

SHORT REPORT

## Population size estimation and metapopulation relationships of Storm Petrels *Hydrobates pelagicus* in the Gulf of Biscay

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Storm Petrels *Hydrobates pelagicus* are notoriously difficult to census because they nest in burrows and crevices, they visit land at night, and colonies are usually visited by large numbers of itinerant pre-breeding birds (Ratcliffe *et al* 1998, Insley *et al* 2002). The Spanish Storm Petrel population has been estimated at 5,005–7,900 breeding pairs (bp) spread over the Cantabrian Sea (Galicia 10–240 bp, Asturias 412–805 bp, Cantabria 93–325 bp, Bizkaia 63–220 bp), the Mediterranean coast (Alicante 555–685 bp, Murcia 360–544 bp, Baleares 2,912–4,064 bp) and the Canary Islands (595–1,000 bp) (Minguez 2003). The difficulty of reaching many nest sites and of conducting capture–recapture studies on islands has meant that most of these population estimates were based only on nests found on accessible faces (Boersma & Groom 1993, Minguez 1994, Minguez & Vigil 1995). To evaluate the accuracy of these estimates and produce better approximations of population size, we carried out a 16-year (1990–2006) ringing project on Aketx Island, which harbours the largest Storm Petrel population of the area (Azkona *et al* 2006).

Aketx Island, one of the Bizkaia Islands in the Gulf of Biscay (Basque Country, Northern Iberian Peninsula, Fig 1), is a long limestone island facing north–south (length 300 m x width 200 m x height 80 m), located 800 m offshore. The southeastern part of the island has vertical, inaccessible cliffs with crevices and caves where Yellow-legged Gulls *Larus michahellis*, Shags *Phalacrocorax aristotelis* and Storm Petrels breed. The rest of the island has a different structure, with an initial 5–20 m vertical cliff-face leading to a smooth slope about 100 m wide. The western hillside is covered by rocky outcrops or large rocks fallen from the cliff walls. Gulls nest in large numbers among the rocks and under the vegetation. There are also small cavities in the rocks where Storm Petrels breed. Above this hillside, the terrain is steep but, unlike the eastern slope, is partially covered by vegetation, mainly stunted Holm Oak *Quercus ilex*, Olive *Olea europea* and Fig Trees *Ficus*

*carica*, adapted to the water and saline stress, and the strong marine winds. Here too there are many crevices where Storm Petrels nest. The summit of the island is flat and occupied by shrubs and nitrophilous plants. Gulls are less numerous here because of the frequent exposure of the summit to northwesterly winds. The area has an Atlantic climate, characterised by an average precipitation of 1,800 l/m<sup>2</sup> during 150 to 200 days of rainfall per year, a high frequency of northwesterly winds, and mild temperatures (average 13°C throughout the year). The difference between maximum and minimum temperatures is 12°C (National Meteorological Institute).

The first studies of Storm Petrels on Aketx began in 1989 (Minguez *et al* 1992, 1995), and a regular ringing programme took place between 1993 and 2006. Surveys were usually



**Figure 1.** The map shows the Biscay shore with relevant places: Aketx Island (the study area and the main colony), Iزارo Island (a secondary colony), Billano Island (an inaccessible secondary colony) and Gaztelugatxe coast (ringing site, with some nests).

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conducted in mid-July; at this time, breeding Storm Petrels are closer to the colony because chicks need the attendance of their parents (Ratcliffe *et al* 1998, Cadiou 2001) and 65% of nests are occupied by a chick (Mínguez *et al* 1995). In some years (1997 and 2001) the ringing visit was postponed until the last week of July because of rough seas, while in other years (1994, 1998, 2000 and 2002), colony visits were prevented by incessant bad weather or a heavy swell. In 1995, fieldwork had to be interrupted after one crew member suffered an accident. Sampling effort was increased during the three years after the Prestige oil spill (5 and 19 July and 2 August 2003, 10 and 23 July and 6 August 2004, and 15 July and 12 August 2005, see Azkona *et al* 2006) to gain better estimates of population size.

At each ringing visit, three mist-nets (12 m long x 2.5 m high) were placed on the northwestern slope of the island, parallel to the cliffs, for seven hours (from 2230 to 0530 h). The nets were always placed in the same orientation and location, to facilitate between-year comparisons of capture rates and to detect changes in the number of breeding pairs or their distribution (Furness & Baillie 1981). Although sound lures were used in 1989, all subsequent studies were carried out without using sound lures because these would have increased the likelihood of capturing non-breeders (Furness & Baillie 1981, Fowler *et al* 1982). The Jolly-Seber method based on mark-recapture was used to estimate Storm Petrel population size (Krebs 1989) for the period 2003–06 (see Insley *et al* 2002).

Between 1990 and 2006, in total 2,365 Storm Petrels were marked on Aketx Island, 105 of which were recaptured at least once (4.4%). The number of birds recaptured was highly correlated with the number of birds marked (correlation coefficient  $r_s = 0.821$ ,  $P = 0.004$ ). The average

period between tagging and first recapture was 3.76 years (SD = 3.65, range = 1–16; intra-season recaptures were not considered). Twenty Storm Petrels were recaptured twice on average after 4.7 years (SD = 3.1, range = 2–10), 12 petrels were recaptured for a third time on average after 6.08 years (SD = 2.9, range = 3–12), five petrels were recaptured for a fourth time on average after 7.5 years (SD = 2.6, range = 7–13) and one petrel was recaptured for a fifth time after 11 years (Table 1).

Population estimates for 2004 and 2005 were similar (5,389 and 5,299) but that for 2003 was lower at 3,882 birds (Table 2). The overall survival rate was 0.76 in 2003, similar to the 0.87 calculated by Insley *et al* (2002), but decreased to 0.57 in 2004. This reduction could have been a consequence of the Prestige oil spill on the Storm Petrel population (see Azkona *et al* 2006).

Ringing data obtained by other teams suggest a population connection between Aketx and other Bizkaia Island colonies within a 10 km radius. Seven Storm Petrels marked on Aketx were recorded on the mainland at Gaztelugatxe, 800 m away from the colony, and 11 were recorded on Izaro Island (8.3 km). These were among 192 Storm Petrels ringed on Gaztelugatxe and Izaro caught using sound lures (Rafael Garaita pers comm). Furthermore, two Storm Petrels marked on Gaztelugatxe and three marked on Izaro were recaptured on Aketx. The time lapse between mark and recapture was of several days for 17 birds, one year for three birds, three years for two birds and seven years for one bird. Although sound lures were not used on Aketx, this does not preclude the possibility that wandering, non-breeding birds (immatures) were also caught. Nevertheless, these data suggest the existence of a connected Storm Petrel metapopulation in the Bizkaia islands, centred on Aketx Island.

**Table 1.** Capture–recapture data for Storm Petrels on Aketx Island. N = number captured, marked and released. Subsequent columns show the numbers of birds ringed in one year and recaptured in the following years.

Year	N	Number of years between the capture and the first recapture/second recapture/third recapture/fourth recapture/fifth recapture															
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1990	169			4		1	1	2								1	2
1991	181		3		2	1			1		0/2		0/0/1	1	1	1	
1993	134						1		2/2		0/1/2	1/1/0/1/1	1	0/0/0/1			
1995	87	4	4/3					0/0/1		0/0/1/1							
1996	199	2		2/1										1			
1997	163		4/1		2	0/1	5/2/5	1/0/0/1	0/0/0/2	1							
1999	178		2		1				1								
2001	232		10/1	4/1/2		3/5											
2003	317	10/1	8	1/1													
2004	249	7/1	1														
2005	259	5/2															
2006	197																
Total	2,365	28/4	32/5	11/3/1	5	5/6	7/2/6	4/0/0/1	3/2/1/3	1	1/3/2	1/1/0/1/1	1/0/1/	1/0/0/1	1	2	2

**Table 2.** Jolly–Seber analysis for Storm Petrels on Aketx Island. N = number captured and released, Pop = population estimate (birds), Surv = estimated annual survival rate, Dil = estimated annual dilution rate, 95% CI = 95% confidence interval for population size.

Year	N	Pop	Surv	Dil	95% CI
1990–2001	1,343				
2003	317	3,882	0.76	1.83	1,590–4,799
2004	249	5,389	0.57	1.73	2,077–7,012
2005	259	5,299			
2006	197				

A large number of Storm Petrels have been marked and controlled in western Europe: 15,904 marked and 801 controlled in Spain (1980–2004; Iraeta 2005, Frias *et al* 2006), 2,261 marked and 166 controlled in Portugal (1976–99; the Portuguese Bird Ringing Centre, CEMPA/ Instituto da Conservação da Natureza, unpublished data), 410,784 ringed and 11,322 controlled in Britain & Ireland (1936–2004; Clark *et al* 2005) and 9,072 marked in Brittany, France (1997–2006; Bernard Cadiou pers comm). However, despite this high level of ringing activity, to date none of the Storm Petrels ringed on Aketx has been recovered beyond the Bizkaia Islands and only four birds ringed outside the Bizkaia Islands have been controlled within the archipelago: a bird marked in Biarritz, Pyrénées-Atlantiques (France), in July 2003 was sound-lured on Izaro in June 1991 (90.5 km); one released from a wildlife rehabilitation centre on Tenerife (Canary Islands, Spain) in April 2002 was recaptured on Aketx in August 2003 (2,064 km) and two sound-lured on A Coruña's coast in July 2003 were recaptured two years later on Aketx (471 km). This suggests very limited interchange between Storm Petrels in the Bizkaia Islands with populations further away.

In conclusion, the capture and recapture rates of Storm Petrels on Aketx suggest that this is an important breeding colony in the area (see Insley *et al* 2002). The population estimate from these ringing studies is at least double the previous estimates for the whole of the Cantabrian Sea area (see Minguez 2003).

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