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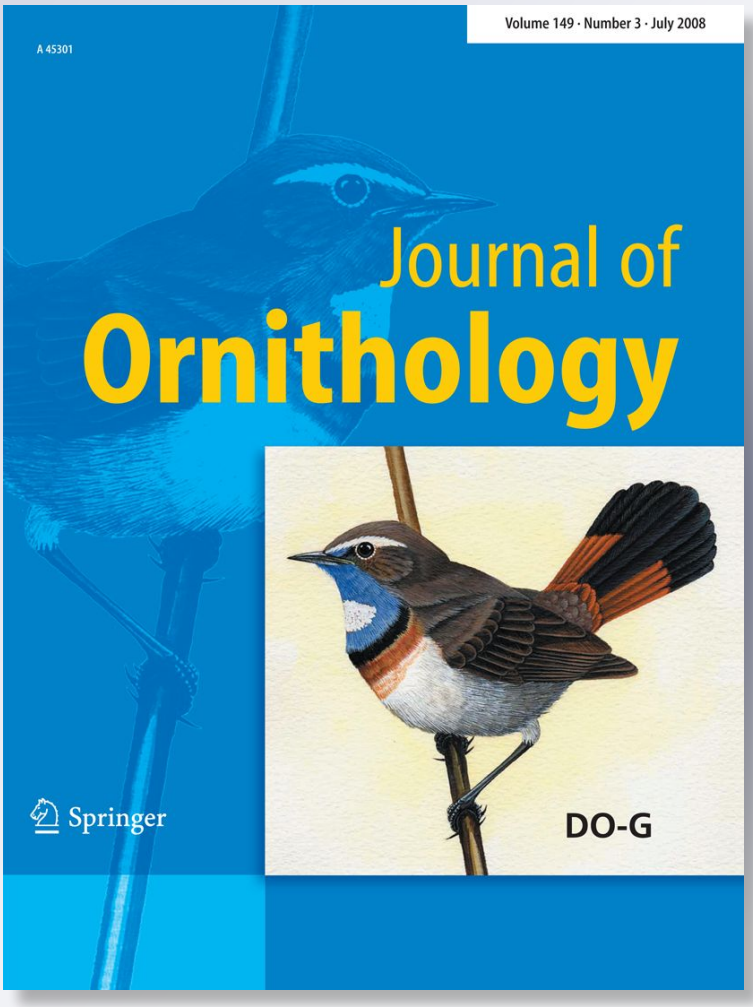

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ORIGINAL ARTICLE

Mediterranean Gulls *Larus melanocephalus* wintering along the Mediterranean Iberian coast: numbers and activity rhythms in the species' main winter quarters

Albert Cama · Pere Josa · Joan Ferrer-Obiol · José Manuel Arcos

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Abstract Knowledge of the winter distribution of the Mediterranean Gull *Larus melanocephalus* is poor. The limited and geographically patchy data on the species' winter distribution is of concern because current estimates of the wintering population do not agree with those for the global breeding population. We assessed the winter distribution and abundance patterns of this gull in Mediterranean Iberia, a historically important wintering area for which recent data are lacking. Information for the whole study area was obtained from a systematic boat-based survey over the continental shelf in 2003. Then, particular attention was paid to St. Jordi Gulf, a known hotspot for the species, where we studied the temporal patterns in abundance throughout the winter months, and daily activity rhythms, between 2005–2006 and 2008–2009. To set our results in a global context, the available information of the winter range of the species was collated and synthesised. The results indicate that the Iberian Mediterranean coast is the main winter quarters of the species. An average population of ca. 41,000 individuals was present in the area, representing approximately half the 86,311 individuals (range 50,747–121,875) recorded across the whole of the species' winter range. At the local scale, the St. Jordi Gulf represented the most important area for the species in winter, with an average of around 17,000 individuals and peaks of up to 45,000 in early and late winter. Thus, we argue that this is a globally important area for the species. Daily rhythms involve birds moving between offshore feeding areas during the day (where they largely consume fishing discards) to inland olive crops and bathing and drinking sites (Riudecanyes reservoir) in the afternoon, and finally to coastal roost sites at dusk (Cambrils). Given the global significance of the population wintering in this small area, measures to protect Riudecanyes reservoir and the marine and inland foraging areas should be implemented as a matter of priority. Further research is needed to assess the actual population size of the Mediterranean Gull global population and its conservation status, as well as the threats that the species faces.

Keywords Foraging ecology · Important bird area (IBA) · Population estimates · Seabird · Winter distribution

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Zusammenfassung Nur wenig ist von der Winter-Verbreitung der Schwarzkopfmöwen *Larus melanocephalus* bekannt; dabei sind gerade die begrenzten und geographisch nur sporadischen Verbreitungs-Daten dieser Art im Winter deshalb speziell interessant, weil die derzeitigen Schätzungen der Winterpopulation nicht zu denen der globalen Brutpopulation passen. Wir untersuchten das Vorkommen und Verteilungsmuster dieser Möwenart entlang der spanischen Mittelmeerküste, einem für sie schon seit langem wichtigen Überwinterungsgebiet. Die Daten wurden 2003 in einer systematischen Erhebung über dem Kontinentalschelf von einem Boot aus gesammelt. Daran anschließend wurde der Golf von St. Jordi, ein bekannter hotspot dieser Spezies, genauer untersucht: das zeitliche Verteilungsmuster der Möwen sowie ihr täglicher Aktivitätsrhythmus von Juni 2005 bis September 2008. Um unsere Ergebnisse in einen größeren Zusammenhang zu setzen, wurden alle anderen verfügbaren Informationen über die Winterverbreitung dieser Art gesammelt und vergleichbar gemacht. Die Ergebnisse legen nahe, dass die spanische Mittelmeerküste das Winterquartier dieser Möwenart ist. In dieser Gegend betrug die durchschnittliche Population ca. 41,000 Individuen, was etwa die Hälfte der 86.311 Individuen ausmacht (50.747 - 121.875), die über alle Winterquartiere dieser Art hinweg gezählt wurden. Im örtlichen Maßstab erwies sich der Golf von St. Jordi mit im Schnitt 17,000 beobachteten Individuen und Spitzen von bis zu 45,000 im frühen und späten Winter als wichtigstes Überwinterungsgebiet für diese Spezies. Deshalb postulieren wir, dass dies eine auch im globalen Maßstab wichtige Gegend für diese Art ist. Die Tagesrhythmen ergaben sich aus den Bewegungen der Vögel von den Futterplätzen auf dem Meer, wo sie sich tagsüber hauptsächlich von weggeworfenen Fischabfällen ernähren, zu den Olivenhainen und Bade- und Trink-Gelegenheiten (das Wasserreservoir von Riudecanyes) am Nachmittag und schließlich gegen Sonnenuntergang zu den Schlafplätzen an der Küste (Cambrils). In Anbetracht der globalen Bedeutung dieser in einem solch kleinen Areal überwinternden Population, sollten Maßnahmen zum Schutz des Riudecanyes-Reservoires und der Gebiete im Meer und auf dem Land, in denen die Vögel Nahrung aufnehmen, mit Priorität ergriffen werden. Weitere Untersuchungen sind notwendig, um die tatsächliche globale Populationsgröße der Schwarzkopfmöwen sowie die sie bedrohenden Faktoren und den aktuellen Stand ihres Schutzes festzustellen.

Introduction

The Mediterranean Gull (*Larus melanocephalus*) is a Western Palaearctic species whose breeding population is concentrated (ca. 90%) in the northern coasts of the Black sea (mainly Ukraine). However, this gull has expanded north-westwards in recent decades, and currently shows a widespread and patchy distribution across most of Europe, including the North Sea and Atlantic coasts (Cramp and Simmons 2004; Zielinska et al. 2007). Its conservation status is considered secure, based on a large and stable overall population that is estimated at around 120,000–320,000 breeding pairs and 360,000–960,000 individuals (BirdLife International 2004).

Historically, in winter, the species has been recorded in the Mediterranean, especially the Nile delta, the central Mediterranean (including the Ionian Sea, Sicily, Malta, Tunisia and Libya), and the Gulf of Lion and the Mediterranean coast of Iberia (Cramp and Simmons 2004). In recent decades, due to the expansion of the species towards the NW, some areas of the European Atlantic coast have also become important as winter quarters (Poot and Flamant 2006). However, information on winter distribution and population estimates is patchy, and the last global reviews yielded total figures well below those expected from the breeding population estimates (about 12,000–40,000 in Europe; BirdLife International 2004). This could be due to either a lack of survey effort and/or patchy survey coverage, as some of the most important wintering grounds have not been systematically surveyed for more than 20 years. Of particular concern is the Mediterranean Iberia region. Here, ca. 50,000 individuals were counted in 1985 (Carrera 1988), but, other than some local studies (Hidalgo 1992), no detailed information has since been published. The paucity of data meant that the region was not mentioned in the most recent review of European wintering populations (BirdLife International 2004).

In this paper, we aim to provide updated and detailed information on the population numbers and distribution patterns of the Mediterranean Gull in Mediterranean Iberia. Particular attention was paid to the main wintering area for this gull in the region, the St. Jordi Gulf (NE Spain). A review of published and unpublished information on wintering numbers across the species' winter range was also conducted, to put our empirical survey results in a wider context. Finally, information on the foraging ecology of the Mediterranean Gulls was also collected, namely distribution patterns and foraging strategies at sea (across Mediterranean Iberia), daily activity rhythms and alternation of foraging habitats around the St. Jordi Gulf. Information on these issues for the winter period is scarce (Cramp and Simmons 2004), but knowledge of them is critical for the conservation of the species.

Methods

Study areas

Local scale: roost and pre-roost censuses in the St. Jordi Gulf

At the local scale, the study was focused in the north of St. Jordi Gulf (41°03′N, 1°02′E), NE Spain (Fig. 1). This area supported large numbers of Mediterranean Gulls in the 1980s (Ferrer et al. 1986; Carrera 1988). During the 2005–2006, 2006–2007, 2007–2008 and 2008–2009 winters, censuses were carried out twice a month between 15 October and 31 March at the Riudecanyes reservoir (afternoon pre-roost) and off Cambrils beach (evening/night roost). These sites were selected after preliminary observations on the activity rhythms of the gulls. At Riudecanyes, gulls were counted as they left. The Cambrils roost censuses were conducted while the gulls arrived from inland prior to roosting at sea on inshore waters. All censuses were conducted under equal fishing conditions (weekdays, with trawling activity) by a single observer.

Medium scale: at-sea surveys across the Mediterranean Iberian shelf

Numbers of Mediterranean Gulls wintering across the Iberian Mediterranean coast were estimated by means of systematic surveys at sea, tacking advantage of the ECOMED03 cruise onboard R/V "Cornide de Saavedra" (Spanish Institute of Oceanography, IEO). This cruise covered the whole Mediterranean Iberian shelf (Fig. 1), from NE to SW, from 25 November to 18 December 2003. Systematic transects were surveyed over the continental shelf (as delimited by the 200 m isobath) and uppermost shelf slope, perpendicular to the coastline and spaced between 4 and 8 nautical miles apart, depending on the width of the shelf. In total, 1,829.5 km were surveyed (Table 1). Four areas were differentiated according to their topographic and hydrographic features (see Estrada 1996; Salat 1996; Millot and Taupier-Letage 2005): (I) Alboran Sea—Vera Gulf, (II) Alicante-Valencia, (III) Ebro delta-Columbretes islands (which encompasses the St. Jordi Gulf), and (IV) central-north Catalonia (Fig. 1). The Alboran Sea and the Vera Gulf are characterised by a narrow continental shelf, as well as by the direct influence of Atlantic surface waters, which lead to local areas of relatively high productivity. The continental shelf broadens in the Alicante area, where surface inflowing Atlantic and outflowing Mediterranean waters meet around the Ibiza Sill. Around the Ebro Delta and the Columbretes Islands, the continental shelf is widest (up to 70 km), and the area is particularly productive as a combined effect of the Liguro-Provençal-Catalan slope front, the strong NW winds and outflow from the Ebro River. In the north Catalonia area, the continental shelf becomes narrow again and indented

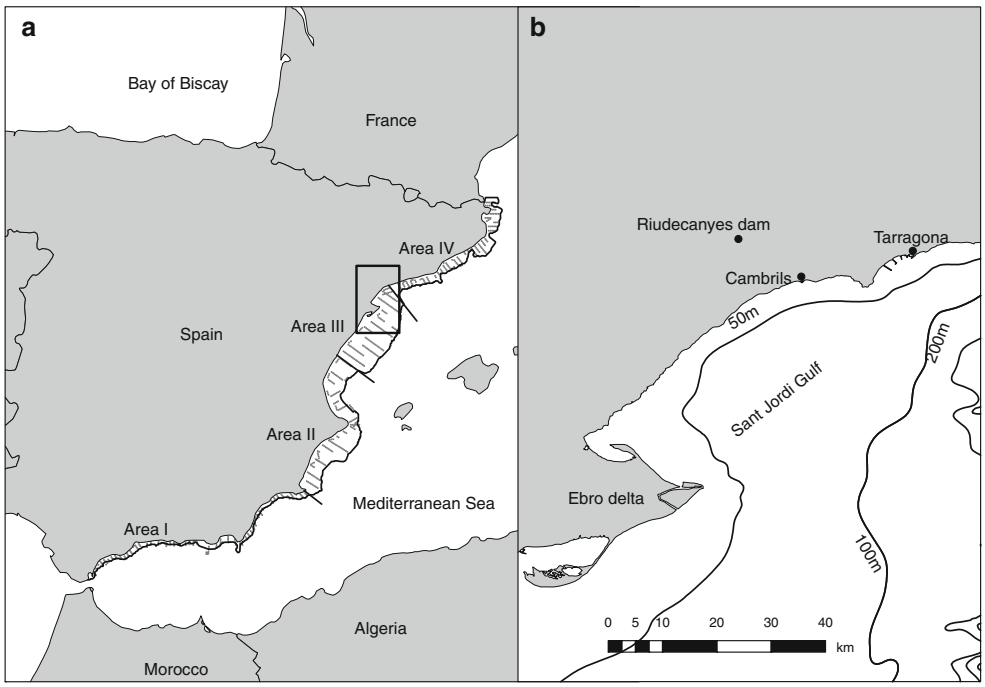

Fig. 1 Area covered by the at-sea surveys (**a**) and location of the Mediterranean Gull (*Larus melanocephalus*) Cambrils roost and Riudecanyes pre-roost (**b**). The areas of the at-sea survey divisions, the survey bins and the 200 m depth isobath are represented in (**a**)

Table 1 Effort devoted to the at sea surveys, according to the area: (I) Alboran Sea—Vera Gulf, (II) Alicante-Valencia area, (III) Ebro delta-Columbretes islands, and (IV) central-north Catalonia

	Area I	Area II	Area III		Area IV	Total
			St. Jordi Gulf	Total		
Number of 10-min bins	161	153	45	141	134	589
Length (km)	498	476.2	139.8	440	415.3	1,829.5
Covered area (km^2)	248	218.8	54.9	163.9	199.3	830
Total area (km^2)	4,230	9,255	2,000	8,180	4,140	25,805

For the Ebro-delta Columbretes area the information is also specified for the St. Jordi Gulf

by marine canyons, with the Liguro-Provençal-Catalan front flowing southwestwards along the continental slope (Salat et al. 2002; Arin et al. 2005). Survey effort for each of these areas is shown in the Table 1.

All observations were made by the same observer (J.M.A.) using standardized strip-transect techniques (Tasker et al. 1984) adapted to match the specific conditions of the study area (SEO/Birdlife 2007). A 300-m strip-width transect band was used, at one or both sides of the vessel (i.e. 600-m band) depending on the observation conditions (visibility and wind). Snapshot counts were used to census flying birds (Tasker et al. 1984). All Mediterranean Gulls observed within the survey transect band were recorded, and data were clumped into 10-min bins, which were georeferenced and for which a density value was obtained (birds observed/km^2). In addition, all feeding events observed were recorded (feeding strategy and number of birds involved). Feeding strategies were categorised as follows: (1) scavenging (mainly consumption of trawling discards); (2) direct capture of small pelagic fish; and (3) capture of small pelagic fish through the interaction with sub-surface predators (cetaceans/tuna). The distance to the coast and the sea depth of the sampled areas were also recorded to assess topographic habitat preferences at sea.

For each area, the number of birds present at sea was inferred from the estimated densities registered there during the ECOMED surveys and extrapolated to the total surface of the area. Since density data were highly variable between transect bins, and did not fit a normal distribution, 95% confidence intervals were estimated using bootstrapping (Efron and Tibshirani 1991; Quinn and Keough 2002). For our analyses, we assumed that fishing activity is likely to be an important factor determining Mediterranean Gull presence and density at sea. On this basis, we applied a Generalized Linear Model (GLM) with a negative binomial distribution, with fishing activity (weekdays vs. weekend days) used as the predictor variable. The significance of this model was assessed using a likelihood ratio test (LRT).

Global wintering population estimates

Published and unpublished data on winter counts were reviewed to update the wintering distribution patterns and population size. The available information from throughout the potential wintering range of the Mediterranean Gull (Cramp and Simmons 2004) was collected (Fig. 2), from Scandinavia to Senegal (N–SW), from Macaronesia to Iran (W–E) and from Kazakhstan to Kenya (NE–SE). Minimum and maximum recorded figures during the most recent 10 mid-winters (December and January) are given and data are grouped in sub-regions to facilitate their treatment and representation (see Fig. 2).

Results

Local scale: roost and pre-roost censuses

Mediterranean Gull figures at Riudecanyes (pre-roost) and Cambrils seaside (roost) along the winter period are shown in Fig. 3. Riudecanyes turned out to be important at the end of the season, when it held most of the birds present in the St. Jordi Gulf area. Cambrils showed a bimodal distribution, with maxima in both early (December) and late winter (February–March) of up to 45,000 individuals. Despite this general pattern, the figures showed high inter-annual variability, especially for maximum counts.

Medium scale: at sea surveys across the Mediterranean Iberian shelf

GLM indicated that the density of Mediterranean Gulls was not significantly influenced by fishing activity (LRT, P value 0.098), and therefore data from both weekdays and weekends were analysed together to assess distribution patterns and numbers at sea. An average of 41,501 Mediterranean Gulls was estimated from the at sea surveys across the Mediterranean Iberian shelf (95% Confidence Interval 24,435–61,297; Table 2). The distribution of the

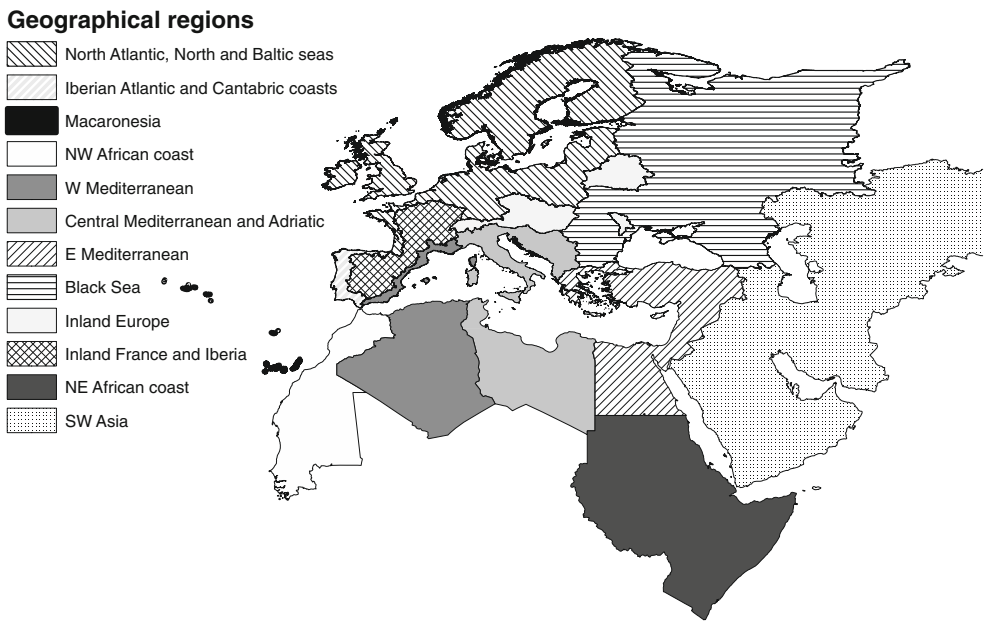

Fig. 2 Potential wintering range of the Mediterranean Gull, where an exhaustive revision work was conducted to assess winter population estimates. Data were grouped into 12 sub-regions, as detailed in the map

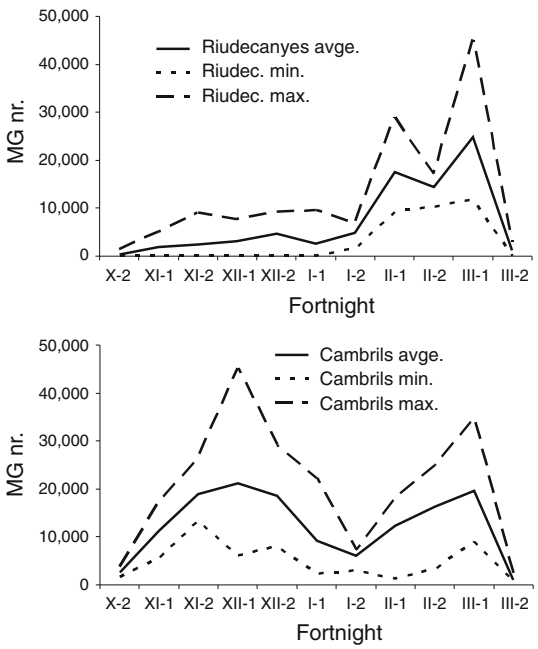

Fig. 3 Half-month number of Mediterranean Gulls at the Riudecanyes reservoir pre-roost and at the Cambrils roost during winters 2005–2006 to 2008–2009. Minimum (*Min.*), maximum (*Max.*) and average (*Avge.*) values are shown. The fortnights are represented by the month in *Roman numerals* and the half of the month (first or second) in *Arabic numerals*

birds was highly non-random, with about 75% of the individuals concentrated in the Ebro delta–Columbretes area (31,384 individuals in average), most of them within the St. Jordi Gulf (17,192 individuals). Correspondingly, density in the Ebro delta–Columbretes area was also the highest (average densities of 3.8 birds/km^2), with a maximum in the St. Jordi Gulf (8.6 birds/km^2). The other areas showed relatively low densities of Mediterranean Gulls, although larger numbers were estimated in the western Alboran Sea and in central Catalonia (Table 2, Fig. 4).

Global wintering population estimation

The detailed results and data sources used in this review are detailed in Table S1 (Electronic Supplementary material). The global winter population of the Mediterranean Gull was estimated at about 86,311 individuals (range 50,747–121,875; Table 3). Data suggest that the majority (82%) of birds winter in the Mediterranean Sea, with the maximum figures occurring in the west (primarily off the Iberian coasts, which support 48% of the global population) and decreasing towards the east. To a lesser extent, significant numbers also occur in southern Portugal (7,000–8,000 individuals) and the Atlantic coast of France (ca. 4,500 individuals). No substantial figures were recorded in the rest of the distribution range.

Winter behaviour, activity rhythms and habitat use of the Mediterranean Gull in the NW Mediterranean

At sea, Mediterranean Gulls dispersed over the whole continental shelf (0–200 m depth), and were also present in lower densities over the continental slope (Fig. 5). This pattern was constant across the whole Mediterranean

Table 2 Estimated winter population of Mediterranean gulls across the Mediterranean Iberian shelf

Area	At sea density		At sea number of individuals		Onshore number of individuals	Source
	Mean	95% CI	Mean	95% CI		
I. Alboran Sea-Vera Gulf	0.67	0.39–1.03	2,840	1,643–4,358	?–9,000	(García-Barcelona 2009; Antonio Fuentes and Antonio Hernández, pers. com.)
II. Alicante-valencia	0.20	0.11–0.30	1,857	1,028–2,778	Few hundreds	(J.Ignacio Dies and Roque Belenguer, pers. com.)
III. Ebro delta-columbretes						
St. Jordi Gulf	8.60	4.41–13.57	17,192	8,815–27,143	14,600–20,900	(Vidal et al. 2006; Vidal et al. 2007; Tirado 2009; own data)
Total	3.83	2.32–5.58	31,325	18,975–45,661	20,600–33,400	
IV. Central-North Catalonia	1.32	0.67–2.05	5,479	2,789–8,499	3,500; 6,150	(Gutiérrez 2004, 2007)
Total			41,501	24,435–61,297	24,100–48,550	

The results inferred from at sea survey data (mean ± 95% Confidence Interval, *CI*) are shown for each of the four areas considered and the total. For the Ebro delta–Columbretes area, the information is also specified for the St. Jordi Gulf. At-sea data are compared with mid-winter onshore censuses

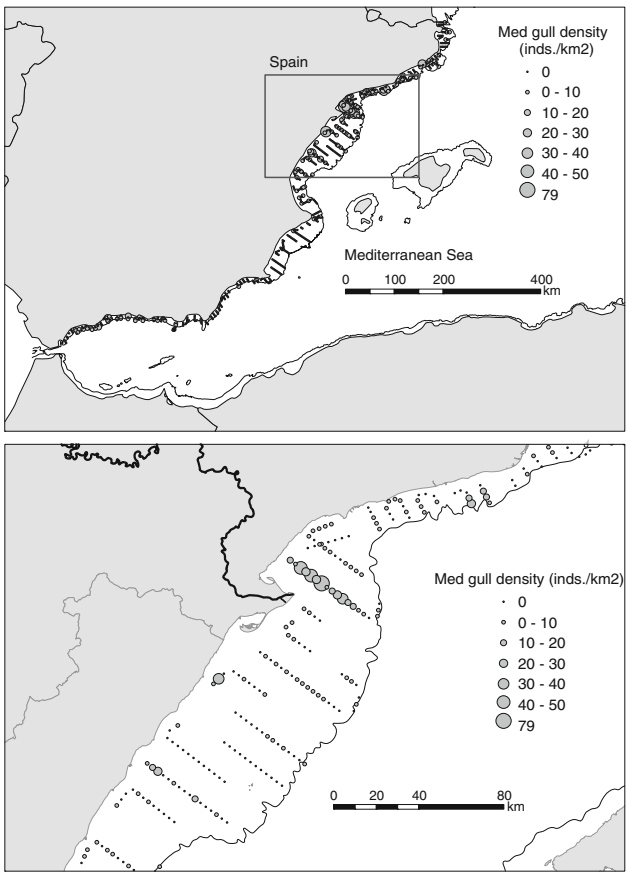

Fig. 4 Mediterranean Gull (*Med gull*) distribution along the Iberian Mediterranean shelf derived from 2003 winter at-sea surveys. The results for the Ebro delta sea shelf are shown in detail. The *circles* are proportional to the number of birds per square kilometre (ind./km^2) estimated at each 10-min bin. The 200 m isobath limit is shown

Iberian shelf, even for the areas where the shelf is at its widest. Thus, in the most important area for the species (i.e. the Ebro delta–Columbretes area) birds were frequent up to 35 nautical miles (n.m. hereafter) offshore, although the highest densities were recorded between 5 and 10 n.m. from the coast (Fig. 5). At sea, many birds were seen associating with trawlers; e.g. feeding on fishing discards was the main foraging strategy observed (78.6% of the feeding cases, involving 87.5% of the feeding individuals). The capture of small pelagic fish, either directly or in association with sub-surface predators (cetaceans and/or tuna), was less frequently observed (10.0 and 2.5% of individuals, respectively).

According to the coastal and inland observations in the St. Jordi Gulf, the Mediterranean Gulls moved up to 10 km inland to feed on fallen olives, once the fishing activity ceased (strictly at 1630 hours each day). In agreement with these observations, hundreds of pellets collected in Cambrils beach and the neighbouring Tarragona harbour contained stones (from up to 25 olives per pellets). Birds then moved to Riudecanyes reservoir (pre-roost), as the census counts there showed (see Fig. 4). Finally, in the late evening (dusk), they moved to roost on the sea off the town of Cambrils.

Discussion

Winter distribution

The overall review of winter counts suggest a global population of about 86,000 Mediterranean Gulls (range about 50,000–120,000). Within this context, the western Mediterranean would become the main wintering area for the species, holding an average population of ca. 46,000 individuals. These results are consistent with those from previous surveys (Bermejo et al. 1986; Carrera 1988), and represent over 50% of the known total winter population. The second wintering area of importance would be the central Mediterranean, as already described by Cramp and

Table 3 Minimum (*Min.*) and Maximum (*Max.*) Mediterranean Gull mid winter population estimates in the different sub-regions considered within its distribution range

Region	Min.	Max.	Average	%	Breeding population
North Atlantic, North and Baltic seas	4,882	4,952	4,917	5.7	2,120–2,583
Iberian Atlantic and Cantabric coasts	8,306	10,545	9,426	10.9	0
Macaronesia	0	0	0	0	0
NW African coast	27	691	359	0.4	0
W Mediterranean	27,930	64,792	46,361	53.7	2,230–2,303
Central Mediterranean and Adriatic	5,863	31,230	18,547	21.5	2,010–2,030
E Mediterranean	3,520	8,815	6,168	7.1	5,900–6,850
Black Sea	206	827	517	0.6	103,120–310,275
Inland Europe	0	2	1	0.0	160–402
Inland France and Iberia	13	20	17	0.0	0
NE African coast	0	0	0	0.0	0
SW Asia	0	1	1	0.0	250–250
Total	50,747	121,875	86,311	100	115,790–324,693

Average values have been used to estimate the percentage of birds wintering in each sub-region. Original data and references are shown in the Table of the Supplementary material. Breeding population in any of these regions is given according to Birdlife International (2004)

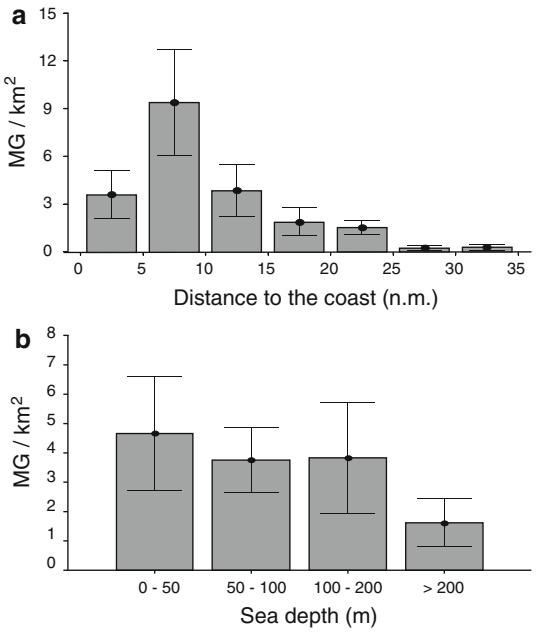

Fig. 5 Density of Mediterranean Gulls (MG/km^2) depending on the distance to the coast (in nautical miles, n.m.) in Ebro delta–Columbretes sector (**a**) and density of Mediterranean in function of sea depth (m) in the Mediterranean Iberian shelf (**b**) during the 2003 winter at-sea surveys. The results show the average value and the standard deviation

Simmons (2004), with an average population of ca. 18,500 individuals. The Atlantic and Cantabrian regions of Iberia, particularly southern Portugal, are also becoming an important wintering area (7,000–8,000 inds.), probably related with the increase of the Atlantic breeding population (Poot and Flamant 2006). The fourth wintering area of importance, the eastern Mediterranean, supports an average winter population of ca. 6,200 individuals. The wintering population in Egypt was expected to be larger (Cramp and Simmons 2004), suggesting that a change in the species' distribution has occurred. It was not possible to find information for some peripheral countries. Russia is the largest country without accurate information about the wintering numbers of the species, although apparently only small numbers of birds winter along the Black sea coasts (Yudin and Firsova 2002). Given the partially pelagic behaviour of the species in some areas during the winter (Baccetti and Smart 1999; Poot 2003), birds could go partly underestimated/unnoticed in some areas. This may be the case for the area around south Italy, Malta and Tunisia (as suggested by Baccetti and Smart 1999) or for the Iberian and Moroccan Atlantic waters. Nonetheless, our results suggest that the birds visit coastal areas on a regular (daily) basis, and therefore should be detected at some point by coastal observers. In fact, this has been reported in other areas in the Mediterranean Sea (Baccetti and Smart 1999; García-Barcelona 2009) and in the Atlantic (Poot 2003).

Mediterranean Iberia wintering population

Population estimates based on at-sea surveys showed that Mediterranean Iberia holds most of the western Mediterranean wintering population, and therefore is the main known wintering area for the Mediterranean Gull worldwide, with an average estimated number of 41,500 individuals in November–December 2003 (i.e. almost 50% of the global population according to winter data). Results of

the at-sea surveys revealed that, within this region, the species concentrates primarily in the Ebro delta–Columbretes area, which is in agreement with the 1980s data from coastal censuses (Bermejo et al. 1986; Carrera 1988). This area hosted more than 75% of the individuals in the region, largely concentrated in the north of the Ebro delta (St. Jordi Gulf). The remaining 25% of Mediterranean Gulls in the region were mostly concentrated in two secondary strongholds: central Catalonia, between Tarragona and Barcelona, and the western-central Alborán Sea.

Data from at-sea surveys were compared with available onshore censuses to find mismatches (see Table 2; and also Arcos et al. 2009). The main difference was found in the Alboran sea, where up to 9,000 birds have been reported in December and early January (García-Barcelona 2009). These differences may respond either to either inter-annual or within-season differences, or also to specific weather conditions that could lead to unusual local concentrations of birds (resulting in peak figures from coastal counts). Information in future years will be needed to assess if these counts are truly unusual in midwinter. Until then, the survey presented here is the most comprehensive approach to assess population numbers and distribution patterns of the Mediterranean Gull along the Mediterranean Iberian shelf in recent decades.

St. Jordi Gulf wintering population

The St. Jordi Gulf turned out to be the most important hotspot for the Mediterranean Gull within Mediterranean Iberia, with at-sea survey data indicating an estimated figure of 17,000 individuals in early winter. Local censuses from the coastal observation points confirmed the significance of the area, which can reach maximums of up to 45,000 birds during the migration periods. These data confirm the relevance of this site, already suggested by previous workers (Bermejo et al. 1986; Carrera 1988). The average estimated figure in the area from the at-sea censuses in early winter (ca. 17,000 individuals) is similar to the highest estimate for Italy, the second most important country for the species in winter (Baccetti and Smart 1999). The differences throughout the winter, with a minimum in midwinter and peaks in the early and late winter, are likely to be caused by a movement of birds to the south of St. Jordi Gulf, as noted by Hidalgo (1992). However, an immigration of birds wintering elsewhere should also occur since the mid-winter figures in the St. Jordi gulf roosts (14,600–20,900; Table 2), are much lower than the maximums detected then.

The cause of such a marked local concentrations is most likely related to a number of factors (Isenmann 1975; Carrera 1987; Baccetti and Smart 1999): (1) important spawning and nursery grounds for small pelagic fish occur here (Palomera et al. 2007; Bellido et al. 2008); (2) important fishing ports are present (Cambrils and l'Ametlla de mar, 2,000 and 2,500 mT catches/year, respectively; IDESCAT 2010a); (3) a freshwater reservoir 10 km inland (Riudecanyes reservoir) provides a bathing site; and (4) farmlands with olive groves covering most (over 2,700 ha) of the inland area (IDESCAT 2010b).

Winter activity rhythms and foraging ecology: alternation of offshore and terrestrial resources

The present study shows alternate use of offshore and inshore resources during the day by the bulk of the Mediterranean Gulls, with marine activity during most of the day, inland activity in the afternoon (the latter at least in the St. Jordi Gulf) and marine roosting at night. Our results do not describe the behaviour of the Mediterranean Gulls in all their winter range, but are likely representative of a very significant fraction of the global population, at least of those birds wintering in the Mediterranean. Indeed, during the day, birds occurred in high densities over the continental shelf and upper slope off the whole of Mediterranean Iberia.

At sea, birds made extensive use of fishing discards, as suggested before for the species (Arcos 2001; Arcos et al. 2001; Poot 2003; Poot and Flamant 2006) and described for other seabird species both locally (Oro and Ruiz 1997; Oro 1999; Arcos 2001; Arcos et al. 2001, 2008; Arcos and Oro 2002) and worldwide (see review in Tasker et al. 2000). Inland observations and regurgitation analyses showed that the Mediterranean Gulls move inland in the St. Jordi Gulf to feed on olives, as described previously in the same area (Ferrer et al. 1986; Carrera 1987), the Alborán sea (García-Barcelona 2009) and Tunis (Baccetti and Smart 1999). Although the quantitative importance of this feeding resource is still unknown, it occurs every day and involves the bulk of the birds scavenging off Cambrils and those coming from other fishing harbours. The olives provide a high energetic content but also a number of important compounds: polyphenols, vitamin E and pigments such as carotenoids and anthocyanins (Roca and Mínguez-Mosquera 2001, 2003; Guimet et al. 2005). These compounds are accepted to be positive for the birds' health and productivity (Blount 2004; Goñi et al. 2007; Brenes et al. 2008; Catoni et al. 2008; Schaefer et al. 2008). After attending olive corps, Mediterranean Gulls visit a freshwater reservoir (Riudecanyes) where they concentrate for drinking and bathing as described before for the species (Isenmann 1975; Paterson 1990; Cramp and Simmons 2004). This behaviour occurs all through the season but is in late winter when most (< ca. 45,000) of the birds in the area visit the reservoir (see Fig. 3).

Conservation considerations

Results presented here confirm the apparent mismatch between breeding and wintering estimates of the Mediterranean Gull global population pointed out by Wetlands International (2006). Even if some information gaps biased the winter estimation, the difference with the breeding population estimate is large enough (about 50,000–120,000 wintering vs. 360,000–960,000 breeding individuals) to suggest that the breeding population could have been overestimated. This is in agreement with Ardamatskaya (1999), who presented estimates below 60,000 breeding pairs for the northern Black Sea (including Ukraine) since the late 1980s, contrary to the official estimates of 100,000–300,000 pairs. This has important implications for the conservation of the Mediterranean Gull. For example, it indicates that information from the breeding stronghold cannot be relied upon to infer population trends, which are key to assessing the conservation status of the species. Notably, the positive trend recorded for the newly colonised areas throughout Western Europe could give a false impression of health if this is not matched by the main population in Ukraine.

Against this background, Mediterranean Iberia gains importance for the conservation of the Mediterranean Gull. Three marine Important Bird Areas (IBAs) have been recently identified in the region for this and other species (Arcos et al. 2009), coinciding with the three hotspots identified in this paper. These sites will play a key role in the conservation of the species, and therefore deserve urgent legal protection through their designation as Special Protection Areas (SPAs) within the EC Natura 2000 framework. Of particular importance is the St. Jordi Gulf area, where the maximum recorded figure (45,000 individuals) would represent 4.5–12.5% of the official global population (BirdLife International 2004). However, if the breeding population has been overestimated, then the St. Jordi Gulf could support up to ca. 50% of the world wintering population. Riudecanyes reservoir deserves particular attention, given the high concentrations of birds at a single location (up to 45,000 individuals). This site should be identified as an IBA, and ultimately designated as a SPA. Moreover, Ramsar 5 and 6 criteria for identifying Wetlands of International Interest (Ramsar 2006) are satisfied by Riudecanyes. Thus, we argue for the designation of this as a RAMSAR area.

Threats to the Mediterranean Gull during the winter in the Iberian Mediterranean region, and particularly in the St. Jordi Gulf area, require careful assessment. Potential threats include inland habitat loss due to housing and industrial development, fishing bycatch, heavy metal accumulation and the risk of oil spills due to the high trade activity of the neighbour harbour of Tarragona (Arcos 2004; Arcos et al. 2009).

Overall, research undertaken for this paper has raised a number of questions that deserve further attention: What is the actual population size of the Mediterranean Gull? Is its conservation status really secure? Do Mediterranean gulls have similar marine behaviour through most of their wintering range? Are the daily activity rhythms described here similar to those in other wintering areas? What is the precise value of olives for the species? What is the origin of the birds wintering in Mediterranean Iberia? Do birds spend the winter in the same area, or do they change their location as the season progresses? What are the threats that the species face in the wintering grounds? These questions need to be addressed in order to improve our understanding of the ecology and distribution patterns of the species. The continuity of extensive ringing programmes, studies using remote tracking technologies and analyses using stable isotopes are likely to prove critical in this understanding, and ultimately contribute to the species' conservation.

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References

Arcos JM (2001) Foraging ecology of seabirds at sea: significance of commercial fisheries in the NW mediterranan. PHD Tesis. Universitat de Barcelona. Barcelona. http://www.tdx.cesca.es/TESIS_UB/AVAILABLE/TDX-0219102-114337//TOL38.pdf. Accessed 12 May 2010

Arcos JM (2004) Gavina capnegra *Larus melanocephalus*. In: Estrada J, Pedrocchi V, Brotons L, Herrando S (eds) Atles dels ocells

nidificants de Catalunya 1999–2002. Institut Català d'Ornitologia (ICO)/Lynx Edicions, Barcelona, pp 230–231
Arcos JM, Oro D (2002) Significance of nocturnal purse-seine fisheries for seabirds: a case study off the Ebro Delta (NW Mediterranean). Mar Biol 141:277–286
Arcos JM, Oro D, Sol D (2001) Competition between the yelow-legged gull *Larus cachinnans* and Audouin's gull *Larus audouinii* associated with commercial fishing vessels: the influence of season and fishing fleet. Mar Biol 319:807–816
Arcos JM, Louzao M, Oro D (2008) Fishery ecosystem impacts and management in the Mediterranean: seabirds point of view. In: Nielsen JL, Dodson JJ, Friedman K, Hamon TR, Musick J, Verspoor E (eds) Reconciling fisheries with conservation: proceedings of the fourth world fisheries congres. American Fisheries Society, Symposium 49, Bethesda, Maryland
Arcos JM, Bécares J, Rodriguez B, Ruiz A (2009) Areas importantes para la conservación de aves marinas en España. LIFE04NAT/ES/000049-Sociedad Española de Ornitología (SEO/Birdlife), Madrid. http://www.seo.org/avesmarinas/flash.html. Accessed 12 May 2010
Ardamatskaya TB (1999) Breeding sites of Mediterranean gull *Larus melanocephalus* in the countries of the former Soviet Union. In: Meininger P, Hoogendoorn W, Flamant R, Raevel P (eds) Proceedings of the 1st Mediterraneal Gull meeting, Le Portel, Pas-de-Calais, France. Econum, Bailleul, pp 19–24
Arin L, Estrada M, Salat J, Cruzado A (2005) Spatio-temporal variability of size fractioned phytoplankton on the shelf adjacent to the Ebro River (NW Mediterranean). Cont Shelf Res 25:1081–1095
Baccetti N, Smart M (1999) On the midwinter population size and distribution of Mediterranean gull *Larus melanocephalus* in Italy and Tunisia. In: Meininger P, Hoogendoorn W, Flamant R, Raevel P (eds) Proceedings of the 1st Mediterraneal Gull Meeting, Le Portel, Pas-de-Calais, France. Econum, Bailleul, pp 91–95
Bellido JM, Brown AM, Valavanis VD, Giráldez A, Pierce GJ, Iglesias M, Palialexis A (2008) Identifying essential fish habitat for small pelagic species in Spanish Mediterranean waters. Hydrobiologia 612:171–184
Bermejo A, Carrera E, de Juana E, Teixeira AM (1986) Primer censo general de gaviotas y charranes (*Laridae*) invernantes en la Península Ibérica (Enero de 1984). Ardeola 33:47–68
BirdLife International (2004) Birds in Europe: population estimates, trends and conservation status. BirdLife Int. (BirdLife Int. Series No. 12), Cambridge, UK
Blount JD (2004) Carotenoids and life-history evolution in animals. Arch Biochem Biophys 430:10–15
Brenes A, Viveros A, Goñi I, Centeno C, Sáyago-Ayerdy SG, Arija I, Saura-Calixto F (2008) Effect of grape pomace concentrate and vitamin E on digestability and antioxidant in chickens. Poult Sci 87:307–316
Carrera E (1987) Gavines. Cyan, Barcelona
Carrera E (1988) Invernada de gaviotas y charranes en la Península Ibérica. In: Tellería JL (ed) Invernada de aves en la Península Ibérica. Sociedad Española de Ornitología, Madrid, pp 79–95
Catoni C, Peters A, Schaefer HM (2008) Life history trade-offs are influenced by the diversity, availability and interactions of dietary antioxidants. Anim Behav 76:1107–1119
Cramp S, Simmons KEL (2004) Birds of the Western Paleartic on interactive DVD-ROM. Birdguides. Oxford University Press, Oxford
Efron B, Tibshirani R (1991) Statistical data analysis in the computer age. Science 253:390–395
Estrada M (1996) Primary production in the North Western Mediterranean. Sci Mar 60:55–64
Ferrer X, Martínez-Vilalta A, Muntaner J (1986) Història Natural dels Països Catalans. Vol. 12 Ocells. Enciclopèdia Catalana S.A, Barcelona
García-Barcelona S (2009) La invernada de la gaviota cabecinegra en la provincia de Málaga. Quercus 286:14–23
Goñi I, Brenes A, Centeno C, Viveros A, Saura-Calixto F, Rebolé A, Arija I, Estevez R (2007) Effect of dietary grape pomace and vitamin E on growth performance, nutrient digestibility, and susceptibility to meat lipid oxidation in chickens. Poult Sci 86:508–516
Guimet F, Ferré J, Boqué R (2005) Study of oils from the protected denomination of origin "Siurana" using excitation-emission fluorescence spectroscopy and three-way methods of analysis. Grasas y Aceites 56:292–297
Gutiérrez R (2004) Resultats del cens hivernal de gavines (*Laridae*) de gener de 2004 a Catalunya. http://www.gencat.net/mediamb/rndelta/gavines2004.pdf
Gutiérrez R (2007) Cens internacional d'ocells aquàtics i marins hivernants a Catalunya de gener de 2006. http://www.gencat.net/mediamb/rndelta/censcat06.pdf
Hidalgo JM (1992) La invernada de la gaviota cabecinegra en el Golfo de St. Jordi (Tarragona). Butll P N Delta De l'Ebre 7:10–13
IDESCAT (2010a) Anuari estadístic de Catalunya. Capítol 6. Agricultura Ramaderia i pesca. Institu d'Estadística de Catalunya. Generalitat de Catalunya. http://www.idescat.net/cat/economia/ecoagrari.html. Accessed 30 April 2010
IDESCAT (2010b) Base de dades de municipis i comarques
Isenmann P (1975) Contribution a l'étude de la reproduction et l'ecologie de la Mouette mélanocéphale. *Larus melanocephalus*. Nos Oiseaux 33:66–73
Millot C, Taupier-Letage I (2005) Circulation in the Mediterranean Sea. Env Chem 5:29–66
Oro N (1999) Trawler discards: a threat or a resource for opportunistic seabirds? In: Adams NJ, Slotow RH (eds) Proceedings of the 22 international ornithological congress. Durban, University of Natal. Bird Life South Africa. Johannesburg, pp 717–730
Oro D, Ruiz X (1997) Exploitation of trawler discards by breeding seabirds in the northwestern Mediterranean: differences between the Ebro Delta and the Balearic Islands areas. ICES J Mar Sci 54:695–707
Palomera I, Olivar MP, Salat J, Sabatés A, Coll M, García A, Morales-Nin B (2007) Small pelagic fish in the NW Mediterranean Sea: an ecological review. Prog Oceanogr 74:377–396
Paterson A (1990) Seasonal evolution of the gull populations in Malaga, Spain. Ardeola 37:19–27
Poot M (2003) Offshore foraging of Mediterranean gull *Larus melanocephalus* in Portugal during winter. Atl Seab 5:1–12
Poot M, Flamant R (2006) Numbers, behaviour and origin of Mediterranean gulls *Larus melanocephalus* wintering along the west coast of southern Portugal. Airo 16:13–22
Quinn GP, Keough MJ (2002) Experimental design and data analysis for biologists. Cambridge University Press, Cambridge
Ramsar (2006) The criteria for identifying wetlands of international interest. Ramsar. http://www.ramsar.org/. Accessed 30 April 2010
Roca M, Mínguez-Mosquera MI (2001) Changes in chloroplast pigments of olive varieties during fruit ripening. J Agric Food Chem 49:832–839
Roca M, Mínguez-Mosquera MI (2003) Carotenoid levels during the period of growth and ripening in fruits of different olive varieties (Hojiblanca, Picual and Arbequina). J Plant Physiol 160: 451–459
Salat J (1996) Review of hydrographic environmental factors that may influence anchovy habitats in northwestern Mediterranean. Sci Mar 60:21–32

Salat J, Garcia MA, Cruzado A, Palanques A, Arín L, Gomis D, Guillén J, de León A, Puigdefàbregas J, Sospedra J, Velásquez ZR (2002) Seasonal changes of water mass structure and shelf slope exchanges at the Ebro Shelf (NW Mediterranean). Cont Shelf Res 22:327–348

Schaefer HM, McGraw K, Catoni C (2008) Birds use fruit colour as honest signal of dietary antioxidant rewards. Funtc Ecol 22:303–310

SEO/Birdlife (2007) Metodología para censar aves por transectos en mar abierto. SEO/Birdlife. http://www.seo.org/media/docs/MetodologíaTransectos1.pdf. Accessed 30 April 2010

Tasker ML, Jones PH, Dixon T, Blake BF (1984) Counting seabirds at sea from ships: a review of methods employed and a suggestion for a standardized approach. Auk 101:567–577

Tasker ML, Camphuysen CJ, Cooper J, Garthe S, Montevecchi WA, Blaber SJM (2000) The impacts of fishing on marine birds. ICES J Mar Sci 57:531–547

Tirado M (2009) La gaviota cabezinegra (Larus melanocephalus) en la comunidad Valenciana. In: Bort J, Bort JL (eds) Anuario ornitológico de Castellón 2007, vol 5. http://www.interantura.org/aocs, Vinaròs, pp 177–182

Vidal F, Bigas D, Piccardo J (2006) Cens d'ocells hivernants al delta de l'Ebre 2006. Parc Natural del Delta de l'Ebre, Departament de Medi Ambient, Generalitat de Catalunya

Vidal F, Bigas D, Piccardo J (2007) Cens d'ocells hivernants al delta de l'Ebre 2007. Parc Natural del Delta de l'Ebre, Departament de Medi Ambient, Generalitat de Catalunya

Wetland International (2006) Waterbirds population estimates—fourth edition. Wetland International

Yudin KA, Firsova LV (2002) Fauna of Russia and neighbouring countries. Charadriiformes. Birds Volume II (In Russian), St. Petersburg

Zielinska M, Zielinski P, Kotodziejczyk P, Szewczyk P, Betleja J (2007) Expansion of the Mediterranean gull *Larus melanocephalus* in Poland. J Ornithol 148:543–548