

## Geographical patterns of seabird attendance to a research trawler along the Iberian Mediterranean coast\*

PERE ABELLÓ<sup>1</sup>, JOSÉ MANUEL ARCOS<sup>2,3</sup> and LUIS GIL DE SOLA<sup>4</sup>

<sup>1</sup> Institut de Ciències del Mar, CMIMA (CSIC), Passeig Marítim de la Barceloneta 37-49, 08003 Barcelona, Spain.  
E-mail: pere@icm.csic.es

<sup>2</sup> Dept. Biologia Animal (Vertebrats), Universitat de Barcelona, Av. Diagonal 645, 08028 Barcelona, Spain.

<sup>3</sup> Institut Mediterrani d'Estudis Avançats IMEDEA (CSIC-UIB), C/ Miquel Marquès 21, 07190 Esporles, Mallorca, Spain.

<sup>4</sup> Centro Oceanográfico de Fuengirola, IEO, Muelle Pesquero, 29640 Fuengirola, Málaga, Spain.

**SUMMARY:** The attendance of seabirds to a research trawler along the Mediterranean coast of the Iberian Peninsula was monitored during six demersal surveys (MEDITS project). Cruises were performed in late spring during the period 1994-1999. Twenty seabird species were recorded, including both breeders and migrants. The four most common species behind the boat were local breeders, namely the Balearic shearwater *Puffinus mauretanicus*, Cory's shearwater *Calonectris diomedea*, Audouin's gull *Larus audouinii* and the yellow-legged gull *Larus cachinnans*. Most seabirds made use of trawler discards to some extent, with the exception of the Puffin *Fratercula arctica*. Geographically consistent patterns were identified in the six years surveyed. Seabirds were most abundant along the eastern coast of Iberia, especially off the Ebro Delta and around the Columbretes Islands, coinciding with one of the major areas of primary productivity and one of the largest trawling fleets in the western Mediterranean. The location of the main seabird colonies also influenced the distribution of breeders.

**Key words:** seabirds, distribution, trawl survey, western Mediterranean

**RESUMEN:** PAUTAS GEOGRÁFICAS EN LA ASOCIACIÓN DE AVES MARINAS A UN ARRASTRERO DE INVESTIGACIÓN A LO LARGO DE LAS COSTAS MEDITERRÁNEAS IBÉRICAS. – La atracción de aves marinas a un buque arrastrero de investigación fue estudiada durante seis campañas pesqueras demersales (proyecto MEDITS). Las campañas se realizaron a finales de primavera durante el periodo 1994-1999. Se registraron un total de veinte especies de aves marinas, incluyendo tanto especies reproductoras como migrantes. Las cuatro especies más comunes a popa del buque fueron especies reproductoras, concretamente la pardela balear *Puffinus mauretanicus*, la pardela cenicienta *Calonectris diomedea*, la gaviota de Audouin *Larus audouinii* y la gaviota patiamarilla *Larus cachinnans*. La mayor parte de las aves marinas usaron descartes pesqueros en mayor o menor grado, con la excepción del frailecillo *Fratercula arctica*. Se identificaron pautas geográficamente consistentes en los seis años muestreados. La mayor abundancia de aves marinas se registró a lo largo de las costas orientales de la península ibérica, especialmente en la zona del delta del Ebro y alrededor de las islas Columbretes, coincidiendo con una de las áreas más importantes de producción primaria y con una de las mayores flotas de arrastre en el Mediterráneo occidental. La localización de las principales colonias de cría también afectó a la distribución de las especies reproductoras en la zona.

**Palabras clave:** aves marinas, distribución, campañas de arrastre, Mediterráneo occidental

\*Received January 23, 2002. Accepted July 25, 2002.

## INTRODUCTION

Mediterranean seabirds are known mainly through land-based field studies, and information from data gathered at sea is very scarce and therefore valuable (e.g. Abelló and Oro, 1998; Conejero and Beaubrun, 1998; Beaubrun *et al.*, 2000). Although some information concerning the ecology of seabirds at sea can be inferred from studies at colonies (e.g. through examining diets and activity patterns), it is important to complement these approaches with information collected directly at sea. For instance, studies at sea can provide a better understanding of the ways seabirds obtain their prey (such as feeding strategies and food sources) (e.g. Arcos *et al.*, 2000), and allow important feeding areas to be located.

Despite the relatively low productivity of the Mediterranean (Estrada *et al.*, 1985; Estrada, 1996), there is a diverse community of breeding seabirds, with some species and subspecies endemic to the area. These features, combined with limited population sizes, make the Mediterranean basin an important zone for seabird conservation (Zotier *et al.*, 1999). In this respect, it is important to document the distribution of different seabird species at sea, as well as to identify their key food resources. This is especially true during the breeding season (spring-

TABLE 1. – Sampling dates of the six cruises considered here.

Year	Initial date	Final date
1994	29 May	19 June
1995	22 April	21 May
1996	2 May	20 May
1997	10 May	3 June
1998	3 May	30 May
1999	4 May	3 June

summer), when the productivity of the Mediterranean Sea is at its lowest (Estrada, 1996).

Most seabird species make use of fishing discards in the western Mediterranean (Oro and Ruiz, 1997; Arcos, 2001), an anthropogenic food source that is readily available. Therefore, a sampling strategy was designed to gather information on seabird abundance and distribution during a series of research cruises (trawl surveys) performed along the Mediterranean coasts of the Iberian Peninsula to study demersal fisheries.

## MATERIAL AND METHODS

The attendance of seabirds at experimental trawling was monitored during six demersal fisheries research cruises performed annually in spring, from

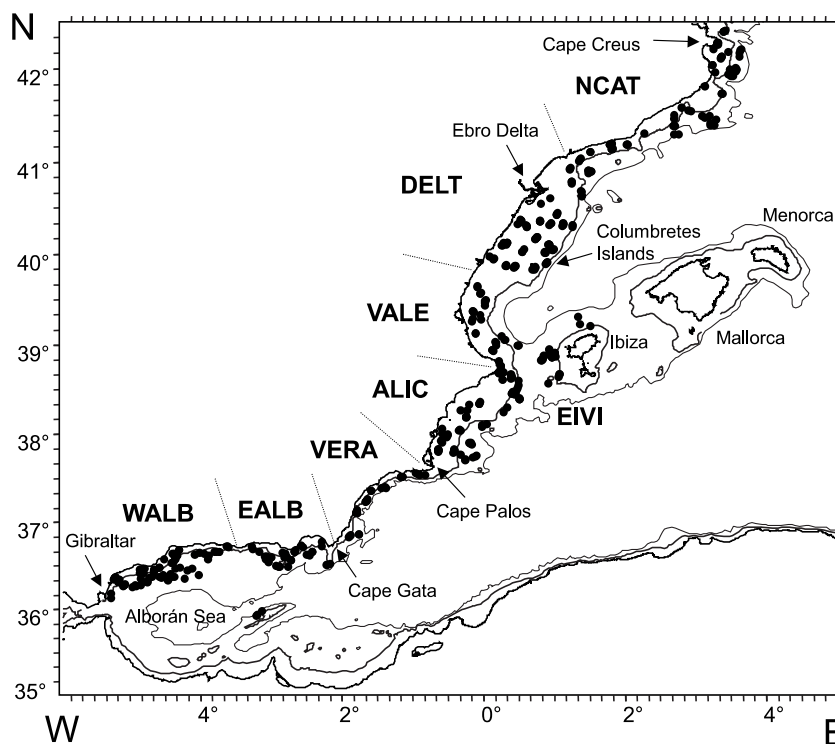


FIG. 1. – Map of the study area showing the sampling points at which seabird attendance to trawling was recorded in spring 1994-1999. The 200- and 1000-m isobaths are shown.

TABLE 2. – Percentage of occurrence (%occ) and total number (N) of the different seabird species attending the research trawler on each cruise from 1994 to 1999 throughout the Iberian Mediterranean, and number of hauls (samples) at which seabird numbers were recorded on each cruise.

SPECIES	1994		1995		1996		1997		1998		1999	
	%occ	N	%occ	N	%occ	N	%occ	N	%occ	N	%occ	N
<i>Calonectris diomedea</i>	52.1	640	20.9	188	34.8	224	51.4	758	38.4	326	12	20
<i>Puffinus mauretanicus</i>	56.3	658	37.2	385	45.7	149	40.3	684	41.1	541	42.4	797
<i>Puffinus yelkouan</i>	0	0	0	0	0	0	0	0	0	5	4.3	0
<i>Puffinus gravis</i>	0	0	0	0	0	0	0	0	0	0	1.1	1
<i>Hydrobates pelagicus</i>	2.1	4	3.5	7	0	0	0	0	0	0	3.3	3
<i>Morus bassanus</i>	12.5	10	12.8	21	17.4	16	4.2	3	5.5	5	4.3	4
<i>Phalacrocorax aristotelis</i>	2.1	3	0	0	0	0	0	0	1.4	2	1.1	1
<i>Catharacta skua</i>	4.2	2	10.5	12	13	12	12.5	11	8.2	6	8.7	22
<i>Stercorarius parasiticus</i>	2.1	1	1.2	1	0	1	0	0	0	0	2.2	2
<i>Stercorarius pomarinus</i>	0	0	4.7	9	4.3	2	0	0	1.4	1	0	0
<i>Larus audouinii</i>	64.6	1110	53.5	348	39.1	144	51.4	662	64.4	752	62	1351
<i>Larus cachinnans</i>	62.5	225	75.6	1056	71.7	535	75	497	75.3	692	71.7	1019
<i>Larus fuscus</i>	8.3	8	9.3	20	6.5	5	6.9	11	6.8	5	4.3	5
<i>Larus ridibundus</i>	0	0	1.2	5	0	0	0	0	0	0	0	0
<i>Rissa tridactyla</i>	0	0	1.2	1	0	0	0	0	5.5	4	0	0
<i>Sterna hirundo</i>	39.6	326	12.8	37	0	0	8.3	12	8.2	19	9.8	21
<i>Sterna paradisaea</i>	0	0	0	0	2.2	1	1.4	2	0	0	0	0
<i>Sterna sandvicensis</i>	0	0	0	0	0	0	0	0	0	0	4.3	5
<i>Chlidonias niger</i>	2.1	3	24.4	203	4.3	3	0	0	12.3	39	6.5	12
<i>Fratercula arctica</i>	4.2	3	1.2	5	0	0	0	0	0	0	3.3	8
No. samples	48		86		46		72		73		92	

1994 to 1999, along the Mediterranean coast of the Iberian Peninsula (MEDITS trawl surveys series) (Bertrand *et al.*, 2000, 2002). These cruises lasted four to five weeks each year, and were centred in May, with small date variations between years (extreme dates being 22 April to 19 June; see Table 1).

The study area encompassed the bottoms of the continental shelf and the upper and middle slope (ca. 50 to 800 m depth), excluding most of the Balearic Islands, from the Straits of Gibraltar (36°07'N, 5°21'W) in the SW to Cape Creus (42°19'N, 3°19'E) in the NE (Fig. 1). The area was divided into eight geographical sectors according to geomorphological characteristics: Western Alborán Sea (WALB), Eastern Alborán Sea (EALB), Vera Gulf (VERA), Alicante Sector (ALIC), Ibiza Island (EIVI), Valencia Sector (VALE), Delta-Columbretes Sector (DELT), and Northern Catalonia Sector (NCAT). From the Straits of Gibraltar to Cape Palos (Alborán Sea) the continental shelf is very narrow, whereas north of Cape Palos it is wider, reaching the largest width (up to 70 km) in the area off Castelló and Tarragona, around the Ebro Delta and west of the Columbretes Islands. The latter localities hold important breeding seabird colonies (see Oro, 1999). North of Barcelona, the area is characterised by important submarine canyons which indent the continental shelf.

During the cruises, up to six hauls were conducted per day. At each trawling station we identified, up to the species level, seabirds attending the boat, and

recorded their numbers from the stern of the vessel during the hauling of the net (i.e. from the moment the trawl doors were secured until the moment in which the net was finally loaded on board). No discarding operations took place while the trawl net was hauled up, although seabirds often managed to get some fish, either lost during the hauling process or directly picked up from the net.

Field data were analysed by geographical sectors in order to establish comparisons. For each species we recorded the percentage of occurrence (i.e. % of hauls in which a species was recorded) and the minimum, maximum, total and mean number of birds ( $\pm$  SE).

## RESULTS

Overall, 20 species of seabirds were recorded (Table 2), including both breeding and migratory species. The puffin *Fratercula arctica* was the only species never seen directly associated with fishing operations. Among local breeders, the most common species were Cory's shearwater *Calonectris diomedea*, the Balearic shearwater *Puffinus mauretanicus*, Audouin's gull *Larus audouinii* and the yellow-legged gull *Larus cachinnans*.

Clumps of seabirds were largest along the eastern coast of the Iberian Peninsula, mainly off the Ebro Delta-Columbretes sector, whereas the smallest

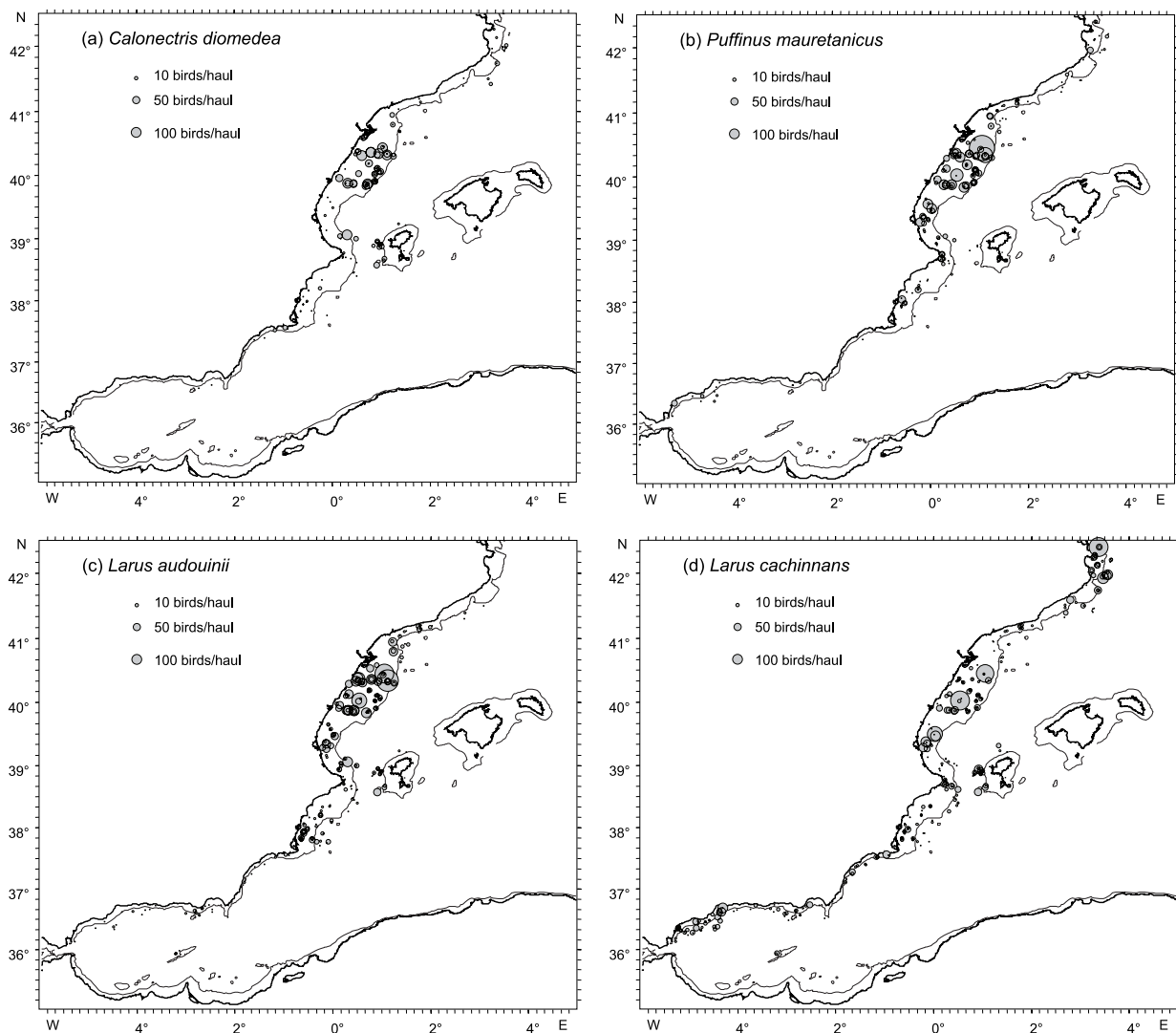


FIG. 2. – Distribution of (a) Cory's shearwater *Calonectris diomedea*, (b) the Balearic shearwater *Puffinus mauretanicus*, (c) Audouin's gull *Larus audouinii*, and (d) the yellow-legged gull *Larus cachinnans* recorded during the study (late spring 1994-1999). Dots represent the number of birds (square-root transformed in order to facilitate their representation) recorded at each trawl station during the hauling of the net. The 200-m isobath, delimiting the continental shelf, is shown.

clumps occurred in the Alborán Sea and the Vera Gulf. This pattern was similar for most species. Only seabird species breeding in the NE Atlantic, such as the northern gannet *Morus bassanus* (mostly immatures), the great skua *Catharacta skua*, and the puffin, were more frequent south of the Ibiza Channel, but always in low numbers.

The major gatherings of Cory's shearwater were located around the Columbretes Islands and the southern sector of the Ebro Delta continental shelf, with up to 250 individuals (Fig. 2a). Large numbers were also recorded around Ibiza, but few were recorded in the Alborán Sea. Overall, we observed a tendency for this species to be more frequent over the continental slope, especially when compared with the distribution of the Balearic shearwater.

The Balearic shearwater was also most abundant in the Ebro Delta-Columbretes sector and nearby areas, where flocks of up to 550 birds were recorded (Fig. 2b). However, this species was more commonly sighted in inshore waters, over the continental shelf. Very few birds were recorded off Ibiza-Formentera, where its major breeding colonies are located. The species was also scarce in the Northern Catalonia sector, and very scarce in the Alborán Sea.

Audouin's gull was regularly observed throughout the study area, and at a wide range of distances from the coast in both inshore and offshore waters, with larger numbers off the Ebro Delta and around the Columbretes Islands (Fig. 2c). Some minor concentrations were also located off Ibiza and north of Cape Palos where some breeding colonies are locat-

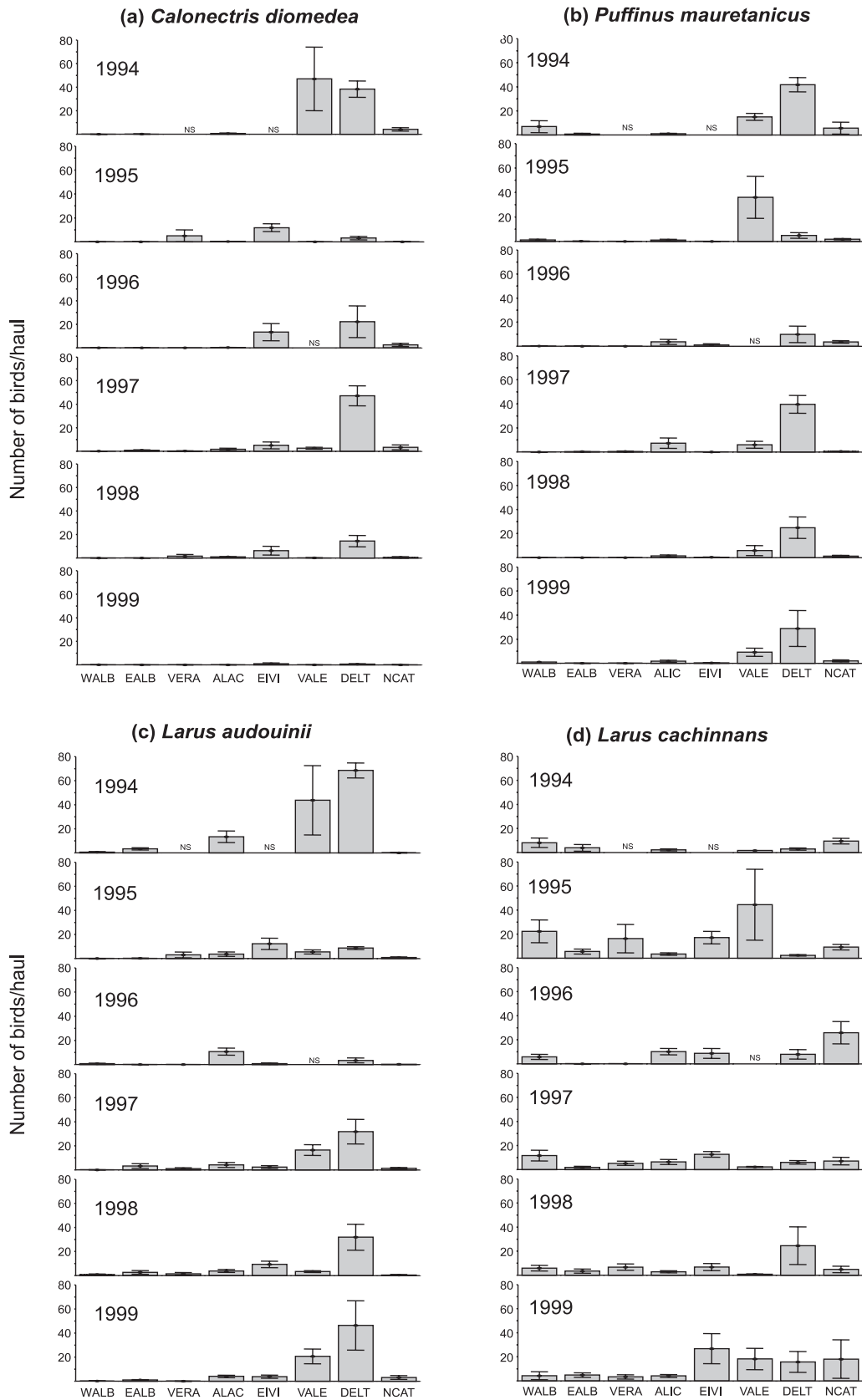


FIG. 3. – Mean number of birds ( $\pm$ SE) observed per haul in each geographical sector by year of sampling for (a) Cory's shearwater *Calonectris diomedea*, (b) the Balearic shearwater *Puffinus mauretanicus*, (c) Audouin's gull *Larus audouinii*, and (d) the yellow-legged gull *Larus cachinnans*.

ed. The species was scarce in the Alborán Sea and the Northern Catalonia sector.

The yellow-legged gull was the most widespread seabird, with large numbers at different sites throughout the study area, especially on the continental shelf (Fig. 2d). However, observations over and off the continental slope were not rare.

Important interannual differences were observed for some species, especially for long-distance migrants such as the black tern *Chlidonias niger*. Among the most common species, Cory's shearwater showed the highest inter-annual variation. Distribution patterns found in the different sectors were consistent from year to year (Figs. 3a-d).

## DISCUSSION

Seabird distribution appeared to be greatly influenced by marine productivity. The largest gatherings of seabirds were observed off the Ebro Delta and the Columbretes Islands. This sector has a wide continental shelf and a high productivity resulting from the Ebro river runoff and the influence of the Liguro-Provençal-Catalan slope front (Salat, 1996; Estrada, 1996). On the other hand, seabirds were least abundant in the Alborán Sea, where the continental shelf is narrow and overall productivity low (Estrada, 1996). Seabirds most frequently sighted in this area were strictly marine species that typically breed in the NE Atlantic, which were either migrating to their summer grounds (i.e. leaving the Mediterranean through the Straits of Gibraltar) or non-breeding resident individuals.

Several seabird species were occasionally observed feeding on their own or in association with sub-surface predators (Arcos *et al.*, 2000), but trawler discards attracted most of the species recorded in the study area. Thus, discards seem to be an important feeding resource for Mediterranean seabirds along the whole Iberian coast, especially during the breeding season, as previously shown for seabird species breeding at the Ebro delta (Oro, 1999 and references therein). It is difficult to discriminate the effects of availability of discards and general productivity as factors influencing seabird distribution since high productivity areas also hold the most important trawling fleets (e.g. Demestre *et al.*, 1988; Irzaola *et al.*, 1996). Breeding seabird distribution was also clearly affected by the location of their colonies. At the spatial scale considered in this study, this factor was especially important for

species with limited foraging ranges, such as the gulls (e.g. Fasola and Bogliani, 1990), whereas wide-ranging species such as the shearwaters (Warham, 1996) were seemingly not influenced to the same extent. In fact, food availability within the foraging range of seabirds may be an important factor determining the location of breeding colonies (e.g. Forbes *et al.*, 2000), and ultimately the distribution of seabirds at sea.

The distribution of the four most common seabird species deserves a more detailed discussion. Cory's shearwaters were especially common in the productive waters off the Ebro Delta, more than 100 km away from their main colonies in the Balearic Islands, though a few tens of pairs also breed in the Columbretes (Sánchez-Codoñer and Castilla, 1997). In addition, considerable numbers were seen off the colonies of Ibiza. On the other hand, very few birds attended trawling operations in the Alborán Sea, where a large colony is located off the African coast (Chafarinas Islands). However, Cory's shearwaters were frequently observed during transect counts at sea in this latter area (authors' unpublished data), which suggests that these seabirds could make less use of discards in the Alborán Sea than in the eastern Iberian coast. Large inter-annual differences in the numbers of Cory's shearwaters could be partly due to differences in the dates of sampling. Indeed, Cory's shearwaters breed later than the other common species (i.e. starting by mid May; Sánchez-Codoñer and Castilla, 1997), so cruises carried out in late April-early May could have detected fewer birds than cruises carried out in late May and early June.

Few Balearic shearwaters were observed close to the main breeding colonies of Ibiza-Formentera (Aguilar, 1991), whereas large flocks were observed off the Ebro delta. This suggests that most of these birds move from their breeding grounds directly to the productive waters of the eastern Iberian coast, which are within the range of shearwaters (e.g. Brooke, 1990), disregarding the less productive areas surrounding colonies. Discards seem to be an important feeding resource for this rare and threatened shearwater that is endemic to the Balearic Islands, given the large number of individuals attending the experimental trawling (cf. Arcos and Oro, 2002).

In spite of the relatively large foraging range of Audouin's gull (Arcos and Oro, 1996; Abelló and Oro, 1998), the distribution of this gull was more influenced by the location of colonies than in the



case of shearwaters. Indeed, the largest flocks occurred off the main colonies of the species, such as the Ebro Delta and the Columbretes Islands, Grossa Island (Alicante sector), and Ibiza (see Oro, 1998). The yellow-legged gull is the most widespread breeder, and consequently has a widespread distribution despite its more limited foraging range (cf. Arcos *et al.*, 2001).

Finally, the interannual consistency of the distribution patterns shown by breeding seabird species in the western Mediterranean shows the value of the use of research cruises aimed at other objectives for obtaining information on seabird distribution and behaviour.

## ACKNOWLEDGEMENTS

We wish to thank all participants in the MEDITS series cruises (1994-1999) on board B/O "Cornide de Saavedra", both scientists and crew, for all their help and support. Peter Becker and an anonymous referee made useful comments on a previous draft of this manuscript. JMA was supported by fellowships from the DURSI-Generalitat de Catalunya (FI/FIAP'98 and BE01).

## REFERENCES

- Abelló, P. and D. Oro. – 1998. Offshore distribution of seabirds in the northwestern Mediterranean in June 1995. *Col. Waterbirds*, 21: 422-426.
- Aguilar, J.S. – 1991. Resum de l'atlas d'ocells marins de les Balears, 1991. *An. Ornith. Balears*, 6:17-28.
- Arcos, J.M. – 2001. *Foraging ecology of seabirds at sea: significance of commercial fisheries in the NW Mediterranean*. PhD Thesis, Univ. Barcelona. (<http://tcat.cesca.es/TDCat-0219102-114337>)
- Arcos, J.M., E. Massutí, P. Abelló and D. Oro. – 2000. Fish associated with floating drifting objects as a feeding resource for Balearic Shearwaters *Puffinus mauretanicus* during the breeding season. *Ornis Fennica*, 77: 177-182.
- Arcos, J.M. and D. Oro. – 1996. Changes in foraging range of Audouin's gulls *Larus audouinii* in relation to a trawler moratorium in the western Mediterranean. *Col. Waterbird.*, 19: 128-131.
- Arcos, J.M. and Oro, D. – 2002. Significance of fisheries discards for a threatened Mediterranean seabird, the Balearic shearwater *Puffinus mauretanicus*. *Mar. Ecol. Prog. Ser.*, 239: 209-220.
- Arcos, J.M., D. Oro and D. Sol. – 2001. Competition between the yellow-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.
- Beaubrun, P., L. David, X. Rufay and S. Conéjéro. – 2000. Off-shore distribution of breeding seabirds on the continental margin of the north-western Mediterranean Sea, from Valencia (Spain) to Rome (Italy) in July 1993. In: P. Yésou and J. Sultana (eds.), *Monitoring and conservation of birds, mammals and sea turtles of the Mediterranean and Black Seas. Proceedings of the 5<sup>th</sup> Medmaravis Symposium, Gozo, Malta, 29 September-3 October 1998*. pp. 91-103. Environment Protection Department, Malta.
- Bertrand, J.A., L. Gil de Sola, C. Papaconstantinou, G. Relini and A. Souplet. – 2000. An international bottom trawl survey in the Mediterranean: the MEDITS programme. In: J.A. Bertrand and G. Relini (eds.), *Demersal resources in the Mediterranean, Proceedings of the Symposium held in Pisa, 18-21 March 1998, Actes de Colloques* 26, pp. 76-93. IFREMER, Plouzané.
- Bertrand, J., L. Gil de Sola, C. Papaconstantinou, G. Relini and A. Souplet. – 2002. The general specifications of the MEDITS surveys. *Sci. Mar.*, 66 (Suppl. 2): .
- Brooke, M. – 1990. *The Manx Shearwater*. T. & A.D. Poyser, London.
- Conejero, S. and P. Beaubrun. – 1998. Distribution comparée des puffins (Procellariidés) dans le Golfe du Lion en juillet 1994. *Rapp. Comm. int. Mer Médit.*, 35: 412-413.
- Demestre, M., J. Lleonart, P. Martín, L. Recasens and P. Sánchez. – 1988. La pesca en Cataluña. *FAO Rapp. Pêches*, 395: 101-103.
- Estrada, M. – 1996. Primary production in the northwestern Mediterranean. In: I. Palomera and P. Rubiés (eds.), *The European Anchovy and its Environment*. *Sci. Mar.*, 60(Suppl. 2): 55-64.
- Estrada, M., F. Vives and M. Alcaraz. - 1985. Life and productivity of the open sea. In: R. Margalef (ed.), *Key Environments: Western Mediterranean*. pp. 148-197. Pergamon Press, Oxford.
- Fasola, M. and G. Bogliani. – 1990. Foraging ranges of an assemblage of Mediterranean seabirds. *Col. Waterbirds*, 13: 72-74.
- Forbes, L.S., J. Martin and G.W. Kaiser. – 2000. Habitat constraints and spatial bias in seabird colony distributions. *Ecography*, 23: 575-578.
- Irzaola, M., A. Lucchetti, J. Lleonart, A. Ocaña, J.M. Tàpia and S. Tudela. – 1996. *La pesca en el siglo XXI: Propuestas para una gestión pesquera racional en Catalunya*. CEPROM, Barcelona.
- Oro, D. – 1998. Audouin's Gull *Larus audouinii*. In: M.A. Ogilvie (ed.), *The Birds of the Western Palearctic Updated. Vol. 2*, pp. 47-61. Oxford University Press, Oxford.
- Oro, D. – 1999. Trawler discards: a threat or a resource for opportunistic seabirds? In: N.J. Adams and R.H. Slotow (eds.), *Proceedings of the 22 International Ornithology Congress. Durban, University of Natal*, pp. 717-730. Bird Life South Africa, Johannesburg.
- Oro, D. and X. Ruiz, X. – 1997. Exploitation of trawler discards by breeding seabirds in the north-western Mediterranean: differences between the Ebro Delta and the Balearic Islands areas. *ICES J. mar. Sci.*, 54: 695-707.
- Salat, J. – 1996. Review of hydrographic environmental factors that may influence anchovy habitats in northwestern Mediterranean. In: I. Palomera and P. Rubiés (eds.), *The European Anchovy and its Environment*. *Sci. Mar.*, 60(Suppl 2): 21-32.
- Sánchez Codoñer, A. and A. Castilla. – 1997. *La pardela cenicienta (Calonectris diomedea) en las islas Columbretes. Biología y conservación*. Ajuntament de Castelló de la Plana, Castelló de la Plana.
- Warham, J. – 1996. *The Behaviour, Population Biology and Physiology of the Petrels*. Academic Press, London.
- Zotier, R., V. Bretagnolle J.C. Thibault. – 1999. Biogeography of the marine birds of a confined sea, the Mediterranean. *J. Biogeogr.*, 26: 297-313.

