraltar. Four species

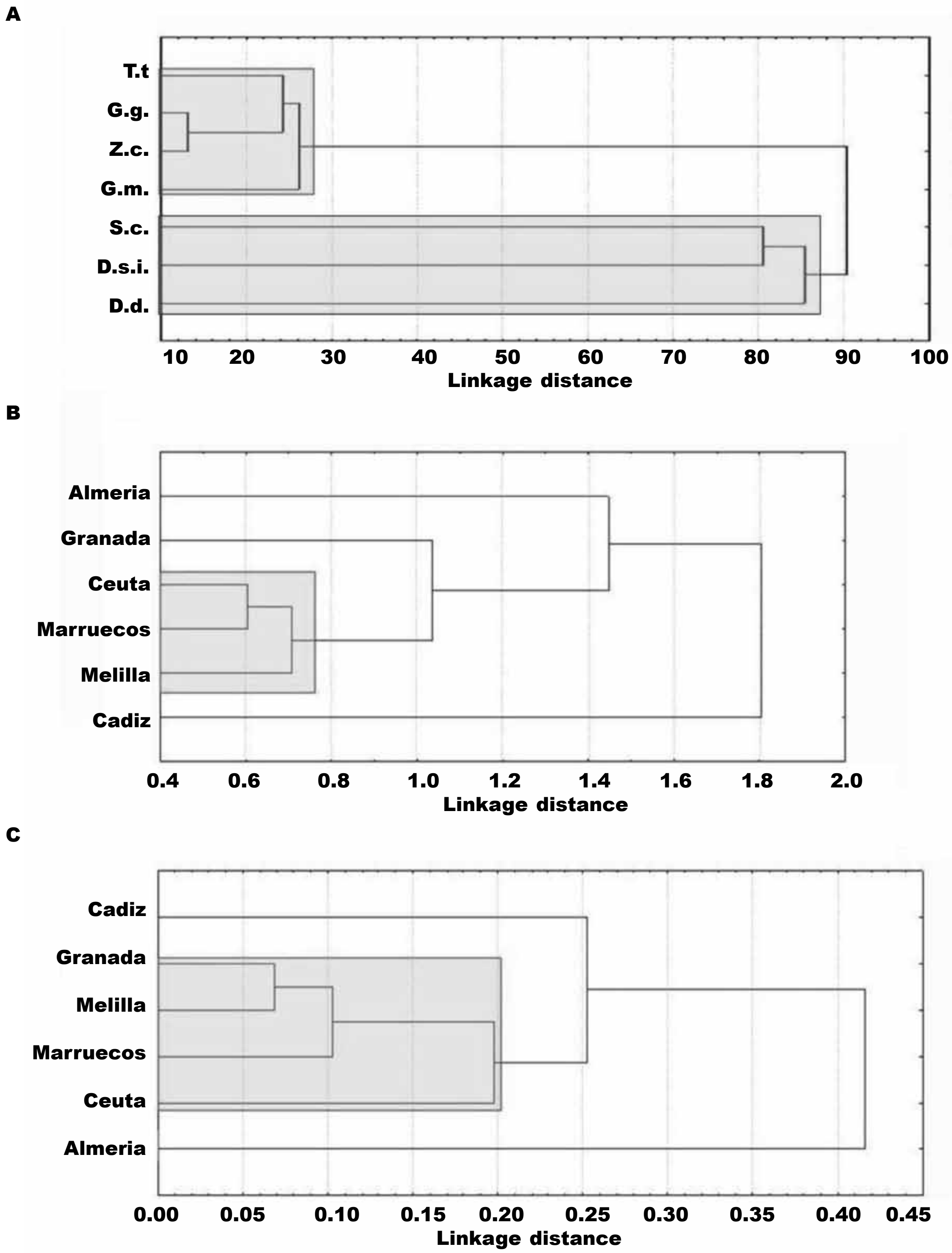

Fig. 4. Cluster analysis results by cetacean species (A); by location, taking cetacean species into consideration (B); and by location, taking turtle species into consideration (C).

Fig. 4. Resultados del análisis de grupos por especies de cetáceos (A); por localización geográfica considerando las especies de cetáceos (B) y por localización geográfica considerando las especies de tortugas (C).

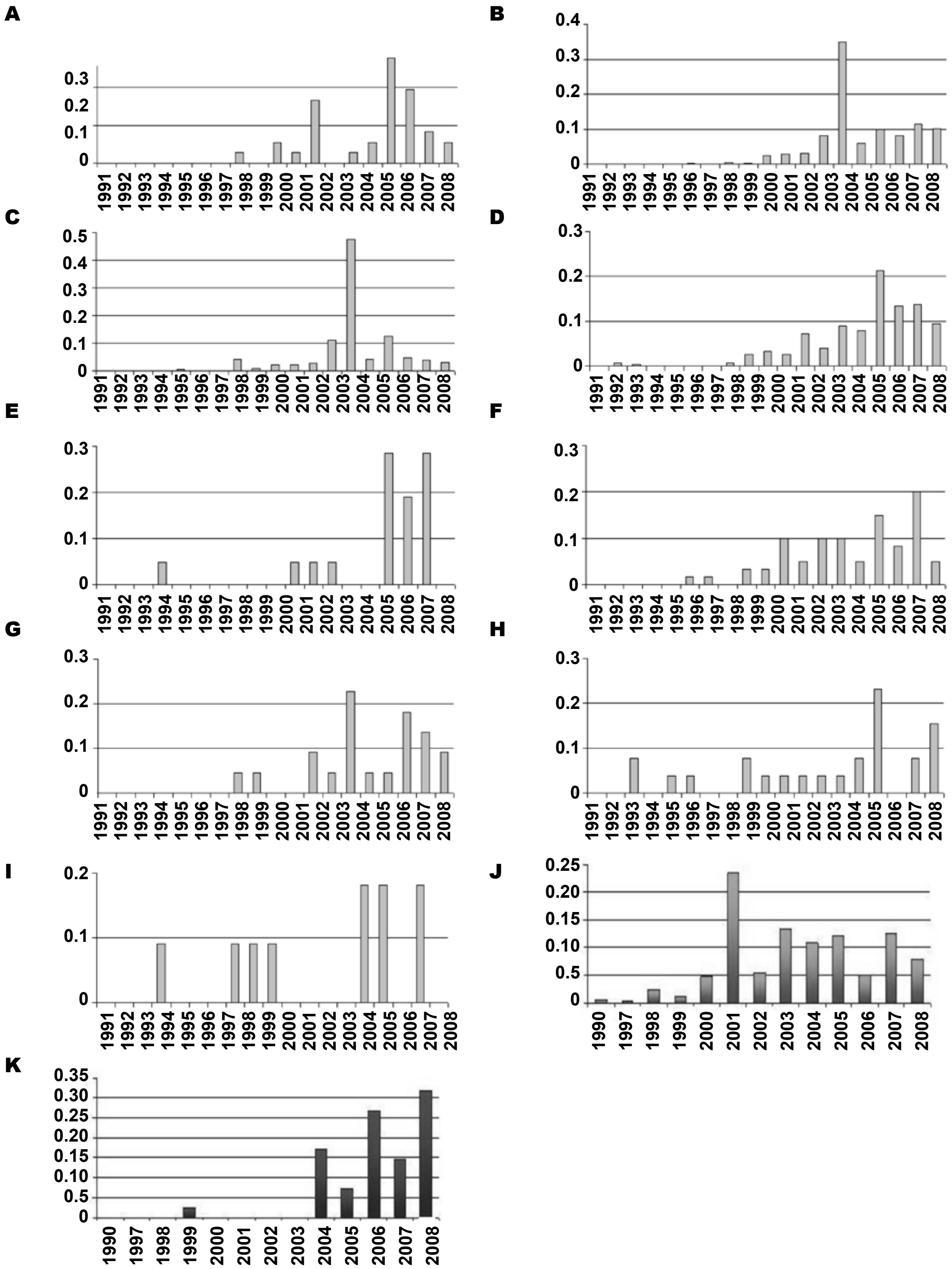

Fig. 5. Temporal trends of strandings in the study area from 1991 to 2008. Data are standardised: A. *T. truncatus*; B. *S. coeruleoalba*; C. *D. delphis*; D. Unidentified dolphin; E. *Z. cavirostris*; F. *G. melas*; G. *G. griseus*; H. *B. physalus*; I. *B. acustorata*; J. *C. caretta*; K. *D. coriacea.*

Fig. 5. Tendencias temporales de los varamientos en la zona de estudio, de 1991 a 2008. Los datos han sido estandarizados: A. T. truncatus*; B.* S. coeruleoalba*; C.* D. delphis*; D. Delfín sin identificar; E.* Z. cavirostris*; F.* G. melas*; G.* G. griseus*; H.* B. physalus*; I.* B. acustorata*; J.* C. caretta*; K.* D. coriacea.

were found stranded in the study area. Data were grouped by location (table 2). A total of 574 animals were recorded and this is also the widest compilation recorded in the area to date. These data may also be used as an approximation of knowledge of the species present in the study area, but not as an approximation of population abundance.

Loggerhead sea turtle and leatherback turtle were the most frequent and abundant species in the Western Mediterranean (92.9% and 7.8% respectively). Two other species were found on the beaches, *C. mydas* and *L. olivacea*. These strandings were considered 'rare' in this area; the first one because the population was located in the Eastern Mediterranean, and the second was an extremely rare stranding because in the Mediterranean Sea it is considered neither a migration nor resident species in the area. Both species only occurred once in the study period.

Spatial distribution

Figure 2B shows the percentages of strandings for each species (data are standardized for comparisons). The species that beached most frequently (more than 90%) was the loggerhead sea turtle, followed by the leatherback turtle.

Figure 3B shows a comparison between the strandings occurring on the north coast and the south coast of the Alboran Sea and the Strait of Gibraltar. Data have been standardized with respect to the total strandings on each coast (total strandings on each coast is equal 100). The results for the most abundant and representative species (loggerhead sea turtle and leatherback turtle) revealed slight spatial difference in frequency of the beached animals: the loggerhead sea turtle stranded more on the north coast (although the difference was not significant, 93.3% *vs.* 82.5) and the leatherback turtle stranded more on the south coast (5.4 *vs.* 17.4%). The reasons for this could be due to the distribution patterns of each species in the study area and/or by the oceanographic characteristics.

In this case, the factorial analysis was not used because there were only two factors (the two main species). Cluster analysis was used to zone the study area according to stranding occurrence (fig. 4C). Cluster analysis was carried out using the two main species. Figure 4C shows how southern areas were highly related and formed a group (including one of the northern areas). The north area did not make a differentiated group, but as found in the cetacean analysis, the cluster analysis showed a certain trend. Further studies would be necessary to contrast that trend.

Temporal trends

Figure 5B shows the temporal trends of the two main species. Data were standardised with respect to the total stranding of each species. These temporal trends were only obtained for those species with more than 10 stranding events. Over the years, most of the strandings occurred in summer; however, data for this study were not analysed by seasons. Future analysis will show whether there are patterns in these trends.

Although little information is available to determine the causes of these deaths, the reason appears to be mainly human induced for the marine turtles, but cetacean deaths were less clear. This paper does not attempt, however, to explain the causes of mortalities.

Conclusions

This study is the widest compilation made to date of cetacean and sea turtles stranded in the Strait of Gibraltar–Alboran Sea: 1,198 strandings of cetaceans and 574 strandings of sea turtles were recorded. Thirteen species of cetaceans, one species of pinnipeds and four species of sea turtle were identified. Two of these species were recorded for the first time in the area of Cadiz (*Mesoplodon bidens* and *Lepidochelys olivacea*). A trend can be observed in the strandings for cetaceans and sea turtles. There are two differentiated areas: the north coast and south coast of the study area. This zoning could be due to the distribution patterns of the species in the study area and/or to oceanographic characteristics. Further studies with future data will provide information to ascertain whether the observed variations were isolated events or part of a defined zoning. For cetaceans, specifically in the case of delphinids, two groups can be defined according to stranding occurrence; one of them is formed of common and striped dolphins, and the other group consists of the remaining delphinids. The first group was by far the most important group of cetaceans that stranded in the study area.

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References

Aguilar, A. & Borrell, A., 1994. Abnormally high polychlorinated biphenyl levels in striped dolphin (*Stenella coeruleoalba*) affected by the 1990–1992 Mediterranean epizootic. *Science of The Total Environment*, 154: 237–247.

Aguilar, R., Mas, J. & Pastor, X., 1995. Impact of the Spanish swordfish longline fisheries on the loggerhead sea turtle *Caretta caretta* population in the Western Mediterranean. In: *Proceedings of the 12th Annual Workshop on Sea Turtle biology and Conservation* NOAA Tech Memo NMFS–SEFSC, 361: 1–6 (J. I. Richardson & T. H. Richardson, Eds.). Gland, Switzerland.

Camiñas, J. A., Báez, J. C., Valeiras, Z. & Real, R., 2006. Differential loggerhead by–catch and direct mortality due to surface longlines according to boat

strata and gear type. *Scientia Marina*, 70: 661–665.
Cañadas, A., Sagarminaga, R. & García–Tiscar, S., 2002. Cetacean distribution related with depth and slope in the Mediterranean waters off southern Spain. *Deep–Sea Research I,* 49: 2053–2073.
Castellote, M., Clark, C. W. & Lammers, M. O., 2010. Population identity and migration movements of fin whales (*Balanoptera physalus*) in the Mediterranean Sea and Strait of Gibraltar. *Journal of Cetacean Research and Management,* SC/62/SD2.
Deflorio, M., Aprea, A., Corriero, A., Santamaría, N. & De Metrio, G., 2005. Incidental captures of sea turtles by swordfish and albacore longlines in the Ionian sea. *Fisheries Science*, 71: 1010–1018.
DELPHIS, 2005. *Informe de varamientos. Cetáceos y Tortugas marinas en la provincia de Cádiz 2004–2005*.
– 2009. *Informe de varamientos. Cetáceos y Tortugas marinas en la provincia de Cádiz. 2003–2009*. http://www.ecologistasenaccion.org/IMG/pdf_Informe_de_varamientos_de_Cadiz_2003–2009.pdf
Echevarría, F., García Lafuente, J., Bruno, M., Gorsky, G., Goutx, M., González, N., García, C. M., Gómez, F., Vargas, J. M., Picheral, M., Striby, L., Varela, M., Alonso, J. J., Reul, A., Cózar, A., Prieto, L., Sarhan, T., Plaza, F. & Jiménez–Gómez, F., 2002. Physical–biological coupling in the Strait of Gibraltar. *Deep–Sea Research Part II: Topical Studies in Oceanography*, 49(19): 4115–4130.
Fernández, A., Esperon, F., Herraez, P., Espinosa, A., Clavel, C., Bernabe, A., Sanchez–Vizcaino, J., Verborgh, P., De Stephanis, R., Toledano, F. & Bayon, A., 2008. Morbillivirus and Pilot Whale Deaths, Mediterranean Sea. *Emerging Infectious Diseases*, 14: 792–794.
Forcada, J. & Hammond, P., 1998. Geographical variation in abundance of striped and common dolphins of the western Mediterranean. *Journal of Sea Research,* 39: 313–325.
García–Lafuente, J. & Ruiz, J., 2007. The Gulf of Cádiz pelagic ecosystem: A review. *Progress in Oceanography*, 74(2–3): 228–251.
Geraci, J. R. & Lounsbury, V. J., 1993. *Marine mammals ashore: a field guide for strandings*. Texas A & M Univ. Sea Grant College Program. Galveston, TX. 305.
Gómez de Segura, A., Crespo, E. A., Pedraza, S. N., Hammond, P. S. & Raga, J. A., 2006. Abundance of small cetaceans in waters of the central Spanish Mediterranean. *Marine Biology*, 150(1): 149–160.
IUCN, 2007. *International Union for the Conservation of Nature and Natural Resource Red List of Threatened Species.*
Jerez, S., Motas, M., Cánovas, R. A., Talavera, J., Almela, R. M. & Del Río, A. B., 2010. Accumulation and tissue distribution of heavy metals and essential elements in loggerhead turtles (*Caretta caretta*) from Spanish Mediterranean coastline of Murcia. *Chemosphere*, 78(3): 256–264.
Jonsgård, A., 1966. The distribution of Balaenopteridae in the North Atlantic Ocean. In: *Whales, dolphins and porpoises*: 114–124 (K. S. Norris, Ed.). Univ. California Press, Berkeley.
Lewison, R. K., Freeman, S. A. & Crowder, L. R., 2004. Quantifying the effects of fisheries on threatened species: the impact of pelagic longlines on loggerhead and leatherback sea turtles. *Ecological Letters*, 7: 221–231.
Libro Rojo de los Vertebrados Amenazados de Andalucía, 2001. Consejeria de Medio Ambiente, Junta de Andalucía, Spain, 2001.
Margaritoulis, D., Argano, R., Baran, I., Bentivegna, F., Bradai, M. N., Camiñas, J. A., Casale, P., De Metrio, G., Demetropoulos, A., Gerosa, G., Godley, B. J., Haddoud, D. A., Houghton, J., Laurent, L. & Lazar, B., 2003 Loggerhead turtles in the Mediterranean sea: present knowledge and conservation perspectives. In: *Loggerhead sea turtles*: 175–198 (A. B. Bolten & B. E. Witherington, Eds.). Smithsonian Books, Washington, DC.
Massart, D. L. & Kaufman, L., 1983. *Interpretation of analytical chemical data by the use of cluster analysis.* Wiley, New York.
Moore, S. E. & Clarke, J. T., 2002. Potential impact of offshore human activities on grey whales. *Journal of Cetacean Research and Management*, 4(1): 19–25.
Norman, S. A., Bowlby, C. E., Brancato, M. S., Calambokidis, J., Duffield, D., Gearin, P., Gornall, T. A., Gosho, M. E., Hanson, B., Hodder, J., Jeffries, S. J., Lagerquist, B., Lambourn, D. M., Mate, B., Norberg, B., Osborne, R. W., Rash, J. A., Riemer, S. & Scordino, J., 2004. Cetacean strandings in Oregon and Washington between 1930 and 2002. *Journal of Cetacean Research and Management,* 6(1): 87–99.
Notarbartolo di Sciara, G., 2002. Cetacean species occurring in the Mediterranean and Black Seas. In: *Cetaceans of the Mediterranean and Black Seas: state of knowledge and conservation strategies*. (G. Notarbartolo di Sciara, Ed.) A report to the ACCOBAMS Secretariat, Monaco, February 2002. Section, 3: 17.
Pierce, G. J., Caldas, M., Cedeira, J., Santos, M. B., Llavona, A., Covelo, P., Martinez, G., Torres, J., Sacau, M. & López, A., 2010. Trends in cetacean sightings along the Galician coast, north–west Spain, 2003–2007, and inferences about cetacean habitat preferences. *Journal of the Marine Biological Association of the United Kingdom*, 90(8): 1–14.
Reul, A., Rodríguez, V., Jiménez–Gómez, F., Blanco, J. M., Bautista, B., Sarhan, T., Guerrero, F., Ruíz, J. & García–Lafuente, J., 2005. Variability in the spatio–temporal distribution and size–structure of phytoplankton across an upwelling area in the NW–Alboran Sea, (W–Mediterranean). *Continental Shelf Research*, 25(5–6): 589–608.
Woodhouse, C. D., 1991. Marine mammal beachings as indicators of population events. Marine mammal strandings in the United States. *Proceedings of the second marine mammal stranding workshop. US Dep. Commer.*, NOAA Tech. Rep. NMFS, 98: 111–115.