High importance of fish prey in the diet of Yellow-legged Gull *Larus michahellis* chicks from the southeast Bay of Biscay

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Abstract
The aim of the study was to describe Yellow-legged Gull *Larus michahellis* chick diet in the southeast Bay of Biscay. Sampling was carried out in three colonies (Ulía, Santa Clara, Guetaria) in Gipuzkoa, northern Iberia, during the breeding seasons of 2007 and 2008. Regurgitates (n = 70) were collected from chicks of c. 20 days old when they were ringed. Overall, 79 prey items were found, and each item was weighed and classified into one of the following prey-groups: marine (fish (Pisces), crab (Brachyura)), refuse tips (pork, beef, rabbit, chicken), terrestrial (earthworms (Lumbricinae), molluscs (Mollusca), insects (Insecta)), others (mainly vegetables or unidentified prey). The proportion of each prey-group did not differ from one year to the next and most prey was of marine origin (59.5%; all fish except for one crab), followed by refuse tips (22.8%), terrestrial (13.9%), and others (3.8%). These findings concur with those at colonies in northwest Iberia, and while local exceptions might occur, Yellow-legged Gull chick diet in northern Iberia is predominantly marine fish.

Introduction
Human activities often have an impact on population size of wild vertebrates, and many opportunistic species have adapted to exploit some superabundant food resources generated by man (Garrott *et al*. 1993). This phenomenon is well known in gulls, and populations of several species have increased in response to anthropogenic factors (e.g. Steele & Hockey 1990; Skorka *et al*. 2005; Duhem *et al*. 2008).

With a population of some 200,000 breeding pairs, the Yellow-legged Gull *Larus michahellis* is one of the most abundant large gulls in Europe (Olsen & Larsson 2004). Nearly 100,000 pairs breed in Iberia, where the species has shown a notable population increase during the second half of the twentieth century (Bermejo & Mouriño 2003; Arizaga *et al*. 2009). Such an increase can generate problems, due to unsanitary (Monaghan *et al*. 1985; Ramos *et al*. 2010), safety (Brown *et al*. 2001), ecological (Rusticali *et al*. 1999; Vidal *et al*. 2000; Oro *et al*. 2005; but see

Oro & Martinez-Abrain 2007) or social impacts (Raven & Coulson 1997). Consequently, the species has been the target of management policies, often based on culling that normally have a null or very short-term effect on population trends (e.g. Bosch *et al.* 2000). Diet analyses can be of key importance from this standpoint, because they provide quantitative data on which colonies depend on which prey types (Ramos *et al.* 2006; Ramos *et al.* 2009), and breeding success is largely determined by diet (Annett & Pierotti 1999).

The Yellow-legged Gull is able to forage on a wide spectrum of prey, from marine prey to refuse tips, and including freshwater prey, crops or earthworms (Lumbricinae) (Álvarez & Méndez 1995; Munilla 1997; Ramos *et al.* 2006; Moreno *et al.* 2009). In Iberia, the diet has been studied mainly at colonies in the Mediterranean, and in Galicia, northwest Iberia. Although fish (Pisces) are one of the preferred resources during breeding (Ramos *et al.* 2006; Moreno *et al.* 2009), some colonies depend highly on refuse tips (Bosch *et al.* 1994; Ramos *et al.* 2009). Geographic variation in diet is correlated with the distance of colonies to important feeding locations, such as harbours, fishing areas, refuse tips or crops (Moreno *et al.* 2009; Ramos *et al.* 2009). Distribution of food at a local scale hence determines the chief food items for given colonies. In northwest Iberia, the swimming crab *Polybius henslowii* was found in nearly 40% of regurgitates from adult Yellow-legged Gulls (Álvarez & Méndez 1995; Munilla 1997), but was much less important for chicks (Moreno *et al.* 2009). The diet for other areas of northern Iberia is unknown, and the aim of this study is hence to analyse the extent to which Yellow-legged Gulls breeding in the southeast Bay of Biscay depend on refuse tips or other food resources to provision their chicks.

Material and methods

Sampling area and diet determination: The study was carried out in three colonies (Ulía, Santa Clara, Guetaria) in Gipuzkoa during the 2007 and 2008 breeding seasons. The colonies were found along 25 km of coastline from Úlia (43°20'N 01°57'W) to Guetaria (43°18'N 02°12'W) on natural cliffs near urban areas (Figure 1), and in 2007 totalled c. 700 breeding pairs (Arizaga *et al.* 2009).

Regurgitates were collected when chicks were handled for ringing and kept frozen in bags until they were analysed (n = 70 regurgitates; 2007: 38; 2008: 32). Only one regurgitate per chick and brood was analysed in order to avoid statistical replication. Regurgitates were separated into items (n = 79), and each item was weighed and classified into one of the following prey groups (Bosch *et al.* 1994): marine (fish, crab (Brachyura)), refuse tips (pork, beef, rabbit, chicken), terrestrial (earthworms, molluscs (Mollusca), insects (Insecta)), others (vegetable remains or unidentified prey). When possible, fish were identified to Family (Bauchot & Pras 1993). Diet analyses were based on these prey groups as these could be linked to the species' trophic ecology (Ramos *et al.* 2009).

Statistical analyses: Because of sample size constraints (number of regurgitates: Guetaria 6; Santa Clara 16; Ulía 48), we grouped the three colonies for the analysis.

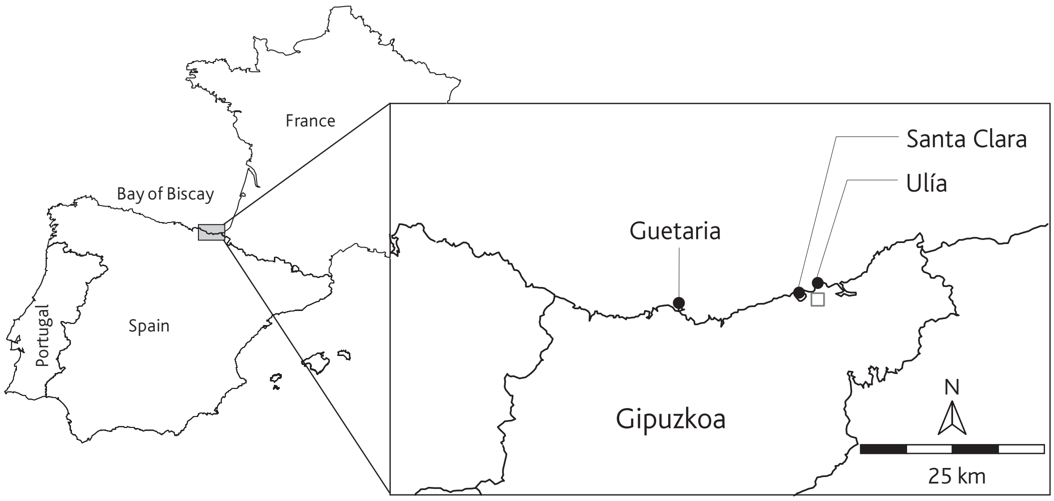

Figure 1. Location of the three study colonies in Gipuzkoa, southeast Bay of Biscay. The white square shows the location of the main refuse dump of Gipuzkoa in 2007 and 2008.

Although diet can differ considerably among gulls from different colonies (Ramos *et al*. 2009), in our case the study was carried out in three close colonies along the coastline and relatively close to both fishing harbours and waste dumps. In this scenario, grouping all the colonies into a single unit for the analyses made biological sense. First, we studied whether the proportion of each prey group changed between years, for which a chi-square test was used. Secondly, we compared the foraging heterogeneity between years using indices of diversity (Duffy & Jackson 1986). Diet diversity was estimated using the Shannon-Weaver index, *H'*:

$$H' = - \sum p_i \times \ln(p_i)$$

where p_i was the proportion of biomass of each prey category. *H'* values from 2007 and 2008 were pair-compared by means of a Hutcheson's *t*-test (Magurran 1989). Programs used were SPSS v.15.0 and PAST v.1.6 (Hammer *et al.* 2001).

Results

The proportion of prey groups did not vary from 2007 to 2008 (χ^2 = 5.889, df = 3, P = 0.110). Most prey was of marine origin (59.5%; all fish, except for one unidentified crab), followed by refuse tips (22.8%), terrestrial (13.9%), and others (3.8%) (Table 1). Identified fish belonged to Families Belonidae, Clupeidae, Sparidae, Gadidae, Carangidae and Trachinidae (Table 1). A relatively high number of fish items (73.9%) could not be identified due to a lack of diagnostic elements. Quantitatively, marine prey tended to be more prevalent in chicks' diet in 2008 than in 2007 (*H'* values: 2007, 0.77; 2008, 0.68), but the difference was not statistically significant (*t* = 1.710, P = 0.088).

Discussion

Yellow-legged Gull chicks at colonies in the southeast Bay of Biscay were fed mainly fish (60% of biomass), similar to what was observed at colonies in northwest Iberia

Table 1. Diet of Yellow-legged Gull *Larus michahellis* chicks at three study colonies in Gipuzkoa, southeast Bay of Biscay, 2007-08. %P: proportion of regurgitates within the category. %N: proportion of items within the category.

	2007					2008				
Prey	**No. Item**	**%P**	**%N**	**Weight (g)**	**Weight (%)**	**No. Item**	**%P**	**%N**	**Weight (g)**	**Weight (%)**
Marine prey	25	65.8	56.8	373.0	59.4	22	68.8	62.9	270.1	77.9
Fish: *Belonidae*	2	5.3	4.5	24.1	3.8	-	-	-	-	-
Fish: *Carangidae*	1	2.6	2.3	23.5	3.7	-	-	-	-	-
Fish: *Clupeidae*	1	2.6	2.3	41.1	6.5	2	6.3	5.7	42.7	12.3
Fish: *Gadidae*	2	5.3	4.5	49.2	7.8	-	-	-	-	-
Fish: *Sparidae*	1	2.6	2.3	52.6	8.4	-	-	-	-	-
Fish: *Trachinidae*	2	5.3	4.5	17.6	2.8	1	3.1	2.9	10.8	3.1
Fish: Undetermined	16	42.1	36.4	164.8	26.2	18	56.3	51.4	216.1	62.3
Crab	-	-	-	-	-	1	3.1	2.9	0.6	0.2
Dump	13	34.2	29.5	240.0	38.2	5	15.6	14.3	58.6	16.9
Terrestrial	6	15.8	13.6	15.2	2.4	5	15.6	14.3	5.6	1.6
Molluscs	1	2.6	2.3	8.4	1.3	-	-	-	-	-
Earthworms	5	13.2	11.4	6.7	1.1	4	12.5	11.4	3.3	0.9
Insects	-	-	-	-	-	1	3.1	2.9	2.4	0.7
Others	-	-	-	-	-	3	9.4	8.6	12.6	3.6

(Moreno *et al*. 2009); thus, although local exceptions might occur, Yellow-legged Gull chick diet in northern Iberia is largely fish. As deduced from the fish Families identified, Yellow-legged Gulls from the southeast Bay of Biscay foraged both on pelagic species (which presumably could be captured by themselves) and demersal/benthonic fish scavenged from boat discards. Further research involving larger sample sizes of regurgitates, or based on more accurate techniques such as stable isotopes (Moreno *et al*. 2009), is necessary to better quantify which of these two ecological type of fish prey are more important for the Yellow-legged Gull diet.

Food from refuse tips comprised 30% of the diet and its importance was therefore low compared to fish. Nevertheless, this percentage is high compared to some isolated Mediterranean colonies where distances to refuse tips were too great for provisioning chicks, e.g. 0% at Columbretes (Ramos *et al*. 2009), and intermediate in comparison with some other colonies close to urban areas such as Medes Isles and Mazarrón, where organic waste can comprise up to c. 45% of chick diet (Ramos *et al*. 2009). Refuse tips provide an accessible and energy-rich source of food (Pons 1992) that, therefore, can act as a complement to fish in the diet of chicks.

Previous studies of Yellow-legged Gulls in northwest Iberia found a high incidence of the swimming crab *Polybius henslowii* in the diet of adults (Álvarez & Méndez 1995; Munilla 1997) but not in chicks, of which it was only a minor component (Moreno *et al*. 2009). This species was also absent in the chick diet at the study sites in the southeast

Bay of Biscay. Due to their lower calorific content than fish, crabs and other invertebrates with hard structures are only a supplementary food for gull chicks. Moreover, although *Polybius henslowii* also occurs along the coast of the southeast Bay of Biscay (Hayward & Ryland 1995), it is unlikely to be as abundant there as in northwest Iberia (Munilla 1997), and therefore as available to local breeding gulls.

Although non-significantly, marine prey tended to be proportionally more abundant in chicks' diet in 2008 than in 2007 (78% versus 59% of biomass), with less food obtained from refuse tips. Both the use of falconry to deter gulls from the main refuse tip in the region (I. Mendiola pers. comm.) and a reduced volume of waste dumped into this landfill in 2008 may have contributed to this, but with the relatively low sample size and a lack of significance, such a difference remains speculative.

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