

## Short-term effects of the prestige oil spill on a colony of European storm-petrels *Hydrobates pelagicus* \*

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**Abstract** We monitored a colony of European storm-petrels *Hydrobates pelagicus* before and after the *Prestige* oil spill (November 2002) at Aketx Island (Gulf of Biscay, Northern Iberian Peninsula). A census of a part of the colony was carried out by mist-netting birds between 1993 and 2005, whereas fledgling success was studied by direct observation of the nests. Before the spill, the population of the colony was characterised by oscillations among years. The bird's sensitivity to changing weather and prey availability are probably the ultimate causes of the fluctuations. During the 2003 breeding season, the body condition of breeding storm-petrels was worse than previous years and the number of breeding pairs and fledgling success diminished. In 2004, the number of storm-petrels that bred was less than the year before, the body condition of those birds was bad but slightly better than in 2003 and all the clutches were successful. In 2005, the number of ringed storm-petrels reached the level before the oil spill, almost all of the detected pairings were successful and the body condition of those birds was similar to the years before the sinking. However, the reduction of the minimal age of the studied birds continued, suggesting an effect of oil pollution on population turnover. Further studies must determine exactly the effects of pollutant bioaccumulation on these seabirds [Acta Zoologica Sinica 52 (6): 1042-1048, 2006].

**Key words** European storm-petrel, *Hydrobates pelagicus*, Oil spill

## 石油泄漏对暴风海燕群体的短期影响 \*

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**摘要** 2002年11月原油泄漏前后,我们对伊比利亚半岛比斯开湾内的 Aketx 岛上的暴风海燕 (*Hydrobates pelagicus*) 进行了监测。1993-2005年期间,利用雾网法调查了暴风海燕的数量,并通过直接观察法来统计雏鸟出飞率。在石油泄漏前,暴风海燕的种群数量亦存在年际波动,天气变化和食物丰盛度可能是引起这一现象的根本原因。在2003年,繁殖个体的身体条件较前些年差,繁殖对的数量和雏鸟成活率也有所下降。2004年繁殖对的数量明显少于2003年,繁殖个体的身体状况稍强于2003年,且所有卵都孵化成功。2005年的种群数量已经回升到石油泄漏前的水平,几乎所有配对的暴风海燕都能成功繁殖,亲鸟的身体条件也恢复到了石油泄漏前

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的水平。值得注意的是,这一群体中幼年个体的数量仍在减少,表明石油污染对种群数量的影响仍然存在,确定污染物在体内积累对这些海鸟所造成的影响将是下一步研究的重点 [动物学报 52 (6): 1042-1048, 2006]。

**关键词** 暴风海燕 石油泄漏

On 13 November 2002 the tanker *Prestige*, carrying 77 000 tons of oil sank 120 miles from the coast (García et al., 2003). The first oil slicks arrived at the coast of Galicia on 16 November. The first beaches of Biscay appeared covered by oil on 5 December and from that moment on, the arrival of fuel to the Basque coast was almost uninterrupted, depending on the stream regimes and dominant winds. A total of 21 070 tons was collected from beaches and cliffs in the Basque Country within the first year of the spill, while 2 950 tons were collected off-shore (www.Prestige.ej-gv.net). At the beginning of 2004 the fuel was still over the Bay of Biscay in fragmented, scattered small oil slicks continuously washing the shore.

The *Prestige* wreck occurred when the Bay of Biscay hosts its yearly maximum in wintering seabirds (Zuberogoitia and Torres, 1998). They are attracted to the area because of the prey abundance in the Galicia upwelling (Mougin et al., 1990). This would determine a greater impact in the number of oiled birds (Cámphuysen and Heubeck, 2001). On 30 November 2002, oiled birds began arriving in Biscay, with most of the birds arriving between the middle of January and the middle of February. In all, the amount of oiled birds collected in Spain, France and Portugal was 23 181 (García et al., 2003). While the percentage of beached birds is estimated conservatively to be between 10% - 20% of the birds affected by oil slicks, the total number of birds affected by the *Prestige* oil spill was estimated to be between 115 000 and 230 000 (García et al., 2003). Oiled storm-petrels totalled 34 individuals: 19 European storm-petrels *Hydrobates pelagicus*, seven Leach's storm-petrels *Oceanodroma leucorhoa*, one white-faced storm-petrel *Pelagodroma marina* and seven unidentified storm-petrels (García et al., 2003).

The effects of oil spills may be especially severe for European storm-petrels because, being pelagic birds, they spend almost all their lifetime out in the ocean, landing solely for breeding (Cramp, 1985; Butler et al., 1988). Therefore, they are more vulnerable to oil-induced feather disorders than coastal birds (Vermeer and Vermeer, 1975). In addition, they feed on the surface of the sea (where this pollutant remains principally) and are attracted by oily and fatty substances because these are part of their natural foods (Boersma, 1986; Butler et al., 1986; Nevitt and Haberman, 2003). On the other hand, their pelagic habits cause studies to underestimate the actual number of casualties caused by catastrophic events, because most casualties occur off-shore and go un-

noticed (Cámphuysen and Heubeck, 2001).

Mass mortality of seabirds has been largely documented as a consequence of oil spills (e.g. the *Exxon valdez* oil spill, Piatt and Ford, 1996; the *Treasure* oil spill, Crawford et al., 2000; the *Prestige* oil spill, García et al., 2003). Such studies have pointed out the importance of describing short-term effects such as the acute-mortality phase during a relatively short period after the spill (Piatt and Ford, 1996; Crawford et al., 2000) and long-term effects produced by prolonged exposure to hydrocarbons, such as the bioaccumulation of lethal or sublethal concentrations of pollutants (Butler et al., 1988; Irons, 1996; Wiens et al., 1996; Andres, 1997, 1999; Murphy and Mabee, 2000; Seiser et al., 2000; Irons et al., 2000; Esler et al., 2002; Golet et al., 2002; Kingston, 2002; Wikelski et al., 2002). In this paper we aim to describe the short-term effects caused by the *Prestige* oil spill on a colony of European storm-petrels in the Bay of Biscay. This bird is of special interest because it is highly protected throughout its distribution range (Massa and Catalisano, 1986; Galarza, 1998; Minguez, 2003).

## 1 Study area and methods

### 1.1 Study area

The study area was the island of Aketx, located in the Gulf of Biscay (Basque Country, northern Iberian Peninsula: Fig. 1). This area is included in the IBA of Urdaibai and the Protected Marine Biotope of Gaztelugatxe. Aketx is a limestone island facing north-south (length 300 m × width 200 m × height 80 m), located 800 m offshore.

The south-eastern part of the island has vertical, inaccessible cliffs. There are plenty of crevices and caves where yellow-legged gulls *Larus michahellis*, shags *Phalacrocorax aristotelis* and European storm-petrels breed. The rest of the island shows a different structure, with an initial 5-20 m vertical slope leading to a smooth slope about 100 m wide. The western hillside is covered by large rocks fallen from the cliff-walls or outcropping. Gulls nest in large numbers among the rocks and under the vegetation. There also are small cavities in the rocks where the European storm-petrels breed. Above this hillside, the terrain becomes steep but, unlike the eastern slope, it is partially covered by vegetation, mainly stunted trees adapted to the water and saline stress and the strong marine winds (holm oaks *Quercus ilex*, olive trees *Olea europea*, and fig trees *Ficus carica*). There are many crevices where European storm-petrels nest.

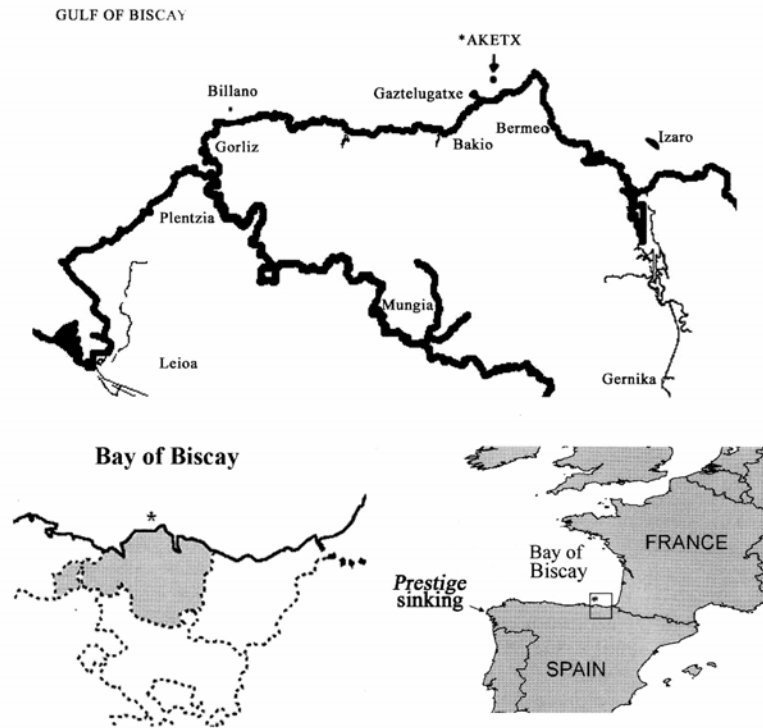


Fig. 1 Study area location (Aketx \*) and the place of the Prestige sinking

The summit of the island is flat and is occupied by shrubs and nitrophilous plants. Gulls are less numerous here because of the frequent exposure of the summit to north-westerly winds.

The area has an Atlantic climate, characterised by an average precipitation of 1 800 L/m<sup>2</sup> with 150 to 200 days of rainfall per year, a high frequency of north-westerly winds, and mild temperatures (average 13°C throughout the year). The difference between maximal and minimal temperatures is 12°C (National Meteorological Institute).

### 1.2 Methods

The first studies on European storm-petrels on this island began in 1989 (Minguez et al., 1992, 1995). Their censuses were undertaken by both mist-netting and tape luring. In 1993, this colony, the largest of the Basque Country (Minguez et al., 1992), was chosen for surveillance of the population of European storm-petrels. We kept basically the same survey method throughout our study period (1993–2005), with slight variations. Our surveys were conducted in mid-July; at this time, breeding European Storm-petrels are closer to the colony because the chicks need the attendance of their parents

(Ratcliffe et al., 1998; Cadiou, 2001). According to the dates obtained at this colony, 65% of nests were occupied by a chick in the middle of July (Minguez et al., 1995). In some years (1997 and 2001) the visit was postponed until the last week of July because of the rough seas, while in other years (1994, 1998, 2000, 2002), it was not possible to visit the colony, due to incessant bad weather or heavy seas. In 1995, fieldwork had to be interrupted because one crew member suffered an accident.

Three mist-nets (12 m long × 2.5 m high) were placed on the north-western slope of the island, parallel to the cliffs, for seven hours (from 22:30 to 5:30 h). The nets were always placed in the same way and location to facilitate among-year comparisons of capture rates and, thus, detection of changes in the number of breeding pairs or the distribution of the colony (Furness and Baillie, 1981). Our main goal was initially to monitor breeding European Storm-petrels at the colony. Therefore, we did not broadcast taped calls because this method increases the likelihood of capturing non-reproductive birds (Furness and Baillie, 1981).

### 1.3 Adaptation of methods to the *Prestige* oil spill

The above-mentioned methods were maintained throughout the study, but small adjustments were made to accommodate conditions caused by the oil spill. We increased sampling effort to detect the highest peak of appearance of the species on the island, and monitored the colony each fortnight (5 and 19 July and 2 August 2003, 10 and 23 July and 6 August 2004, and the 15 July and 12 August 2005). This sampling regularity was regarded as not harmful according to Blackmer et al. (2004), who avoided daily or weekly sampling. All of the European storm-petrels were measured. Their body condition was determined by the ratio of the maximal chord length of the wing and weight, and the status of moult was determined. Moreover, we selected 200 m of accessible cliff where European storm-petrels breed and all the nests were located and, subsequently, monitored. On the first visit, all nests were marked, while during the next visits of 2003 and the following years, the known nests were monitored and surrounding areas were searched to locate any other breeding pairs.

## 2 Results

### 2.1 Captures and recaptures

In the summers of 1990 and 1991, 350 European storm-petrels were trapped and ringed on Aketx Island, using the combined methods of mist-netting and tape lures. Among 14 sampling days of mist-netting from 1993 to 2005, we captured and ringed 1964 European Storm-petrels (Table 1). Consequently, 2 314 individuals have been ringed in the last 16 years, and 146 of them have been recaptured, some of them up to 6 times.

**Table 1** Number of captures (ringed European storm-petrels and controlled birds ringed by us) between 1993 and 2005

Date	Ringed	Recaptured	Total captures
July 13, 1993	134	7	141
July 12, 1995	87*	3	90*
July 12, 1996	198	6	204
July 30, 1997	164	11	175
July 15, 1999	178	9	187
July 24, 2001	232	10	242
July 05, 2003	144	6	150
July 19, 2003	122	16	138
Aug. 08, 2003	51	13	64
July 10, 2004	128	6	134
July 23, 2004	85	17	102
Aug. 06, 2004	36	12	48
July 15, 2005	190	14	204
Aug. 12, 2005	69	16	85
Total	1 818	146	1 964

\* On 12 July 1995 the ringing session was incomplete (until 2 am) due to an accident.

None of the European storm-petrels ringed in

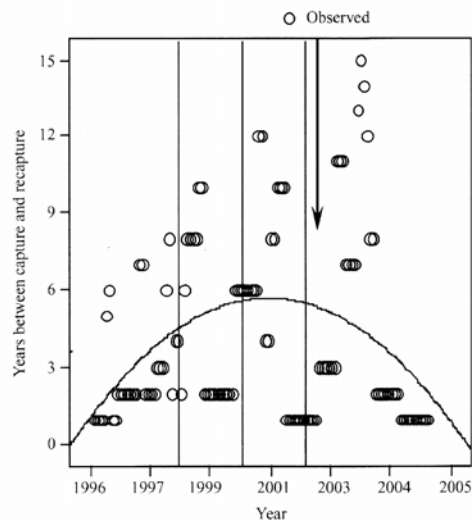
Aketx has been recorded elsewhere, and only one bird ringed elsewhere was recorded in the colony. It was captured on 2 August 2003 and had been ringed in Tenerife (Canary Islands, Spain) on 27 April 2002 (Data from the Ringing Office of San Sebastian, ESA).

There were significant differences in the number of captures between 1993 and 2005, considering only the highest capture-rates for each year ( $\chi^2 = 57.48$ ;  $P < 0.001$ ). The years 1993, 2003 and 2004 represented the lowest capture-rates during this period.

Ringed birds accounted for 5.6% of the total captures during the ringing period. The minimal age of the recaptured birds (number of years between when they were ringed and their recapture) was increasing through time until the oil spill, then started to decrease (Quadratic Function,  $R^2 = 0.15$ ,  $F = 41.119$ ,  $P = 0.0001$ , Fig.2). Most of the captured birds (97, 2%) had a complete and vascularised brood patch; hence, almost all the captured birds were breeding.

### 2.2 Reproduction

In 2003, we found 12 nests in the selected area; 10 of them lost the egg and only 2 chicks fledged. In 2004, we found only 6 nests in the selected area (4 within the 12 holes used the year before and 2 in different places): all of them were successful. In 2005, we found 15 nests in the selected area (12



**Fig.2** Yearly changes in the ages of storm-petrels in the study area

The age of storm-petrels is measured as the number of years passed from capture to recapture. The curve shows the quadratic function. The discontinuous lines represent the years without sampling. The arrow shows the date of the *Prestige* oil spill (2002).

within the 14 holes used the years before and 3 in different places): 14 were successful and only one lost the egg.

### 2.3 Body condition

Body condition measured as wing/weight ratios, as was represented by the samples collected during mid-July of 1993, 1995, 2003, 2004 and 2005, varied among years (ANOVA,  $n = 559$ ,  $df = 4$ ,  $F = 6.525$ ,  $P < 0.001$ ). There were significant among-year differences in body condition before the oil spill (1993 and 1995: mean 4.54,  $n = 128$ ) and the two years after the spill (2003 and 2004: mean 4.83,  $n = 227$ ; Duncan post hoc test). There also were differences in body condition between the two years immediately after the spill and the third year after it (2005: mean 4.48,  $n = 204$ ). Finally, there were no differences between the samples taken before the oil spill and the ones of 2005.

## 3 Discussion

The breeding population of the European storm-petrel in Aketx Island is subjected to strong oscillations. Variation in offshore weather or in food resources before laying, when females accumulate fat reserves for egg production, can account for up to 31% of the between-year variation in the size of this species' colonies (Hémerly et al., 1987). European storm-petrels are long-lived birds, reaching ages to at least 33 years (Staav\*). Likewise, 5% of the Leach's storm-petrel population is estimated to be older than 17 years (Huntington in Mauck and Grubb, 1995). Fittingly, we recaptured one bird aged 17 calendar years or more. Moreover, our recaptures were adult breeding birds.

Increased longevity could account for stability in the size of the colony under favourable environmental conditions. However, the rates of capture of birds on Aketx Island suffered significant variations that may depend on factors such as reduced availability of prey (Minguez and Vigil, 1995; Cadiou, 2001) or long periods of heavy storms that reduce their flight efficiency (Mauck and Grubb, 1995; Boersma and Parrish 1998; Sydeman et al., 1998). Likewise, European storm-petrels can interrupt their reproduction during periods of poor body condition (Butler et al., 1988; Mauck and Grubb, 1995). In fact, those authors suggest that this bird's reproductive behaviour is based on prioritising its own body condition. They even desert the nest if environmental conditions become unfavourable, implying great variations in numbers of reproductive birds from year to year. Therefore, variations after catastrophic events are expected to be extreme. In the case of the Aketx colony, dur-

ing the 2003 breeding season, when the *Prestige* oil was present everywhere, the number of captures of European storm-petrels was less than expected for the middle of July. To avoid the possibility of a delayed or advanced breeding period (Ratcliffe et al.; 1998; Cadiou, 2001; Insley et al., 2002), after the oil spill the sampling effort was increased to cover the main part of the breeding season of the species (Minguez et al., 1995; Cadiou 2001). In spite of this increased effort, the number of captures was not comparable to the previous rates.

This result is similar to what was expected for the Leach's storm-petrel suffering an oil spill: rejection or desertion of the eggs or chicks (Butler et al., 1988) or lower growth rates of chicks, because oiled adults do not feed them as often as they need to (Trievelpiece et al., 1984). Moreover, in our study, most of the controlled breeding pairs lost clutches and the body condition of the breeding birds was worse than before.

The high number of reproductive failures at Aketx Island would explain the decline in the number of captures over the summer. Initially, European storm-petrels returned in March (Cramp, 1985) from clean waters. They came back healthy, and most of them had a good body condition for laying eggs; however, as soon as reproduction began, and as soon as several waves of oil arrived, about three-quarters of the monitored breeding pairs failed reproductively.

We suggest that the spill was the main cause for the low hatching success and the low nesting success in 2003. The low number of fledglings on Aketx Island (16%) was similar only to colonies that have been subjected to extreme circumstances: for example, high rates of predation and flooding of nests in a Storm-petrel colony in eastern Spain (Minguez, 1994) or snow storms that entombed the entrance of the nests of Wilson's storm-petrels (*Oceanites oceanicus*; Büßer et al., 2004). However, with the exception of the oil spill, no great catastrophe occurred at Aketx Island.

Oil spills usually affect the whole food web unselectively (Irons et al., 2000; Golet et al., 2002; Wikelski et al., 2002; Peterson et al., 2003). Accordingly, one of the possible underlying mechanisms explaining the 2003–2004 failure rates in our study area could be a reduction in the abundance or availability of prey caused by exposure to oil during the previous winter and the breeding season, as has been shown for the Shag in Galicia (Velando et al., 2005). As a large amount of oil was spilled, it might be expected to have long-term effects in trophic

\* Staav R, 1998. Longevity list of birds ringed in Europe. EURING News Letter 2.

webs, probably becoming more noticeable as the breeding season progressed and favouring nest desertion. Similar effects have been described elsewhere, for example, El Niño-Southern Oscillation (a variation of the climatic regimen that perturbs coastal food webs and often reduces greatly the availability of seabird's prey) caused fewer ashy storm-petrels *Oceanodroma homochroa* to visit their colony and fewer still to reproduce (Sydeman et al., 1998).

In 2004, the number of captured storm-petrels was slightly less than the year before, suggesting that this population suffered a severe decline. Moreover, the number of pairs that began breeding in 2004 was even smaller and, although their body condition was slightly better than in 2003, it was worse than any one of the years before the oil spill. Unlike the situation in 2003, however, all of the clutches produced in 2004 were successful. Theoretically, sea conditions changed significantly from 2003 to 2004, and storm-petrels were not as exposed to oil in 2004 as they were in 2003. By contrast, during the breeding season of 2005, the number of birds attending to the colony was similar to that before the oil spill, the number of breeding pairs increased, almost all of them produced fledglings, and, remarkably, the body condition of adult birds was higher than the two previous years and similar to those before the oil spill.

These data show a recovery in the number of individuals and of breeding success; however, the reduction in the average minimal age of recaptured birds suggests an effect on population structure. The number of breeding young birds increased to replace the older birds which died after the oil spill. So this slight recovery of population is due to the recruitment of wandering birds. However, the age-ratio of a healthy population disappeared and until this structure is reached again, the population will not have completely recovered.

In conclusion, oil pollution caused by the wreck of the *Prestige* caused a reduction in the overall number of European storm-petrels and, more specifically, in the number of breeding pairs in the Aketx Island colony. However, an unknown but yet effective degree of connectivity between the islands of the Gulf of Biscay may have allowed wandering birds to take over vacancies and breed. Indeed, recruitment has been shown to prevent the decline of those seabird's populations (Butler et al., 1988; Boersma and Groom, 1993). Consequently, a spatially-explicit conservation plan is needed, considering conservation measures aimed at the cluster of islands where breeding is possible, with emphasis on Aketx Island. We have described short-term effects of the spill, but further studies must determine possible effects caused by sublethal bioaccumulation of pollutants in European

storm-petrels.

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