

STATUS AND DISTRIBUTION OF BREEDING SEABIRDS IN THE NORTHERN ISLETS OF LANZAROTE, CANARY ISLANDS

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Rodríguez B., de León L., Martín A., Alonso J. & Nogales M. 2003. Status and distribution of breeding seabirds in the northern islets of Lanzarote, Canary Islands. *Atlantic Seabirds* 5(2): 41-56. *We describe the results of a survey of breeding seabirds carried out between 2000 and 2002 in the northern islets of Lanzarote, Canary Islands, with particular emphasis on their status and distribution. For White-faced Storm-petrel Pelagodroma marina, Madeiran Storm-petrel Oceanodroma castro, Lesser Black-backed Gull Larus [fuscus] graellsii and Yellow-legged Gull Larus cachinnans atlantis, some new colonies were discovered on different islets. All species have maintained their numbers over the last 15 years, with the exception of the Yellow-legged Gull, which has undergone a well-documented increase; in 1987, about 400 breeding pairs were estimated but during the present study, almost 1000 pairs were counted. In addition, some comments on threats to these seabird populations are presented. On La Graciosa, feral cats are a major predator of the European Storm-petrel population, killing more than 50 birds during this study alone.*

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INTRODUCTION

The most important sites for seabirds in the Canarian archipelago are small uninhabited rocks or islets, generally where no introduced predators are present, such as Roques de Salmor (El Hierro), Roques de Anaga (Tenerife), Isla de Lobos (Fuerteventura) and especially the northern islets of Lanzarote (known as the Chinijo Archipelago; Martín & Hernández 1985; Martín & Nogales 1993; Martín & Lorenzo 2001). On the islets of Lanzarote, eight seabird species regularly breed: Bulwer's Petrel *Bulweria bulwerii*, Cory's Shearwater *Calonectris diomedea borealis*¹, Little Shearwater *Puffinus assimilis*, White-faced Storm-petrel *Pelagodroma marina*, European Storm-petrel *Hydrobates pelagicus*, Madeiran Storm-petrel *Oceanodroma castro*, Lesser Black-backed Gull *Larus fuscus graellsii*² and Yellow-legged Gull *Larus cachinnans atlantis*³.

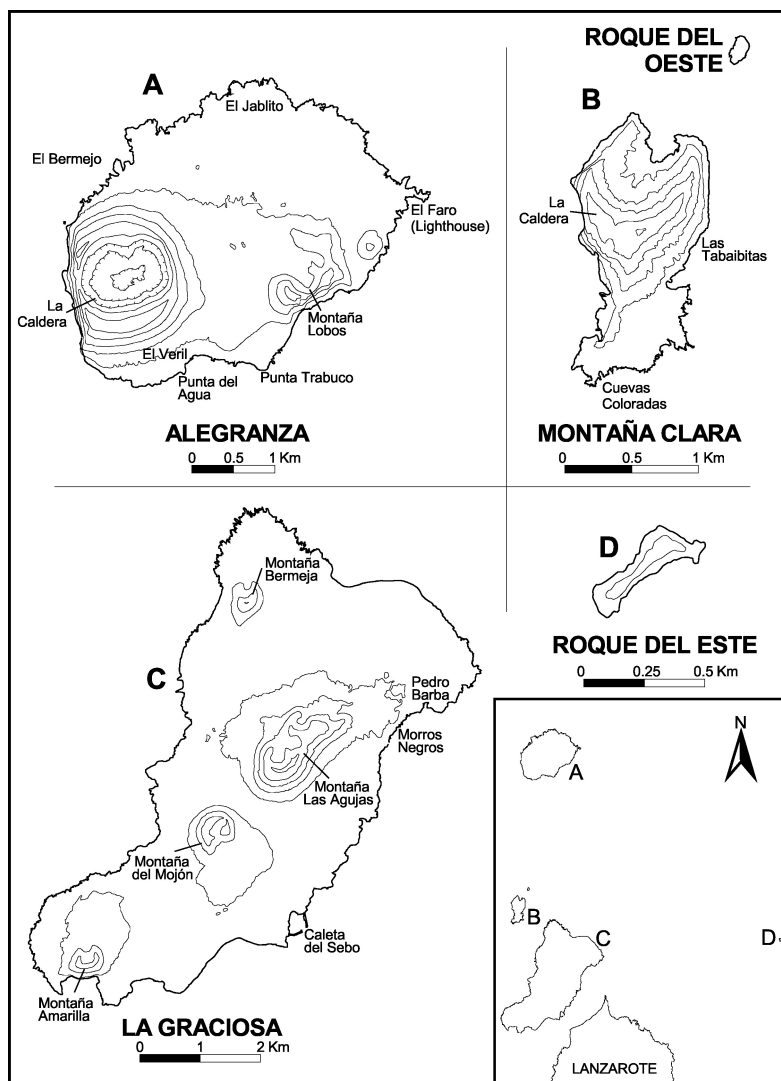


Figure 1. Maps of the northern islets of Lanzarote, Canary Islands, showing the locations of place names mentioned in the text.

Figuur 1. Ligging van de eilandjes ten noorden van Lanzarote (Canarische Eilanden), inclusief de namen van de plaatsen die in de tekst genoemd worden.

The Procellariiformes colonies present in the Chinijo Archipelago are of national importance and include the only extant colony of the White-faced Storm-petrel (Viada 1998; Martín & Lorenzo 2001; Martí & Del Moral 2003). Furthermore, the only Spanish colonies of Bulwer's Petrel, Little Shearwater and Madeiran Storm-petrel occur in the Canaries (Martí & Del Moral 2003). The breeding populations of Cory's Shearwater in this small archipelago represent at least 10% of the whole Macaronesian population (Granadeiro *et al.* 1997). The only known colonies of the European Storm-petrel in the Macaronesian archipelagos are located in the Canaries, and 34% of this population breeds in the Chinijo archipelago (Nogales *et al.* 1993).

Historically in La Graciosa, the extinct shearwater *Puffinus holeae* bred 25 000 years ago; this was a medium sized shearwater that nested in the eastern Canary Islands (Walker *et al.* 1990; Alcover & McMinn 1995). According to Torriani (1978), on the shearwater harvest, it is possible that this species survived on La Graciosa until the 16th century (Martín & Lorenzo 2001).

The importance of the Chinijo Archipelago for seabirds was first noted by Bannerman (1914a,b), who carried out an expedition with the principal aim of exploring these little-known islets and studying their birds. More recently, Lovegrove (1971) also provided new data on the distribution and abundance of seabirds.

The most recent available information on the status and distribution of the breeding seabirds on the Chinijo Archipelago was obtained from an extensive census carried out in the Canarian Archipelago during 1987 (Martín *et al.* 1987; Hernández *et al.* 1990; Delgado *et al.* 1992; Nogales *et al.* 1993). This paper reports the results of seabird surveys in these islets over a two year period (2000-2002); updated information of the status and distribution of the seabirds is presented.

METHODS

Study area The Canary Islands constitute a volcanic archipelago (27°37'-29°25'N, 13°20'-18°10'W) that is located 100 km off the Atlantic coast of north-west Africa. It comprises seven major islands and some small islets and rocks. The northern archipelago of Lanzarote consists of three islets and two small rocks: La Graciosa (with an area of 27 km² and 266 m altitude), Montaña Clara (1.3 km² and 256 m), Alegranza (10.2 km² and 289 m), Roque del Este (0.06 km² and 84 m) and Roque del Oeste (0.01 km² and 41 m; Martín & Lorenzo 2001; Fig. 1). The coastline is predominantly rocky with boulder shore, and cliffs up to 200 m. In some areas of La Graciosa, sandy beaches occur, formed by the accumulation of marine deposits. The climate is subtropical and oceanic. Oceanographic conditions in this archipelago are influenced by marine

Table 1. Total length of coastline, length of coastline surveyed (i.e. of suitable potential habitat) and proportion of the total suitable habitat surveyed for each islet of the Chinijo Archipelago.

Tabel 1. Totale lengte van de kustlijn, lengte van geïnventariseerde kustlijn (i.e. potentieel broedhabitat) en aandeel van de potentiële broedhabitat van ieder eilandje in de Chinijo Archipel.

Islet	Total length of coastline (km)	Length (km) and proportion (%) of suitable coastline surveyed
Roque del Este	1.4	1.4 (100)
Aleganza	20	18.7 (93)
Roque del Oeste	0.6	0.6 (100)
Montaña Clara	8.9	6.6 (74)
La Graciosa	37.5	37.5 (100)

upwelling that occurs off the north-west African coast. All islets are now uninhabited, except La Graciosa where approximately 650 people live (most of them employed in fishing). This archipelago, together with “Riscos de Famara” (Lanzarote), constitutes a natural park, harbouring several endemic plant and animal species. The xeric vegetation is dominated by some shrub species (see Kunkel 1971; Marrero 1991).

Survey methods Fieldwork was carried out from July 2000 to July 2002 in three distinct periods, coinciding with egg-laying to the unfledged young period of each target species (autumn for Madeiran Storm-petrel; spring for Little Shearwater, White-faced Storm-petrel and Yellow-legged Gull; and summer for Bulwer’s Petrel, Cory’s Shearwater, European Storm-petrel and Lesser Black-backed Gull).

All the islets are small enough to allow a complete survey of all suitable habitats for each species. In general, the most suitable breeding habitat for Procellariiformes comprises rocky coasts, volcanic caves, boulder beaches, volcanic badlands, dry stone walls, terrain plains (mainly for Cory’s Shearwater) and sandy areas (especially for White-faced Storm-petrel). All potential coastal sectors for each target species were surveyed in the different islets (Table 1). Interior areas were surveyed by three to 10 observers, following line transects 50 m apart in all suitable areas, for Bulwer’s Petrel and Cory’s Shearwater burrows, and also for counting gull nests.

In the case of the Procellariiformes, only burrows with signs of occupation were counted (i.e. containing faeces, tracks, odour, eggshells, etc.), flashlights being used to inspect the insides of burrows. It is difficult to estimate exactly the number of breeding pairs in a colony, since only a fraction of the

breeding birds are detected. Some burrows may go unnoticed and others are occupied by immature pre-breeders that merely visit the colonies. Furthermore, certainly for the Cory's Shearwater, more than one pair might breed in many of the burrows or caves. In order to estimate their populations, therefore, burrows were classified in three different types with respect to their occupation, following the method employed by Martín *et al.* (1991) in Alegranza.

Due to the methodological problems and the limitations mentioned, we made only crude estimates of the sizes of Procellariiform populations. These were obtained by a combination of direct nest counts (all species) and captures in mist nets (small Procellariiformes), entrance control burrows (Cory's Shearwater) or by nocturnal listening (Little Shearwater and Madeiran Storm-petrel).

For the small Procellariiformes, mist netting (using 9 m nets) began just after nightfall. The duration of these sessions lasted between 2 and 3 hours, and repeated at least twice in each colony. All birds captured were ringed, but the small sample size did not allow us to use capture-recapture methods for estimating colony sizes.

Nocturnal listening (mainly on moonless nights) at potential sites for Little Shearwater and Madeiran Storm-petrel was carried out by between two and 10 fieldworkers. In areas where a nest was found, breeding was assumed when regular nocturnal activity was recorded and estimates were made based on the intensity of birds calling in flight. Calling rate and abundance range of Little Shearwater followed the estimation method applied by Monteiro *et al.* (1999). In the case of the Madeiran Storm-petrel, calling rate and maximum number of captured birds in selected colonies was used to estimate the total number of birds. For the small population of the White-faced Storm-petrel, an endoscope was employed to explore the interior of burrows excavated in sandy areas.

Due to the ease of detecting gull colonies, situated mainly on the slopes of the mountains, these areas were carefully censused. Whenever possible, gull nests were counted individually but at inaccessible places, binoculars were used to estimate the number of pairs based on breeding behaviour of the adults.

RESULTS AND DISCUSSION

Results are presented for each species in turn and for each islet. Table 2 summarises population size estimates made over the previous three decades.

Bulwer's Petrel With the exceptions of Fuerteventura and Gran Canaria, where no precise data exist, this small Procellariiforme breeds in all other Canary Islands. The overall estimate of the whole Canarian population

Table 2. Estimated number of breeding pairs of each seabird species in the northern islets of Lanzarote, 2000-2002 (this study) and in recent decades.

Tabel 2. Schatting van het aantal broedpaar per soort op de eilandjes ten noorden van Lanzarote in 2000-2002 (deze studie), vergeleken met de afgelopen decennia.

Species	Roque del Este	Alegranza	Roque del Oeste	Montaña Clara	La Graciosa
<i>Bulwer's Petrel</i>					
Lovegrove (1971)	-	-	-	c. 100	-
Hernández <i>et al.</i> (1990)*	-	75-100	10	>100	-
Concepción (1992)	-	100-130	-	>100	-
PRESENT STUDY	-	150-200	10	100-130	5?
<i>Cory's Shearwater</i>					
le Grand <i>et al.</i> (1984)	10-15	-	-	-	-
Martín <i>et al.</i> (1987)	<50	-	25	1000	c. 160
Martín <i>et al.</i> (1991)*	-	8000-10 000	-	-	-
Concepción (1992)	8-10	9000-12 000	3-4	600-800	50
PRESENT STUDY	50	10 000-12 000	25	1000-1500	300
<i>Little Shearwater</i>					
Martín & Lorenzo (2001)*	-	some pairs	-	<50	-
PRESENT STUDY	-	10?	-	20-50	-
<i>White-faced Storm-petrel</i>					
Martín <i>et al.</i> (1989)*	-	-	-	10	-
PRESENT STUDY	-	10-15	-	30-40	?
<i>European Storm-petrel</i>					
Delgado <i>et al.</i> (1985)	<10	>100	-	c. 50	1
Nogales <i>et al.</i> (1993)*	20-30	hundreds	20-30	>100	-
PRESENT STUDY	20-30	200-300	10	100	10-20
<i>Madeiran Storm-petrel</i>					
Delgado <i>et al.</i> (1989)*	-	some pairs	-	some tens	-
Concepción (1992)	1	50-70	-	20-40	-
PRESENT STUDY	5	50-100	10	50-70	?
<i>Lesser Black-backed Gull</i>					
Grande & Palacios (2002)	-	>5	-	-	-
PRESENT STUDY	-	10	-	5	-
<i>Yellow-legged Gull</i>					
Lovegrove (1971)	c. 20	-	-	c. 20	-
le Grand <i>et al.</i> (1984)	15-20	-	-	-	-
Delgado <i>et al.</i> (1992)*	35-40	35-41	1	235-245	-
PRESENT STUDY	20	200	-	800	10-20

* data refer to 1987

is about 1000 pairs (Hernández *et al.* 1990), representing 13% of the total population of the Macaronesian archipelagos (Zino *et al.* 1994).

Alegranza A total of 143 burrows was counted, located mainly in the north of the islet. The largest colony is situated near El Bermejo (Fig. 1). Some pairs occasionally breed in burrows excavated by the White-faced Storm-petrel (as occurs in Montaña Clara) and usually breed on “badlands” situated centrally. Although our data do not allow us to determine the precise population, it is possible that there are about 150-200 pairs.

Roque del Oeste Only seven occupied nests were located and the total population is probably not more than 10 pairs; this accords with the data of Hernández *et al.* (1990) (Table 2).

Montaña Clara The species breeds widespread but mainly in Cuevas Coloradas and north-west rocky areas of the interior of La Caldera. A total of 99 burrows with breeding evidence was counted, but the actual size of the population is greater (Table 2).

La Graciosa The species seems to be very scarce here, and was detected only by the presence of wing and feather remains, probably a consequence of feral cat predation. These were observed in three different sites (only one with breeding evidence) on the west coast between Montaña Amarilla and Montaña Bermeja.

Cory's Shearwater This is the most common seabird in the Canary Islands with a total estimated population of more than 30 000 breeding pairs (Le Grand *et al.* 1984; Martín & Lorenzo 2001). The Alegranza colony is the largest in the Canaries with more than 10 000 pairs (Martín *et al.* 1991; Table 2) and one of the most important in the world together with Selvagem Grande, Zembra Island, and some islands of the Azores archipelago (Monteiro *et al.* 1996; Mougín *et al.* 1996; Thibault 1993). It is important to highlight the recovery of eight birds in Alegranza, some of them nesting, originally ringed in Selvagem Grande (Martín & Lorenzo 2001; *pers. obs.*), indicating a link between these colonies.

Roque del Este This site was thoroughly searched and the minimum population is 47 pairs. In a census carried out in 1987, only 31 occupied burrows were located, and a total of no more than 50 pairs were estimated (Martín *et al.* 1987).

Alegranza Although the species breeds widely, the most significant concentrations are located along the north coast and the southern part between El Veril and Punta Trabuco. A total of 6 308 apparently occupied burrows was counted, but given that at least 37 individuals birds entered a single burrow in one night, the true population size might be around 10 000-12 000 pairs.

Roque del Oeste This site was accurately surveyed; 25 pairs were located.

Montaña Clara The species breeds widely here, although the main population is located in the interior of La Caldera and close to Cuevas Coloradas. A total of 917 occupied burrows was counted; in some of them (situated in Cuevas Coloradas), up to 53 individuals were observed entering. The population can be estimated at 1 000-1 500 pairs.

La Graciosa Currently, some individuals are still killed and consumed by local people. Despite the surface of the islet, only 290 occupied burrows were counted. The main colonies are situated in Montaña Amarilla, Montaña de las Agujas, Montaña del Mojón and Morros Negros. The total population is about 300 pairs.

Little Shearwater Although there are signs of the presence of this poorly known species in all the Canary Islands, the only breeding records exist on Alegranza, Montaña Clara, Lanzarote, Tenerife and La Gomera; the population was estimated at around 400 pairs in 1987 (Martín & Lorenzo 2001).

Alegranza The species occurs in two different places: near the lighthouse and at Punta del Agua. Previously, it occurred also in Montaña de Lobos and in some places along the north coast (Lovegrove 1971, Martín & Lorenzo 2001). It was more abundant in the past according to A. Pallarés (*pers. comm.*), referring to the harvesting of young in Montaña de Lobos (in the period 1957-1969).

Montaña Clara Although the Little Shearwater is scarce on this islet, this is nevertheless one of the most important Canarian colonies. Only five occupied burrows were recorded but in six different places we discovered signs of its presence. Given the relatively high number of individuals heard in La Caldera, the population size must be higher, perhaps 20-50. The presence of a small colony in La Caldera was previously noted by Bannerman (1914a,b) and by Lovegrove (1971).

La Graciosa No breeding records exist on this island although one individual was observed in flight in Caleta del Sebo on 15 March 2001. In the past, Bannerman (1914a,b) mentioned a small colony that has been deserted at the time of his visit. According to Lovegrove (1971), the species bred on the islet but no details were presented.

White-faced Storm-petrel Until the present survey, the only known small colony of this species in the Canarian Archipelago was located in a small sandy area of Montaña Clara (Martín *et al.* 1989). During this study, we confirmed breeding on Alegranza for the first time; there is some circumstantial evidence that it also occurs on La Graciosa.

Alegranza In August 2001, a new colony was discovered near El Jablito, the only place of organic sands on the islet. A total of 23 burrows was counted but only five were apparently occupied that year (Table 2). In one burrow, we collected an abandoned egg. On another visit to the colony on 7 June 2002, we counted 35 burrows, and six individuals were captured with two mist nets in 2 hours. Other suitable parts of the islet might repay closer study. The only previous information on the species is a sighting of two live individuals plus two others depredated by Barn Owls *Tyto alba* (O. Trujillo *pers. comm.*; *pers. obs.*).

Montaña Clara The first breeding record in the Canaries was obtained on this islet in 1987, with an estimate of about 10 breeding pairs (Martín *et al.* 1989). The only known colony is situated in the sandy areas of the southern plateau and consists of 30-40 breeding pairs. During spring 2000, a total of 90 burrows was counted but only 34 were occupied (F. Rodríguez *pers. comm.*). It is possible that all small chicks of that year were killed by the endemic Canarian Shrew *Crocidura canariensis*.

La Graciosa Although this island contains much suitable habitat for the White-faced Storm-petrel, no breeding data are available. During the present study, only three dead individuals, apparently depredated by feral cats *Felis catus*, were found (J. Cabrera *pers. comm.*; *pers. obs.*). However, in sandy areas of the north-east we observed a hole, which according to its appearance, dimensions and situation, could have been a burrow of this species. It is possible that further and more exhaustive investigation might reveal the existence of new colonies.

European Storm-petrel The Canarian population breeds in the northern islets of Lanzarote, Isla de Lobos (Fuerteventura), Roques de Anaga (Tenerife), La Gomera and Roques de Salmor (El Hierro), and was estimated to number more than 1000 breeding pairs in 1987 (Nogales *et al.* 1993; Table 2). The Chinijo Archipelago and Roques de Salmor constitute the largest breeding colonies of the Canaries (Martín & Hernández 1985; Nogales *et al.* 1993).

Roque del Este Eighteen occupied nests were located and the population could be around 20-30 breeding pairs.

Alegranza Of all Canarian sites, the species is probably most numerous here (Nogales *et al.* 1993). It breeds in several places on the northern and southern coasts but scattered pairs also nest in other localities such as La Caldera and Montaña de Lobos. A total of 190 occupied burrows was counted, mainly near El Bermejo. Although it is difficult to assess the actual population size, our data agree well with previous estimates of several hundred pairs (Table 2).

Roque del Oeste Only five occupied nests were found and it is likely that no more than ten pairs breed.

Montaña Clara A total of 31 occupied burrows was counted, mainly located in the area known as El Bermejo. True population size might be about 100 pairs given the abundance of tracks and individuals that enter some of the Cuevas Coloradas caves.

La Graciosa At least eight pairs bred in August 2000, all in the same cave near Montaña Bermeja. It was also detected in two places along the north coast and near Pedro Barba.

Madeiran Storm-petrel This species breeds on Lanzarote and surrounding islets and rocks, and also on some small rocks off Tenerife and El Hierro; however, potential sites (rocks and other areas that are inaccessible from land) in other parts of the islands have not been examined in winter (the breeding season) due to difficult sea conditions. The estimated population in the Canaries numbers about 300 pairs (Delgado *et al.* 1989). In other Macaronesian archipelagos (Azores and Madeira), the existence of two types that breed in different seasons, cool and hot (Monteiro & Furness 1998; Nunes 2000), has been confirmed. In the Canary Islands, this storm-petrel breeds in autumn (cool season), but calling birds have also been heard on Alegranza and Montaña Clara in July-August (Martín & Lorenzo 2001; *pers. obs.*). Furthermore, the capture of one individual with a brood patch on Alegranza in August 2001, suggests the existence of a small hot season population.

Roque del Este The first breeding record was obtained on 18 October 2000 when one abandoned egg was collected in a crevice. The only previous information on its presence comes from a dead individual and another observed inside a burrow (Concepción 1992). The number of breeding pairs must be very small (Table 2).

Alegranza It occurs in many places on the islet, but mainly along the north coast, and in the area between El Veril and Punta Trabuco. Only one individual was observed incubating in El Veril. Other evidence of its presence consists of nocturnal calls and individuals captured in mist nets. Our results do not allow us to derive an accurate estimate of total population size, but it is possible that 50-100 pairs breed.

Roque del Oeste In November 2000, one individual was recorded incubating and at least three more were observed inside their holes; these data constitute the first breeding record on this rock.

Montaña Clara Nocturnal calls and mist net captures indicate that Madeiran Storm-petrels are widely distributed here; they seem to favour the southern part of the islet. However, only one breeding record was obtained. Again it is very difficult to estimate population size but according to Delgado *et al.* (1989) only about 10 pairs breed on the islet (Table 2).

La Graciosa The only record obtained from this islet was of an individual calling at night in October 2000 in the north, possibly indicating the existence of a few breeding pairs.

Lesser Black-backed Gull Until spring 2001, the Lesser Black-backed Gull was considered solely as a winter visitor to the Canaries; 22 individuals ringed in the United Kingdom, Denmark, Norway, the Netherlands and Iceland have been recovered in the archipelago (Martín & Lorenzo 2001). Godman (1872) commented on the possibility that this species might breed in the archipelago given its abundance. Bannerman (1912) suggested that they bred on Alegranza, although in his later publications he did not mention it (Bannerman 1914a, 1919).

Alegranza Since spring 2001, we have observed some individuals exhibiting breeding behaviour in the Yellow-legged Gull colonies. On 4 May 2001, one nest containing three eggs, and two birds apparently guarding another nest, were discovered in La Caldera (Grande & Palacios 2002). In June 2002, four nests with eggs were located in a Yellow-legged Gull colony in a plain near El Faro. From observations of individuals during the breeding season, it is possible that the population comprised 10 breeding pairs.

Montaña Clara The first breeding record on this islet was on 6 June 2002 in La Caldera when two nests with eggs were located. Before this, birds were observed in pairs on many occasions during 2000-2001.

The western part of the breeding range of the Lesser Black-backed Gull has expanded since the early 20th century (Pons & Yésou 1997). These breeding records in the Chinijo Archipelago might be the first step in colonization of the other Canary Islands.

Yellow-legged Gull Until recently, the Yellow-legged Gull was the only gull breeding regularly in the Canary Islands (Martín & Lorenzo 2001). The population was estimated in 1987 at 4 000-4 700 pairs (Delgado *et al.* 1992), but now is certainly higher. In previous decades, the species increased not only in the Canaries (Delgado *et al.* 1992), but throughout most of its breeding range (Cramp & Simmons 1983; Carrera 1997; Skornik 1997).

Roque del Este A total of 16 nests was counted on 18 May 2001, situated mainly in the north-east of the rock.

Alegranza The number of breeding pairs increased from 35-45 in 1987 to 181 counted in 2001 (Delgado *et al.* 1992; Table 2). The distribution has grown from the northern top of La Caldera to the base and to other areas in the centre of the islet where scattered pairs breed. It is interesting to note the establishment of a relatively large, new colony near El Faro, where a few pairs of Lesser Black-backed Gull also breed.

Roque del Oeste No breeding evidence was found during this study but in August 1987, one nest was recorded (Delgado *et al.* 1992).

Montaña Clara A total of 792 nests was counted, most of them located in La Caldera and Las Tabaibitas. In common with Alegranza, the number of breeding pairs has increased notably (Table 2); some nests are located on the eastern plateau.

La Graciosa Until our discovery of five occupied nests in Montaña Amarilla in July 2002, the Yellow-legged Gull was considered to be a common non-breeding visitor.

THREATS AND CONSERVATION

Seabird populations on the northern islets of Lanzarote have been negatively affected by some human activities, with introduced predators and human exploitation being of particular importance.

Introduced predators, mainly domestic cats and rats *Rattus* spp., are one of the major conservation threats to seabirds throughout the world (Moors & Atkinson 1984; Burger & Gochfeld 1994). Small petrels are particularly affected because of their small size and vulnerability to predators.

In Alegranza, the presence of feral cats in the past may have been an important threat to seabirds, but in the last 20 years only a few individuals have been present, and their impact was probably minimal because they fed mainly on rabbits *Oryctolagus cuniculus* and mice (Nogales *et al.* 1992). The last cat on this islet was removed in 1998. On La Graciosa, feral cats are still very abundant and the available evidence indicates that they are the main cause of the recorded decreases in the size of breeding seabird populations. Delgado *et al.* (1985) noted the likely role of cats in the destruction of the main European Storm-petrel colony of this islet in 1983, and in September 2000 and August 2001, the remains of at least 54 individuals of this species were found dead together in the same place.

Natural predators such as Eleonora's Falcon *Falco eleonorae*, the Barn Owl, and the Common Raven *Corvus corax* are known to kill adults or chicks mainly of small Procellariiformes (Martín *et al.* 1989; Delgado 1993; Nogales & Hernández 1994; *pers. obs.*) but although they can be locally important, their overall impact is small. However, in Montaña Clara the Canary Shrew reputedly preys heavily upon White-faced Storm-petrel chicks, and the Yellow-legged Gull predation might become an important threat if its population increases further.

Damage to vegetation, competition or destruction of the breeding sites is the most important effect of alien herbivores on seabirds (Bell 1995; Priddel *et al.* 2000). On the islet of Montaña Clara, rabbits may have destroyed some

burrows of the White-faced Storm-petrel (Martín *et al.* 1989), but a rabbit eradication plan has been implemented recently, and is thought to have been successful. In Alegranza, however, rabbits remain plentiful and they could affect the small colony of this species here.

The long-established tradition of harvesting well-grown chicks of the Little Shearwater and especially Cory's Shearwater for food, oil or feathers on these islets no longer occurs (Martín & Nogales 1993; Martín & Lorenzo 2001). On Alegranza, at the end of the 19th century, 12 000 Cory's Shearwater chicks were caught annually; the slaughter was reduced to half that number during the middle of 20th century (Hernández-Pacheco 2002; de la Hoz 1962). On Montaña Clara, Little Shearwaters – called “tahoces” – were collected as chicks by people from Lanzarote (Bannerman 1914a) and this also occurred on Alegranza in the period 1957-1969 (A. Pallarés *pers. comm.*). On Alegranza, Bulwer's Petrels also were harvested in great numbers (Bolle 1855). This exploitation clearly indicates that these species were more abundant in the past and perhaps current populations are only now exhibiting a slow recovery. All these species are now legally protected but some Cory's Shearwaters are still captured illegally, mainly on Alegranza and La Graciosa.

These islets, together with the nearby cliffs of Famara (Lanzarote), have constituted a Natural Park since 1986; in addition, Montaña Clara, Roque del Oeste and Roque del Este were declared a Natural Reserve in 1994, with access allowed only for research and conservation purposes. This region has now also been recognised as an Important Bird Area (Viada 1998) and as a Special Protection Area under the EU Birds Directive (EEC 1979).

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AANTALLEN EN VERSPREIDING VAN BROEDENDE ZEEVOGELS TEN NOORDEN VAN LANZAROTE OP DE CANARISCHE EILANDEN

Dit artikel beschrijft de resultaten van een inventarisatie van broedende zeevogels die in 2000-2002 werd uitgevoerd op eilandjes ten noorden van Lanzarote (figuur 1). De nadruk van de inventarisatie lag op het vaststellen van de aantallen en verspreiding. Aantalsschattingen werden gemaakt van

Bulwers Stormvogel *Bulweria bulwerii*, Kuhls Pijlstormvogel *Calonectris borealis*, Kleine Pijlstormvogel *Puffinus assimilis baroli*, Bont Stormvogeltje *Pelagodroma marina*, Stormvogeltje *Hydrobates pelagicus*, Madeira Stormvogeltje *Oceanodroma castro*, Kleine Mantelmeeuw *Larus graellsii* en Geelpootmeeuw *Larus michahellis atlantis* (tabel 2). Op verschillende eilandjes werden nieuwe kolonies ontdekt van Bont Stormvogeltje, Madeira Stormvogeltje, Kleine Mantelmeeuw en Geelpootmeeuw. De aantallen van alle soorten zijn de laatste 15 jaar vrijwel gelijk gebleven, uitgezonderd de Geelpootmeeuw. De toename van deze soort is goed gedocumenteerd: in 1987 werd de populatie geschat op 400 paar, in 2003 werden ca 1000 paar geteld. Dit artikel eindigt met een paragraaf over bedreigingen van de beschreven zeevogelpopulaties. Op La Graciosa zijn verwilderde katten een belangrijke predator van Stormvogeltjes; tijdens de inventarisatie in 2000-2001 alleen al werden restanten van meer dan 50 dode vogels gevonden.

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¹ *Calonectris diomedea borealis* is considered as *Calonectris borealis* on the Dutch List (Sangster et al. 1999).

² *Larus fuscus graellsii* together with *L. f. intermedius* are considered conspecific and known as *Larus graellsii* on the Dutch List (Sangster et al. 1999).

³ *Larus cachinnans atlantis* is considered as *Larus michahellis atlantis* on the Dutch List (Sangster et al. 1999).

MASS MORTALITY OF ATLANTIC PUFFINS *FRATERCULA ARCTICA* OFF CENTRAL NORWAY, SPRING 2002: CAUSES AND CONSEQUENCES

TYCHO ANKER-NILSSEN¹, TOMAS AARVAK¹ & GEORG BANGJORD²

Anker-Nilssen T., Aarvak T. & Bangjord G. 2003. Mass mortality of Atlantic Puffins *Fratercula arctica* off Central Norway, spring 2002: Causes and consequences. *Atlantic Seabirds* 5(2): 57-72. In late March and early April 2002, at least 300 dead or dying Atlantic Puffins *Fratercula arctica* were reported beached on the coast of Central Norway between 62°30' and 65°00'N. Post-mortem examinations of 30 individuals, 93% of which were adult birds, revealed that they had starved. No signs of injuries, parasites, diseases or external contamination were found, but levels of accumulated contaminants were not measured. The most likely origin of these birds were breeding sites at or in the vicinity of Røst (c. 450,000 pairs in 2001) 400-600 km further north. Based on a large difference between expected and observed adult survival rate for Atlantic Puffins at Røst between 2001 and 2002, it is possible that as many as 100,000 puffins died in this unusual but seemingly minor incident.

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INTRODUCTION

The Atlantic Puffin *Fratercula arctica* is the most abundant seabird in Norway with a total breeding population of 1.5-2 million pairs, most of which breed in colonies along the Norwegian Sea (Anker-Nilssen 1991; unpubl. data). The largest colonies in this area are in the Røst archipelago (c. 67°30'N 12°00'E), where breeding numbers decreased by 73%, from almost 1.5 million pairs in 1979 to less than 0.4 million pairs in 2002 (Anker-Nilssen & Røstad 1993; Anker-Nilssen & Aarvak 2003). This massive decline was primarily explained by frequent reproductive failures due to shortage of young herring *Clupea harengus* after the Norwegian spring-spawning stock collapsed in the late 1960s (e.g. Anker-Nilssen 1992; Durant *et al.* 2003) and, occasionally, reduced survival of adults (Anker-Nilssen & Aarvak 2003). North and south of the Norwegian Sea, chick diet is mainly based on other prey species, and populations have been stable or slightly increasing (Barrett *et al.* 1987; Barrett 2001, 2002; Lorentsen 2003).

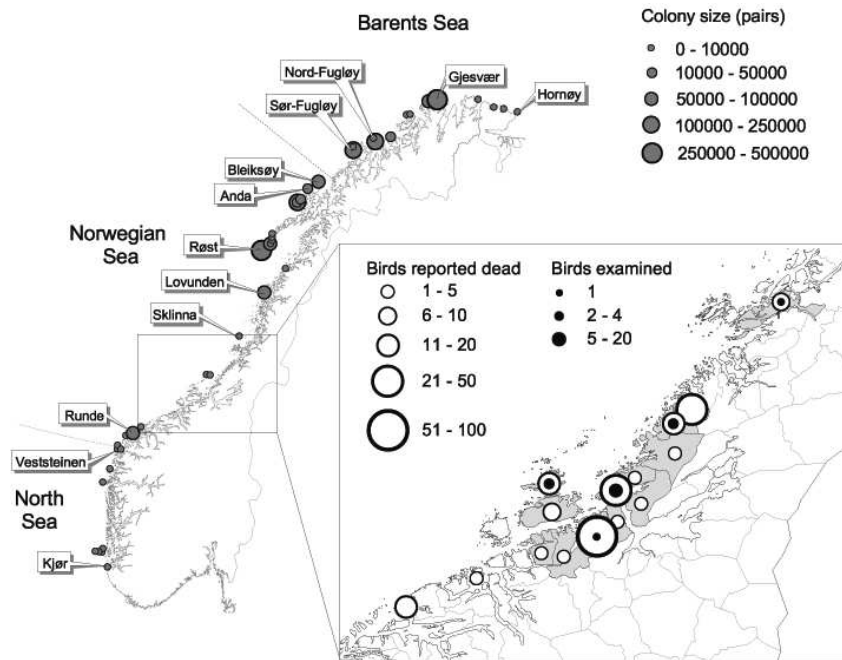


Figure 1. Geographical position of Norwegian colonies of Atlantic Puffins mentioned in the text, the area where Puffins were beached (box), and indications of the distribution by municipality (grey areas) of numbers of individuals reported dead (white circles, $n = 206$) and examined (black circles, $n = 30$).

Figuur 1. Ligging van de Noorse kolonies van Papegaaiduiker die in de tekst worden genoemd, het gebied waar Papegaaiduikers aanpoelden en de verspreiding per gemeente (grijs) van het aantal gemelde slachtoffers (witte rondjes, $n = 206$) en het aantal onderzochte slachtoffers (zwarte rondjes, $n = 30$).

No factors other than those directly or indirectly affecting food supply during the breeding season have been documented to affect population parameters of Atlantic Puffins in Norway (Anker-Nilssen & Tatarinkova 2000). However, the movements and diets of these birds outside the breeding season and, consequently, the environmental conditions they experience at that time of year, are not well known (Anker-Nilssen *et al.* in prep.). It is therefore difficult to assess to what degree factors such as various sources of pollution and extreme weather events affect the highly variable survival of adults between breeding seasons (Anker-Nilssen & Aarvak 2003). The distribution of non-breeding Atlantic Puffins is more pelagic and less aggregated than that of other auks

(Harris 2002). This probably explains why there are few incidents reporting large numbers of beached Atlantic Puffins (Camphuysen 2003). However, it is difficult to determine if this is mainly because they (for the same reasons) are less likely to be hit (e.g. by oil spills) or less likely to beach in significant numbers if they die at sea.

Massive die-offs (wrecks) of emaciated seabirds are known to occur irregularly but relatively frequently in many areas of the NE Atlantic (Blake 1984). Long periods of starvation and extreme weather events (or a combination of both) are the most likely reasons for such incidents, although it is usually impossible to identify the actual cause for any given event. Unfortunately, the possibility that the birds had initially been exposed to hazardous chemicals, or something else rendering them unable to feed, is rarely examined as such causes are both difficult and expensive to establish.

Also, the possible consequences of the incidents at the population level are rarely explored in any detail (Harris *et al.* 2000). One reason is that it may be difficult to determine the origin of wrecked seabirds. For most auks in the NE Atlantic, however, morphometric data for breeding birds are available from a large number of colonies throughout most of the birds' breeding range. These species form geographical races that are relatively distinct in size and often there is also a clinal increase in size with increasing latitude or decreasing sea temperatures in their breeding areas (Barrett *et al.* 1985; Anker-Nilssen *et al.* 1988; Barrett *et al.* 1997; Moen 1991). Thus, by comparing the sizes of wrecked adult birds with those measured at their colonies, it may be possible to identify the core areas from which they originated. Often, a large proportion of beached auks are immatures that have not yet reached the size of adults, making the use of biometry less applicable, but such incidents are less likely to be the most severe in terms of their effects on breeding numbers (Harris *et al.* 2000). Moen (1991) explored differences in body size and allozyme patterns within and among five Atlantic Puffin colonies, and found that they exhibited significant differences in size without significant differences in genetic structure. Thus, differences in body size might to a large degree be phenotypic rather than genotypic. As more refined genetic methods are not available to explore differences on small spatial scales (e.g. Moum & Árnason 2001), biometric comparison is still the most precise and cost effective way to assess the origin of dead birds outside the breeding season.

In late March and early April 2002, many dead and moribund Atlantic Puffins were beached on the coast of Trøndelag, Central Norway. The first birds were found on 26 March and from numerous reports received daily by local authorities it was soon realised that the extent of the incident was extraordinary, with varying numbers of dead puffins found along the whole coastline between 62°30'N and 65°00'N (Fig. 1). Large numbers of adult

puffins are rarely observed close to the coast in this area and to the best of our knowledge, massive wrecks of puffins have never previously been registered so far north. No other species were found dead in significant numbers, but many more live puffins were seen at sea close to the shores. No puffins were reported oiled, but many were described as behaving abnormally, seemingly confused and unable to escape approaching humans. With no systematic procedures, the environmental office of the county governor of Sør-Trøndelag registered reports of at least 300 dead Atlantic Puffins (with exact positions known for 206 individuals) and organised the collection of some of these birds. Based on post-mortem examinations and results from the regular monitoring of Norwegian Puffin colonies, this study aims to identify the most likely causes for the wreck, the location of the birds' breeding areas, and the consequences, if any, of the incident at the population level.

METHODS

Post-mortem examinations The external and internal morphology of 30 dead Atlantic Puffins collected during 1-9 April 2002 were examined following the procedures described by Jones *et al.* (1982). Age was determined by the number of bill grooves on the red outer part of the upper mandible (Petersen 1976). Wing length ($n = 28$) was measured as the maximum flattened cord to the nearest 1 mm using a stopped ruler. Culmen length ($n = 30$), total head length (head+bill, $n = 22$) and bill depth at gonys ($n = 26$) were measured to the nearest 0.1 mm with vernier callipers. Sex was determined by inspection of gonads (when present; $n = 19$). Whole carcasses ($n = 14$) were weighed to the nearest 1 g using an electronic balance. If intact and sufficiently fresh, the left breast muscle was carefully removed and weighed to the nearest 1 g ($n = 9$). Three of the adult birds were also autopsied by Kjell Handeland, National Veterinary Institute, Section for Wildlife Diseases, Oslo, who also undertook histological inspection of brain, eyes, lungs, heart muscle, liver and kidney.

Origin Biometric parameters reported by Barrett *et al.* (1985) for breeding Atlantic Puffins in 12 different Norwegian colonies (Fig. 1) were used as baseline reference data for comparisons. This was justified by the mean wing length of adult birds in our sample being close to the centre of the clinal distribution of this parameter with latitude along the Norwegian coast (Barrett *et al.* 1985). We improved the relevance of the cline by substituting latitude with mean sea surface temperature (SST) in April-August within 100 km of each colony during 1950-99, since SST is more likely to affect the morphology of seabirds than light conditions. SST data were provided by Steve Worley from the Hadley Centre for Climate Prediction and Research and summarized by

Table 1. Size parameters (mean \pm 1 SE) for adult Atlantic Puffins beached in Central Norway, spring 2002. Measurements in mm, mass in g. Sample sizes are indicated in brackets.

Tabel 1. Biometrische gegevens (gemiddelde \pm 1 SD) van adulte Papegaaiduikers die voorjaar 2002 zijn aangespoeld in centraal Noorwegen. Lengtes in mm, gewicht in g. Steekproefgrootte staat tussen haakjes.

Sex	n	Wing	Head+bill	Culmen	Gonys	Body mass
Males	11	174.6 \pm 1.45 (11)	83.0 \pm 0.45 (10)	47.9 \pm 0.35 (11)	36.2 \pm 0.69 (10)	339.8 \pm 9.8 (9)
Females	7	168.3 \pm 1.91 (6)	81.1 \pm 0.80 (5)	45.3 \pm 1.00 (7)	31.9 \pm 0.92 (7)	329.3 \pm 23.3 (4)
All	28	172.0 \pm 1.2 (24)	82.2 \pm 0.4 (21)	46.6 \pm 0.4 (28)	34.1 \pm 0.6 (25)	336.5 \pm 9.4 (13)

David Irons, USFWS, Anchorage. Data from colonies outside Norway were excluded from this analysis because those Puffins are either smaller or larger than Norwegian birds (Barrett *et al.* 1985; Anker-Nilssen & Tatarinkova 2000) or, in the case of birds from the NW Atlantic and Iceland (Moen 1991), because they are not expected to visit this area in significant numbers (Harris 1984b; Gaston & Jones 1998).

Total mortality and population effects To assess the scale of the incident and its possible effects at the population level, we used data on population development collected by the Norwegian national monitoring programme for seabirds (Lorentsen 2003; NINA unpubl. data). Such data were available for five of the Norwegian colonies of Atlantic Puffins (Runde, Sklinna, Røst, Gjesvær and Hornøya). We also used annual data collected by Anker-Nilssen & Aarvak (2002, 2003 and unpubl.) on the adult survival and fledging success of Atlantic Puffins at Røst. They estimated survival and recapture rates from resightings of 390 colour-ringed individuals during 1990-2003 using the SURGE model (Lebreton *et al.* 1992) in program MARK (White 2002).

Statistical analyses Most data were analysed using the *Microsoft® Excel 2002* and *SPSS 11.0* software for Windows. Differences in mean wing length between samples were explored with the *t*-test procedure for small samples ($n < 30$) assuming unequal variances (Parker 1979) and adjusted by sequential Bonferroni correction.

Table 2. Mean wing lengths (mm \pm 1 SE) of adult Atlantic Puffins in colonies from south to north along the Norwegian coast (after Barrett et al. 1985) tested against the mean wing length of adults beached in Central Norway, spring 2002 (Table 1).

Table 2. Vergelijking van de gemiddelde vleugellengte (mm \pm 1 SD) van adulte Papagaaiduikers in kolonies van zuid naar noord langs de Noorse kust (naar Barrett et al. 1985) met de gemiddelde vleugellengte van adulte vogels die voorjaar 2002 zijn gestrand in centraal Noorwegen (tabel 1).

Colony	Latitude	Longitude	Wing length	<i>n</i>	<i>t</i>	df	<i>P</i>	Bonferroni <i>P</i>
Kjør	58°53'N	05°26'E	163.8 \pm 0.46	57	6.382	30.0	< 0.001	< 0.01
Veststeinen	61°54'N	04°52'E	166.6 \pm 0.46	60	4.203	30.0	< 0.001	< 0.01
Runde	62°25'N	05°38'E	169.5 \pm 0.36	73	1.997	27.2	0.056	n.s.
Sklinna	65°13'N	10°58'E	170.0 \pm 0.46	70	1.557	30.0	0.130	n.s.
Lovunden	66°22'N	12°20'E	170.2 \pm 0.66	34	1.313	36.8	0.197	n.s.
Hernyken, Røst	67°26'N	11°52'E	172.9 \pm 0.26	229	-0.730	25.1	0.472	n.s.
Anda	69°04'N	15°10'E	174.3 \pm 0.46	92	-1.790	30.1	0.084	n.s.
Bleiksøy	69°17'N	15°52'E	172.9 \pm 0.36	148	-0.720	27.2	0.478	n.s.
Sør-Fugløy	70°06'N	18°30'E	174.5 \pm 0.66	46	-1.340	37.4	0.188	n.s.
Nord-Fugløy	70°15'N	20°15'E	175.4 \pm 0.61	49	-2.520	35.4	0.017	n.s.
Gjesvær	71°06'N	25°23'E	176.6 \pm 0.56	29	-3.470	32.9	0.002	< 0.01

RESULTS

Age and sex distribution Twenty-eight (93%) of the 30 dead Atlantic Puffins were adult birds (all having ≥ 3 bill grooves), two were immature in their 2nd (no bill grooves) and 3rd or 4th (1½ bill grooves) calendar year, respectively. In the further analyses we only use data for the adult birds. The sex ratio for the 18 adults that could be sexed (11♂♂, 7♀♀, Table 1) did not deviate significantly from 50:50 (Fisher's Exact test, $P = 0.315$).

Physical condition All birds examined were extremely emaciated, with visible traces of subcutaneous or deposited fat found in only one of 13 and one of 16 adults, respectively. The mean body mass of adults (339.8 g, Table 1, Fig. 2) was 29.6% lower than the body mass of adult Atlantic Puffins weighed in the colony at Røst one month later (482.9 g, SE = 5.4, $n = 27$) and 29.1% lower than the weighted mean for similar measurements in early May of nine other years between 1980 and 2001 (479.7 g, SE = 7.0, $n = 9$; Anker-Nilssen & Aarvak 2003). The total range in adult body mass at Røst in early May is 360–585 g (10 years, $n = 585$), with the lowest average registered for a small sample in 1996 (446.7 g, SE = 6.1, $n = 18$). However, the mean body mass of 29 adult Atlantic Puffins collected at sea 34 km west of Røst on 12 April 1996, i.e. at the same time of the year as the mass mortality occurred in 2002, had a mean body mass of 531.5 g (SE = 6.5, $n = 29$, range 475–632 g; Anker-Nilssen & Brøseth 1998).

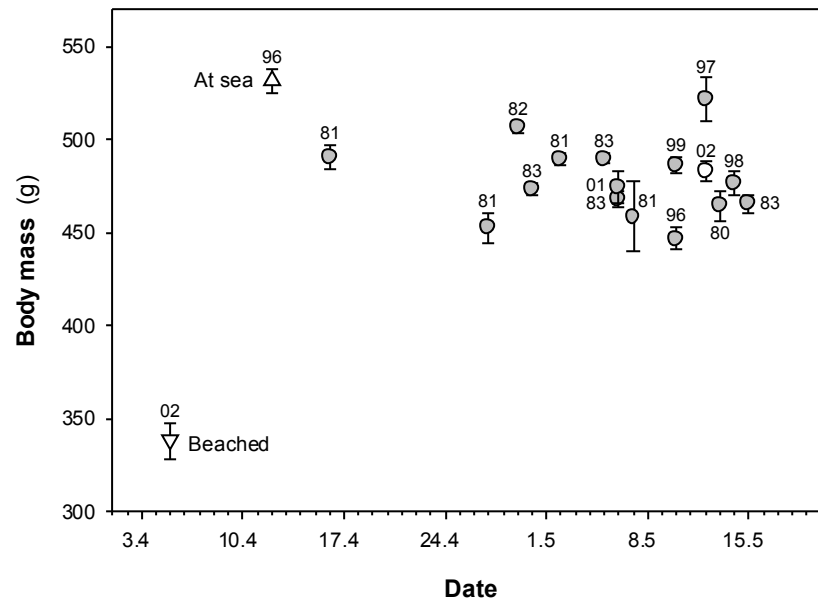


Figure 2. Mean body mass (± 1 SE) of adult Atlantic Puffins beached in Central Norway in early April 2002 (this study, $n = 13$), collected at sea 33 km WSW of Røst on 12 April 1996 (Anker-Nilssen & Brøseth 1998, $n = 29$) and measured in the colony at Hernyken, Røst in April-May on different occasions in 1980-2001 (filled circles, n range 9-214, mean 67) and 2002 (open circle, $n = 27$) (Anker-Nilssen & Aarvak 2003).

Figuur 2. Gemiddeld lichaamsgewicht (± 1 SD) van volwassen Papegaaiduikers die begin april 2002 zijn aangespoeld in centraal Noorwegen (deze studie, $n = 13$), die 12 april 1996 op zee 33 km ten WZW van Røst zijn verzameld (Anker-Nilssen & Brøseth 1998, $n = 29$) en die op verschillende data in april-mei 1980-2001 (gesloten rondjes, spreiding $n = 9-214$, gemiddelde 67) en in 2002 (open rondje, $n = 27$) zijn gewogen in de kolonie in Hernyken, Røst (Anker-Nilssen & Aarvak 2003).

Thus the beached birds were 63.9% lighter than the birds in that sample. Similarly, the weight of their left breast muscles (7♂♂, 1♀, mean 27.4 g, SE = 0.86) was 63.3% lower than for those collected at sea (15♂♂, 14♀♀, mean 43.3 g, SE = 0.61).

Table 3. Estimated annual population changes (%) in 1998-2003 of Atlantic Puffins in the five Norwegian colonies that are monitored, based on counts of apparently occupied burrows in sample plots (Lorentsen 2003; NINA unpubl. data).

Tabel 3. Geschatte jaarlijkse populatieverandering (%) in 1998-2003 van Papegaaiduiker in de vijf Noorse kolonies die met behulp van steekproefplots worden gemonitord (Lorentsen 2003; NINA ongepubl. data).

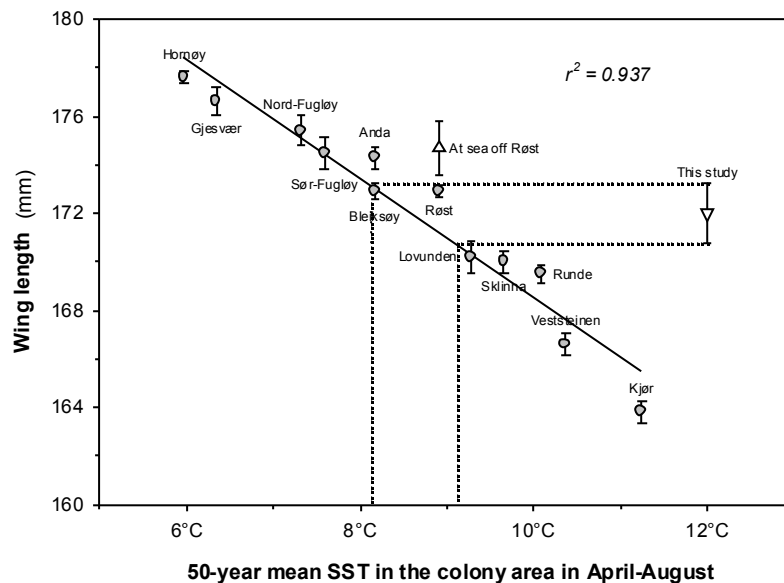
Year interval	Runde	Sklinna	Røst	Gjesvær	Hornøya
1998-1999	+3.6	-5.7	-2.7	+16.0	-5.9
1999-2000	-1.5	-7.8	-0.9	-4.5	+20.0
2000-2001	-11.8	+3.8	-9.6	+3.6	-2.7
2001-2002	+3.9	-20.0	-15.0	-1.9	+8.2
2002-2003	+7.5	+5.7	+6.1	-46.0	+4.5

Histological status The veterinary examination of three adults (2♂♂, 1♀) revealed a total absence of body fat and an atrophied skeleton musculature. No pathogens were isolated by bacteriological sampling of their liver and intestine, nor did they have any substantial load of internal parasites. Tissues of brain, eye, lung, heart, liver and kidney were all judged to be normal by microscopic examinations. The overall conclusion was that the birds were emaciated and had starved to death. This is supported by the fact that the one emaciated individual that was kept in captivity regained full health after one week's feeding (A.O. Folkestad *pers. comm.*).

Origin Mean wing length of the adult Atlantic Puffins that beached was significantly different from similar measurements of adults in colonies south of Runde (62°25'N) and north of Nord-Fugløy (70°15'N), and closest to those for Røst and Bleiksøy (Table 2, Fig. 3). Two birds were still in active moult with their longest primaries not fully regrown, so their wing lengths (142 and 145 mm) were omitted from all statistical analyses.

Total mortality and population effects Estimating the total mortality from only the carcasses recovered is not possible. No standardised beached bird surveys were carried out, and an unknown (but presumably large) proportion of the victims that died at sea never beached.

Since wing length comparisons enabled us to locate the most likely source populations of the birds affected, we can estimate the magnitude of unexplained mortality for the source populations between 2001 and 2002 by simply comparing the expected and observed population development in colonies that are monitored. For the Røst population, Anker-Nilssen & Aarvak



50-year mean SST in the colony area in April-August
 Figure 3. Mean wing length (± 1 SE) of adult Atlantic Puffins beached in Central Norway, spring 2002 (this study, $n = 28$) compared with those of adult birds from different colonies in Norway (filled circles, after Barrett et al. 1985) and adult birds collected at sea 33 km WSW of Røst on 12 April 1996 ($n = 29$). A linear regression line has been fitted to the colony data ($F = 149.5$, $P < 0.0001$).

Figuur 3. Gemiddelde vleugellengte (± 1 SD) volwassen Papegaaiduikers die voorjaar 2002 zijn aangespoeld in centraal Noorwegen (deze studie, $n = 28$) vergeleken met de vleugellengte van adulte vogels van verschillende kolonies in Noorwegen (dichte rondjes, naar Barrett et al. 1985) en met de vleugellengte van adulte vogels die 12 april 1996 op zee 33 km ten WZW van Røst zijn verzameld ($n = 29$). Een lineaire regressielijn is weergegeven voor de gegevens van de kolonies ($F = 149.5$, $P < 0.0001$).

(2003) found a significant relationship between the annual adult survival rate and fledging success in the preceding year. Using their best fitted model for this relationship (quadratic function, $r^2_{11} = 0.65$, $P = 0.015$) the observed fledging success in 2001 (84.4%, Anker-Nilssen & Aarvak 2002) would predict an adult survival rate of 95.3% (95% CI: 91.4-99.2) between 2001 and 2002. However, the true survival rate was estimated at only 84.7% (recapture data from 2003 included, SE = 2.38; Anker-Nilssen & Aarvak unpubl. data), i.e. a mortality rate three times higher than predicted. The observed decrease in breeding numbers

between the two years (15.0%, Table 3) fits this estimate perfectly, as no native recruitment was expected due to the age of first breeding in this colony typically being 5-7 years, and all years in the period 1994-1998 being ones of almost complete breeding failure. Translated into number of birds this corresponds to an unexpected loss of 92 000 adults for this colony alone, the total size of which was estimated at 382 676 pairs (SE = 16 073) in 2002 (Anker-Nilssen & Aarvak 2002).

Breeding numbers at Sklinna also decreased markedly between 2001 and 2002 (Table 3). However, the Sklinna population of Atlantic Puffins is relatively small (*c.* 3 800 pairs in 2000, T. Nygård *pers. comm.*), suggesting that only a small fraction of the victims originated from this colony.



Figure 4. Wing length is the key parameter used to identify the origin of adult Atlantic Puffins from Norwegian colonies. Although the incident occurred in early April, every second adult (as this one) still possessed traces of the winter plumage.

Figuur 4. De vleugellengte is de belangrijkste maat om de herkomst te bepalen van volwassen Papegaaiduikers uit Noorse kolonies. Hoewel het beschreven incident begin april plaatsvond vertoonde een op de twee adulte vogels (zoals deze) nog sporen van het winterkleed.

DISCUSSION

Causes of mortality As there were no signs of bacteriological disease or heavy parasitic burden, we consider it most likely that the birds had starved to death due to prolonged exposure to poor feeding conditions at sea. However, no tests were undertaken to explore if the birds had accumulated any abnormal levels of environmental contaminants, and it is therefore impossible to rule out intake of hazardous compounds as the primary cause for the incident. However, high contaminant levels in emaciated individuals would not necessarily imply that this was the primary cause of death. On the contrary, fat-soluble chemicals (e.g. polychlorinated compounds such as PCBs) that are stored in the fat, will be released and circulated into the blood only during periods of physiological stress caused by food shortage, moult or migration. Thus, when all fat has been used the bird is already extremely distressed and the chemicals might directly result in death (Harris 1984a).

In winter 2001/2002, the string jellyfish *Apolemia uvaria* (Siphonophora) invaded the NE Atlantic and killed salmon *Salmo salar* in farms along the Norwegian coast (Fosså & Asplin 2002). At an early stage, the marine scientist Karl Tangen, OCEANOR, Trondheim, suggested that the puffins could have been blinded from contact with this jellyfish and therefore were unable to locate their prey. We found no support for this explanation because (1) histological examination of eye tissue revealed no abnormal conditions, and (2) the bird that was restored to health was able to pick up from the ground shrimps presented to it (A.O. Folkestad *pers. comm.*); we realise, however, that these observations are based on extremely small samples.

Origin Our analysis strongly indicates that the majority of the beached Atlantic Puffins originated from breeding colonies on the Norwegian coast, primarily from those between Lovunden and Bleiksøy in the northern part of Nordland county (Fig. 1, 3 and 4). The wing lengths of the sample birds resembled most closely those breeding at Røst in the centre of this area, but inter-observer variability in such measurements (Barrett *et al.* 1989) must be borne in mind. The wing lengths of Røst birds in the sample reported by Barrett *et al.* (1985) were measured by TAN and a different observer in 1981, and adjusted for differences between the two (Anker-Nilssen 1983). To simulate that all birds were measured by TAN, this value (Table 2, Fig. 3) should be increased by 0.95 mm, corresponding to half of the significant difference between the two ($t_{519} = 5.264$, $P < 0.001$, Anker-Nilssen 1983). The beached birds were all measured by TAa. However, in 2001 and 2002, 15 breeding adults at Røst were measured by both TAa and TAN, with the mean wing length measured by TAa being 1.43 mm shorter than that measured by TAN (paired sample *t*-test, $t_{14} = 3.647$, $P =$

0.003). Adjusting for both these sources of bias in absolute terms, the sample of dead birds is 0.5 mm (1.43 minus 0.95) closer in size to the birds from Røst than indicated in Fig. 3, i.e. their wing lengths were only 0.4 mm shorter (corresponding to only one third of the SE of their mean wing length).

Total mortality and population effects Atlantic Puffins at Røst visit their breeding sites regularly from early April, after which they probably remain relatively close to the colonies for the rest of the breeding season. However, foraging ranges of up to 140 and 200 km have been documented within the chick period (Anker-Nilssen & Lorentsen 1990; Anker-Nilssen *et al.* in prep.), and it is not unlikely they are far more mobile during the pre-laying period. Our study indicates that large numbers of Atlantic Puffins from this area died from starvation at the coast some 400-500 km to the south just at the onset of the breeding season. As this is immediately north of the main spawning grounds for Norwegian spring-spawning herring (Sætre *et al.* 2002), this area is expected to have the highest abundance of first-year herring at that time of year. Young herring, which drift northwards with the Norwegian Coastal Current to their main nursery areas in the Barents Sea (Dragesund 1970; Sætre *et al.* 2002), is the key determinant of reproductive success for Atlantic Puffins in the NE Norwegian Sea (e.g. Barrett *et al.* 1987; Anker-Nilssen 1992; Durant *et al.* 2003), and possibly also important for the survival of adults from this area when they visit the Barents Sea soon after breeding (Anker-Nilssen & Aarvak 2003; Anker-Nilssen *et al.* in prep.). However, it is not known to what extent they depend on herring earlier in the season. Both the timing and the centre of gravity of herring hatching varies substantially between years (Sætre *et al.* 2002), suggesting the availability of larval herring off Central Norway in March-April is also variable. Moreover, the distribution of herring larvae in April 2002 indicated that an unusually large proportion of the 2002 year class hatched at the northernmost spawning grounds much closer to Røst (Føyn *et al.* 2002). The stomach contents of birds sampled at sea off Røst on 12 April 1996, when the herring year class was moderate, indicated they had mainly fed on *Polychaeta* worms (P. Fossum *et al.* unpubl. data), but few herring spawned that far north in that year (P. Fossum *pers. comm.*).

Mean body mass of the starved individuals was 30% lower than that of adult Atlantic Puffins caught in the colony at Røst just one month later, the latter being close to the overall mean for that time of year. This suggests that those birds appearing in the colony had not been severely exposed to the incident, or they had been able to find sufficient food to fully recover during April and early May. Moreover, the record high resighting rates of colour-ringed birds in June-July 2002 (99.2%, 95% CI: 96.4-99.8), which was an extraordinarily productive breeding season (Anker-Nilssen & Aarvak 2003), indicated that very few birds

refrained from breeding in 2002. Furthermore, it is unlikely that sub-lethal effects lasted beyond the breeding season of 2003 (for which the model cannot distinguish between survival and recapture rates), since both the Røst and Sklinna populations then increased by 6% (Table 3). Consequently, if this was a major incident, most of the puffins affected probably never recovered.

For obvious reasons, it is impossible to conclude that a starvation incident off Central Norway in spring 2002 was the main reason for the unexpectedly poor survival of adult Atlantic Puffins from Røst between 2001 and 2002 and the parallel severe decreases in breeding numbers at Røst and Sklinna. However, if it were, it would imply that close to 100 000 adult Atlantic Puffins died in this wreck. If other colonies of Atlantic Puffins on this part of the coast were also affected, the total number of birds that died could easily be closer to 150 000. In this context, it is important to note that the total number of birds reported beached corresponds to only 0.3% of the more conservative of these estimates. Such a small fraction is intriguing and suggests that wrecks of very pelagic seabirds merit more attention than those of more coastal species.

ACKNOWLEDGEMENTS

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MASSALE STERFTE VAN PAPEGAADUIKERS *FRATERCULA ARCTICA* IN CENTRAAL NOORWEGEN, VOORJAAR 2002: OORZAKEN EN GEVOLGEN

Eind maart, begin april 2002 werden minstens 300 dode of stervende Papegaaiduikers *Fratercula arctica* gemeld die op de kust van centraal Noorwegen waren aangespoeld (figuur 1). Post-mortem onderzoek van 30 slachtoffers, waarvan 93% adult was, bracht aan het licht dat ze waren verhongerd (figuur 2). Er werden geen sporen van verwondingen, parasieten, ziektes of externe besmettingen gevonden; gehalten van contaminanten werden niet bepaald. De slachtoffers waren waarschijnlijk afkomstig van de kolonies op of in de omgeving van Røst (ca 450,000 paar in 2001) 400-600 km noordelijker (figuur 1 & 3, tabel 2). Gebaseerd op een groot verschil in waargenomen en verwachte overleving van volwassen vogels op Røst tussen 2001 en 2002, zijn mogelijk 100,000 Papegaaiduikers omgekomen bij dit ongewone en ogenschijnlijk onbeduidend incident.

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SEXING RAZORBILLS *ALCA TORDA* BREEDING AT MACHIAS SEAL ISLAND, NEW BRUNSWICK, CANADA, USING DISCRIMINANT FUNCTION ANALYSIS

V. D. GRECIAN¹, A.W. DIAMOND¹ & J.W. CHARDINE²

Grecian V.D., Diamond A.W. & Chardine J.W. 2003. Sexing Razorbills *Alca torda* breeding at Machias Seal Island, New Brunswick, Canada, using discriminant function analysis. *Atlantic Seabirds* 5(2): 73-80. *In 2000 and 2001, we determined the sex of 80 adult Razorbills Alca torda caught on Machias Seal Island, New Brunswick, Canada, 71 birds in 2000 and 9 in 2001. Sex was determined for the 2000 birds using DNA from feathers, and for the 2001 captures using behavioural observations. Males averaged significantly larger than females in head+bill (3% larger), culmen (3%) and bill depth (4%). Discriminant Function Analysis (DFA) was used to classify birds that were not sexed. The function correctly classified 78% of birds using the linear measurements (head+bill, bill depth, wing chord, and tarsus) and 79% when a stepwise procedure was used. The highest classification success rate (80%) resulted from using only head+bill and bill depth. Bill size of Razorbills from Quebec and Labrador is very similar to those from Machias Seal Island, suggesting that the functions reported here may apply throughout the North American breeding population.*

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INTRODUCTION

Ornithological field observations are enhanced if the sex of the individual birds being studied is known. Without performing autopsies, laparotomies, or inferring the gender of an individual by behaviour, the sex of an individual bird is often difficult to determine. In monomorphic birds such as the Razorbill *Alca torda*, discriminating sexual characteristics are not observable. However, most otherwise sexually monomorphic species show some degree of size difference between the sexes, although this may be obscured by clinal differences across the geographic range of the species (Monaghan *et al.* 1983; Barrett *et al.* 1997). Bédard (1985) suggested that Razorbills from different locations should not be grouped for morphometric analysis because of such clinal variation.

Males and females of monomorphic species are commonly distinguished by Discriminant Function Analysis (DFA) using various morphometric

measures in a sample of known-sex birds (for example, larids: Fox *et al.* 1981; Coulson *et al.* 1983; Hanners & Patton 1985; Chardine & Morris 1989; Mawhinney & Diamond 1999; Devlin & Diamond, unpublished; and other seabirds: van Franeker & Ter Braak 1993; Weidinger & van Franeker 1998). Wagner (1999) presented extensive data on sexual dimorphism in Razorbills but did not explore the possibility of using the information to predict the sex of individual birds. In this study, we explore the potential of using Razorbill body measurements to predict the sex of birds using DFA.

METHODS

The study was carried out on a population of about 550 breeding pairs of Razorbills (Grecian & Diamond, unpublished) at Machias Seal Island (44° 30'N, 67° 06'W), which lies at the mouth of the Bay of Fundy, New Brunswick, Canada. In 2000, we determined the sex of 71 adults using the genetic technique developed by Fridolfsson and Ellegren (1999). A sample of DNA from each bird was extracted from the pulp of a few plucked breast feathers and processed to amplify different-sized introns from the gene CHD1 on each of the W and Z sex chromosomes. Individuals with a single band were scored as male, those with two bands as female. Twenty of the feather samples were processed twice to ensure correct identification; ten were retested because the DNA extraction cocktail was thought to be old and the other ten because there was insufficient DNA in the sample. The sex determination results of both tests were identical for all 20 birds. Nine birds in 2001 were sexed using mounting behaviour as described by Wagner (1992, 1999). Wagner found that while males would mount other males, either by mistake or while learning, females never mounted. Close observation of banded pairs (in which at least one individual was banded) during courtship and early egg laying allowed us to assign sex to 9 individuals.

For each bird, we measured natural wing-chord with a steel ruler to the nearest mm, head+bill length from the bill-tip to the extreme back of the head, exposed culmen from the bill-tip to the point at which the top of the bill and feathers meet, bill depth at gonys, and tarsus, all with vernier calipers to the nearest 0.1 mm. Body mass was measured with a Pesola balance to the nearest 5 g. Most of the birds were captured and measured by the same person (VDG), and a standardized measurement protocol was used to minimize variation between observers.

We performed DFA on the sample of 80 birds (71 sexed genetically, nine by behaviour), initially including wing chord, head+bill, bill depth, and tarsus, using *SPSS v. 10* (SPSS 1999). We also ran analyses using only the measurements selected by the default stepwise method provided in *SPSS*, and on

measurements whose means differed significantly between males and females in univariate comparisons and remained in the analysis. Birds for which any of the measurements were missing were automatically excluded from the analyses. Classification success rates were based on the jack-knife (leave-one-out) method. The method of determining the unstandardized discriminant functions, which could be used to classify birds of unknown sex in morphometrically similar populations, followed Phillips and Furness (1997) and Chardine (2002).

RESULTS

Mean measurements did not vary significantly between years (ANOVAs with effect of sex removed, $P > 0.05$) so data from 2000 and 2001 were pooled. Measurements for males ($n = 42$) and females ($n = 38$) are given in Table 1. Males were on average larger than females in all measurements except wing chord but differences were small and statistically significant only for head+bill (males 3% larger), culmen (3% larger), and bill depth (4% larger; t -tests, $P < 0.05$; Table 1). Results of the various discriminant function analyses are presented in Table 2. Culmen was not included in the discriminant function analyses in Table 2 because of the difficulty in measuring it consistently, but where it was included in a stepwise procedure it was always removed by the discriminant function. The function that included the linear measurements head+bill, bill depth, wing chord, and tarsus correctly classified 78% of birds (jack-knife classification). In the stepwise analysis of the same linear measurements, tarsus was dropped from the resulting discriminant function with a slight increase in the classification success rate to 79%.

The function giving the highest classification success rate, 80%, included head+bill and bill depth, which were the only two measurements used in the DFA that differed significantly between males and females. The discriminant function was:

$$D = 0.25(HB) + 0.73(DEP) - 40.84$$

where D is the discriminant score and HB and DEP are measurements in mm. Using this function, D was calculated for each bird, which in turn was used to determine the *a posteriori* probability (PP) of group membership based on Bayes' Rule (D and PP calculated by *SPSS*). Figure 1a shows the relationship between PP of being a male ($PP_{\text{female}} = 1 - PP_{\text{male}}$) and D for this discriminant function. The value of D associated with $PP = 0.5$ gives the cut-off discriminant score between males and females (D_{crit}). In this case, $D_{\text{crit}} = -0.04$; birds having a score greater than -0.04 were predicted to be males and those having a score less than -0.04 were predicted to be females.

Table 1. Measurements of known-sex adult Razorbills caught on Machias Seal Island in 2000 and 2001.

Tabel 1. Maten van adulte Alken van bekend geslacht, die in 2000 en 2001 gevangen zijn op Machias Seal Island.

Measurement	Sample	n	Mean	SD	t ¹	P
Head+bill	Male	42	96.7	2.6	5.69	< 0.001
	Female	38	93.6	2.2		
Culmen	Male	37	35.5	1.7	2.67	< 0.05
	Female	34	34.5	1.4		
Bill depth (mm)	Male	42	23.5	0.7	5.53	<0.001
	Female	38	22.5	0.9		
Wing chord (mm)	Male	42	204	5	- 0.53	0.60
	Female	38	205	5		
Tarsus (mm)	Male	42	34.9	1.9	0.84	0.41
	Female	38	34.6	1.5		
Body mass (g)	Male	42	700	46	0.61	0.55
	Female	35	693	55		

¹t-test for independent means; DF = male+female sample size; all variances were homogeneous (Levene's tests, $P > 0.05$).

Table 2. Results of stepwise discriminant function analyses classifying adult Razorbills caught on Machias Seal Island in 2000 and 2001 into male and female groups.

Tabel 2. Resultaten van een stapsgewijze discriminant functie analyse om adulte Alken in te delen in groepen mannen en vrouwen.

Analysis	Discriminant function ¹	Jack-knife classification success ²		Statistical significance	D _{crit} ³
		Males n = 42	Females n = 38		
All variables	$D = 0.28(\text{HB}) + 0.91(\text{DEP}) - 0.11(\text{WCH}) - 0.12(\text{TAR}) - 21.63$	76%	79%	Wilks' Lambda = 0.55 $\chi^2_4 = 45.1, P < 0.001$	-0.04
Stepwise variable selection	$D = 0.27(\text{HB}) + 0.87(\text{DEP}) - 0.11(\text{WCH}) - 22.6$	81%	76%	Wilks' Lambda = 0.56 $\chi^2_3 = 44.1, P < 0.001$	-0.04
HB and DEP	$D = 0.25(\text{HB}) + 0.73(\text{DEP}) - 40.84$	79%	82%	Wilks' Lambda = 0.64 $\chi^2_2 = 34.6, P < 0.001$	-0.04
HB	$D = 0.41(\text{HB}) - 39.27$	71%	76%	Wilks' Lambda = 0.71 $\chi^2_1 = 26.9, P < 0.001$	-0.03
DEP	$D = 1.27(\text{DEP}) - 29.25$	76%	66%	Wilks' Lambda = 0.72 $\chi^2_1 = 25.6, P < 0.001$	-0.03

Figure 1b depicts bill depth in relation to head+bill length, with the line dividing predicted males (upper right portion of graph) and females (lower left portion). This line was calculated from the discriminant function for head+bill

and bill depth given above, setting D to -0.04 and solving for bill depth as follows:

$$BD = (0.25(HB) - 40.84 + 0.04) / -0.73$$

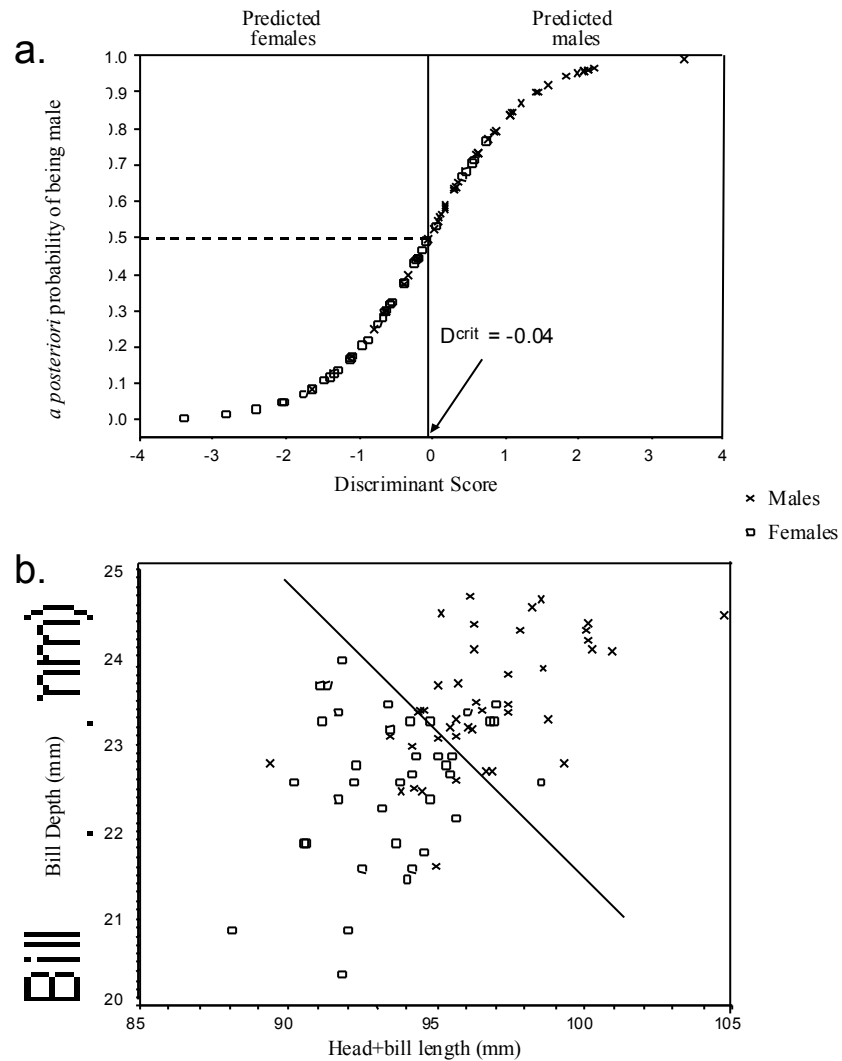
Discriminant functions that included head+bill or bill depth alone discriminated between males and females least well (74% and 72% respectively). All functions discriminated male and female Razorbills statistically better than by chance (χ^2 tests, $P < 0.05$; Table 2) and while determining sex through sexual behaviour observations may be difficult, all 9 birds from 2001 were correctly classified using any of the given discriminations.

DISCUSSION

We aimed to develop a method to sex Razorbills at Machias Seal Island from body measurements. Despite the relatively low degree of sexual size dimorphism, we were able to successfully sex about 80% of Razorbills using head+bill and bill depth measurements.

Our data show that male Razorbills on Machias Seal Island had significantly larger head+bill, culmen, and bill-depth measurements than females. The trend for males to have larger bill dimensions than females has been found in other alcids (Corkhill 1972; Nelson 1981; Jones 1993) and may be a standard feature across the family. Jones (1993) suggested that the larger bill of male Crested Auklets *Aethia cristatella* was the result of sexual selection for fighting ability amongst males for access to mates. As some male Razorbills obtain matings in a lek situation (Wagner 1992), larger bills may indeed confer a competitive advantage to males.

The differences between males and females in head+bill, culmen, and bill depth measurements were relatively small (males 3-4% larger than females), but (in the case of head+bill and bill depth) were sufficient to discriminate between the sexes with a success rate of 80% when the measurements were included in a discriminant function. Typically, auks show little sexual dimorphism in size (Gaston & Jones 1998), and discriminant function analysis might yield similar discrimination rates in other species. For example, only 65% of Atlantic Puffins *Fratercula arctica* were sexed correctly using a discriminant function that included culmen and bill depth (Corkhill 1972). In related species such as gulls, sexual size dimorphism is more pronounced and the classification success rates of discriminant functions using body measurements often exceed 90% (Fox *et al.* 1981; Coulson *et al.* 1983; Monaghan *et al.* 1983; Chardine & Morris 1989; Mawhinney & Diamond 1999).



The applicability of this function to other populations of Razorbills depends upon the variation in size among the populations. Culmen and bill depth measurements of Razorbills from Quebec and Labrador are very similar to those from Machias Seal Island (Hipfner & Chapdelaine 2002), suggesting that the function might apply throughout the North American breeding population.

Opposite page. Figure 1a. Logistic relationship between a posteriori probability (PP) of being a male, as calculated by SPSS using Bayes' Rule (SPSS 1999) and discriminant score (D) calculated for each bird using the discriminant function that included head+bill length and bill depth. The discriminant function was $D = 0.25(HB) + 0.73(DEP) - 40.84$. The value of D associated with PP = 0.5 gives the cut-off discriminant score between males and females ($D_{crit} = -0.04$).

Figure 1b. The relationship between bill depth and head+bill length for each bird in the sample. The line divides the cloud of points into predicted males (upper right) and predicted females (lower left) based on the above discriminant function and the observed value of D_{crit} . The actual sex of each bird as determined genetically is shown in both graphs.

Tegenoverliggende pagina. Figuur 1a. Logistische relatie tussen de a posteriori (achteraf bepaalde) kans (PP) een man te zijn, zoals berekend in SPSS (1999) met de regel van Bayes, en de discriminantscore (D) berekend voor iedere vogels met behulp van de discriminantfunctie $D = 0.25(HB) + 0.73(DEP) - 40.84$, waarbij HB kop+snavel lengte is en DEP de snavelhoogte. De waarde van D voor PP = 0.5 geeft de onderscheidende score tussen mannen en vrouwen ($D_{crit} = -0.04$).

Figuur 1b. De relatie tussen snavelhoogte en kop+snavel lengte voor iedere vogel in de steekproef. De lijn verdeelt de puntenwolk in mannen (rechtsboven) en vrouwen (linksonder) zoals voorspeld met bovenstaande discriminantfunctie en de bijbehorende waarde van D_{crit} . In beide figuren is het werkelijke geslacht van iedere vogel weergegeven zoals vastgesteld aan de hand van DNA.

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GESLACHTSBEPALING VAN ALKEN *ALCA TORDA* BROEDEND OP MACHIAS SEAL ISLAND, NEW BRUNSWICK, CANADA, MET DISCRIMINANT FUNCTIE ANALYSE

In 2000 en 2001 bepaalden we het geslacht van 80 adulte Alken *Alca torda* die waren gevangen op Machias Seal Island, New Brunswick Canada (71 in 2000, 9 in 2001). Het geslacht van de vogels uit 2000 werd bepaald aan de hand van DNA afkomstig uit enkele veren, het geslacht van de vogels uit 2001 aan de hand van waargenomen gedrag. Maten van mannetjes waren gemiddeld groter dan vrouwtjes voor kop+snavel (3% groter), bovensnavel (3%) en snavelhoogte (4%) (tabel 1 & 2). Discriminant functie analyse (DFA) werd gebruikt om vogels met onbekend geslacht te kwalificeren. DFA kwalificeerde 78% van de vogels correct met behulp van lineaire maten (kop+snavel, snavelhoogte, vleugel en tarsus) en 79% met behulp van een stapsgewijze procedure (figuur 1). Het hoogste 'kwalificatiesucces' werd behaald door alleen kop+snavel en snavelhoogte te gebruiken.

Aangezien de grootte van de snavel van Alken in Quebec en Labrador vrijwel identiek is aan die van vogels van Machias Seal Island, zouden de beschreven DFA-functies gebruikt kunnen worden voor de gehele Noord-Amerikaanse broedpopulatie.

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A FOSSIL OF THE GREAT AUK *PINGUINUS IMPENNIS* FROM MIDDLE PLEISTOCENE DEPOSITS IN BERMUDA

STORRS L. OLSON¹

Olson S.L. 2003. A fossil of the Great Auk *Pinguinus impennis* from Middle Pleistocene deposits in Bermuda. *Atlantic Seabirds* 5(2): 81-84. *A partial premaxilla of a Great Auk Pinguinus impennis was recovered from Middle Pleistocene deposits on Green Island, Bermuda. These deposits formed during the interglacial sea-level rise of Marine Isotope Stage 11 and are about 400 000 years old. This constitutes the first record of Great Auk for Bermuda and probably represents a bird that died at sea and was washed ashore.*

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The Great Auk *Pinguinus impennis*, exterminated by humans in the 19th century, was known historically from both sides of the North Atlantic. Archaeological and fossil records indicate that the wintering range may have extended as far south as Florida and the Mediterranean (Greenway 1958, Brodkorb 1967, Fuller 1999, Mourer-Chauviré 1999). The species was never documented historically from Bermuda, although Amos (1991) and Fuller (1999: 347) mention Bermuda in the range of the species based on word-of-mouth reports of the specimen described here.

By sheer coincidence, the first fossil collected from a bone bed in extremely indurated carbonate sandstone on Green Island, directly south of Nonsuch Island on the southeast shore of Bermuda, on 28 August 1981, turned out to be part of the premaxilla of a Great Auk, the tip of which remained in the rock. This was one of only a few fragments that could be extracted using only a chisel and hammer. Three years later, the tip was recovered on 8 August 1984 using a gas-powered saw that allowed the collection of dozens more specimens of bird bones. The two portions fit together nearly perfectly (Fig. 1), so there was relatively little erosion of the exposed portion that remained in rock for an additional three years.

All other bird bones recovered at this site belonged to embryos, juveniles, and adults of Short-tailed Albatross *Phoebastria albatrus*, which, with fossil eggs recovered nearby, showed that this was once a breeding area for this

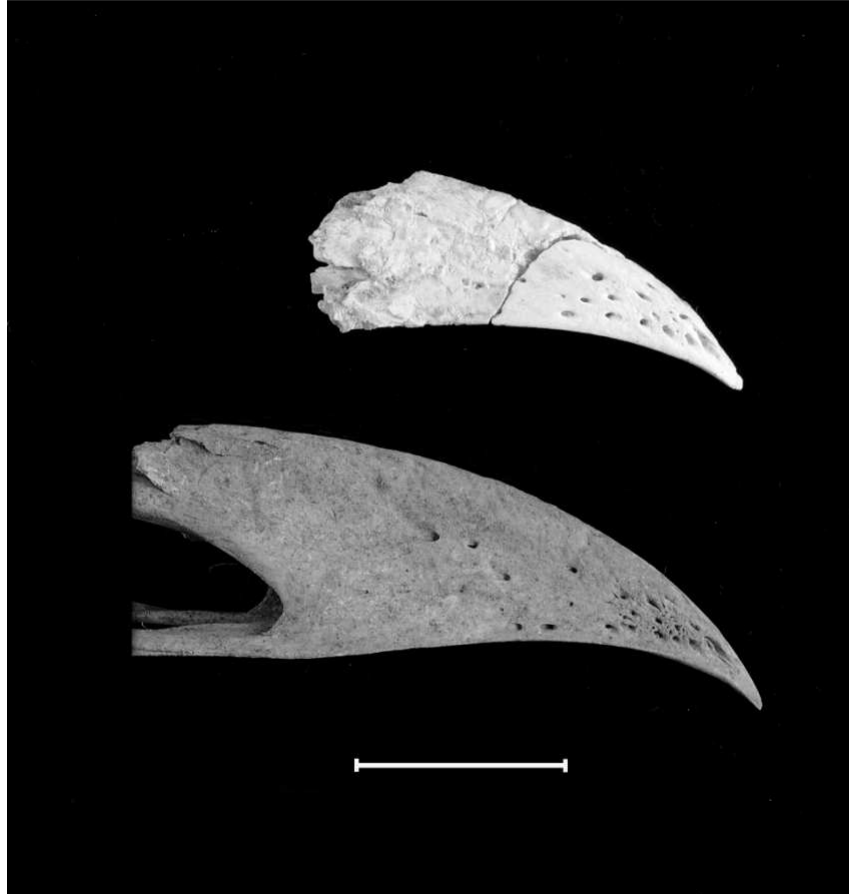


Figure 1. Right lateral view of the fossil tip of a premaxilla (USNM 523861) of a Great Auk from the middle Pleistocene of Bermuda (above) compared with a modern specimen (USNM uncataloged) from Funk Island (below). Scalebar = 2 cm.

Figuur 1. Rechterzijaanzicht van een fossiele punt van een premaxilla (USNM 523861) van een Reuzenalk uit Bermuda uit het Midden Pleistoceen (boven) vergeleken met een modern specimen (USNM ongecatalogiseerd) van Funk Island (onder). Schaalbalk = 2 cm.

species (Olson & Hearty 2003). Not one additional bone of Great Auk has ever been recovered here.

The Green Island deposits have been correlated with the Middle Pleistocene Lower Town Hill Formation, which formed during the interglacial

period equivalent to Marine Isotope Stage 11. They were deposited rapidly during a massive storm at the onset of that interglacial, as sea levels began to rise, and are therefore about 400 000 years old (Olson & Hearty 2003). During this interglacial, sea levels continued to rise until reaching more than 21 m (70 feet) above present (Hearty *et al.* 1999), thus nearly obliterating Bermuda and causing the extirpation of the albatross colony (Olson & Hearty 2003). Seabird biologists should be made more aware of that catastrophic event, which would have caused dramatic restructuring of seabird breeding colonies on low-lying islands at the time.

The Great Auk fossil from Bermuda consists of most of the premaxilla anterior to the osseous nostril (Fig. 1). It falls within the considerable variation in size and shape of this element seen in a large series of remains collected on Funk Island, Newfoundland (USNM uncataloged). The extinct species *Pinguinus alfrednewtoni* from the Pliocene of North Carolina (Olson 1977), was postulated as possibly being a western Atlantic counterpart of the Great Auk that may have been replaced by the historic species after the early Pliocene (Olson & Rasmussen 2000). The premaxilla of *P. alfrednewtoni* is unknown, however, and the Bermuda fossil is too similar to *P. impennis* to be referred to anything else.

There is no way to know how frequently wintering Great Auks may have approached Bermuda in the past. However, there is no reason for thinking that the single fossil reported here originated in anything other than an individual that either died at sea and was washed ashore or concerned a sick or weakened bird that came ashore and died. In an instance that is probably similar, the sternum of a Great Auk was found in latest Pleistocene deposits on the island of Porto Santo in the Madeiran archipelago, the southernmost record for the eastern Atlantic (Pieper 1985).

I thank David Wingate for calling my attention to the Green Island deposits and doing everything possible to make the collection of fossils possible. Frederick V. Grady, Department of Paleobiology, Smithsonian Institution, assisted in collection and prepared the fossil out of its indurated matrix. Comparisons were made with the avian skeleton collection in the Division of Birds, National Museum of Natural History, Smithsonian Institution (USNM). Paul Hearty, James Cook University, Townsville, Australia, was responsible for geological interpretations of the site. The photograph is by John Steiner, Smithsonian Center for Scientific Imaging and Photography, and the figure was arranged by Brian Schmidt, Division of Birds, Smithsonian Institution. This is contribution #65, Bermuda Biodiversity Project, Bermuda Aquarium, Natural History Museum and Zoo.

EEN FOSSIEL VAN EEN REUZENALK *PINGUINUS IMPENNIS* IN MIDDENPLEISTOCENE AFZETTINGEN OP BERMUDA

Op Green Island Bermuda werd in Midden Pleistocene afzettingen een deel van een premaxilla van een Reuzenalk *Pinguinus impennis* gevonden (figuur 1). Deze afzettingen zijn ca 400.000 jaar oud

en zijn ontstaan tijdens de interglaciale zeespiegelstijging in de zogenaamde Marine Isotope Stage 11. Deze vondst is het eerste geval van een Reuzenalk voor Bermuda. Waarschijnlijk is de vogel op zee gestorven en op het strand aangespoeld.

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DARK-RUMPED *OCEANODROMA* STORM-PETRELS IN THE CENTRAL ATLANTIC OCEAN

STEVE HALES¹ & JIM VAUGHAN²

Hales S. & Vaughan J 2003. Dark-rumped *Oceanodroma* Storm-petrels in the central Atlantic Ocean. *Atlantic Seabirds* 5(2): 85-86. *On 15 April 2003, two dark-rumped Oceanodroma Storm-petrels were observed in a mixed feeding flock of seabirds, at 04°13'N, 19°10'W. It is argued that both appear to be Swinhoe's Storm-petrel Oceanodroma monorhis.*

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On a recent voyage back from the Southern Atlantic Ocean on the m.v. *Professor Molchanov*, extensive notes on seabirds were made. Shortly after crossing the equator, following a heavy early morning thunderstorm on 15 April 2003, the ship sailed into another heavy squall of rain at 04°13'N, 19°10'W. Within the squall, the sea was dead calm and we saw a feeding flock of seabirds, slowly gliding and feeding just above sea level at very close proximity (10-20m). The flock consisted of at least 63 Madeiran Storm-petrels *Oceanodroma castro*, 7 Arctic Terns *Sterna paradisaea*, 4 Bulwer's Petrels *Bulweria bulwerii* and two small dark-rumped *Oceanodroma* type Storm-petrels. The birds were dark sooty brown all over, which gave them a squat looking appearance although the size was comparable to Leach's Storm-petrel *O. leucorhoa*. The wing tips seemed more rounded rather than the more angular appearance of those of Leach's Storm-petrel and the wings did not show a prominent carpal bar -even at these close quarters. The flight was sedate and resembled British Storm-petrel *Hydrobates pelagicus* rather than the more erratic flight of Leach's. The flying pattern was gentle and smooth although the calm sea conditions might have had an effect on this. The bill was dark and the back and rump were very dark sooty brown with no trace of white anywhere. The birds appeared graceful, buoyant and took on a circular feeding pattern. The tail was forked and the feet not seen to be projecting beyond it. They were feeding in with Madeiran Storm-petrels. We saw many Leach's Storm-petrels and Bulwer's Petrels on this trip and the behaviour and appearance of these birds did not resemble either of them in any way. We are both aware of and have seen dark-rumped variants of Leach's Storm-petrel (Bourne & Simmons 1997). Swinhoe's Storm-petrels *O. monorhis* have been trapped on Selvagem Grande for some years and breeding

is strongly suspected there (Francis Zino *pers comm.*) and they have been turning all up the west coast of Europe (Cubitt *et al.* 1992; Jardine *et al.* 1993; Jäbekk 1996). As the chance of finding two dark Leach's Storm-petrels together in the Atlantic would be most unlikely, these birds appear to be Swinhoe's Storm-petrels indicating their winter quarters in the Atlantic Ocean.

We thank Francis Zino and Bill Boume for information and comments.

STORMVOGELTJES MET EEN DONKERE STUIT
IN DE CENTRALE ATLANTISCHE OCEAAN

Op 15 april 2003 werden op 04°13'NB, 19°10'WL in een gemengde groep foeragerende zeevogels twee stormvogeltjes met een donkere stuit gezien. De auteurs beargumenteren dat beide vogels Chinese Stormvogeltjes *Oceanodroma monorhis* zijn.

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News and notices

OBITUARY

RALPH SIMON PALMER 1914-2003

Ralph Palmer was one of the inadequately-appreciated pioneers of marine ornithology. Born and brought up in Maine, USA (for which he wrote a local avifauna, *Maine Birds*), he obtained high honours in zoology at the University of Maine in 1937, and his Ph D thesis for Cornell University on a developing theme, A behaviour study of the Common Tern, was published in the prestigious *Proceedings of the Boston Society of Natural History* (42 (1), 1941). He taught at Vassar College for a while, and was then New York State Zoologist for 27 years. He produced a *Mammal Guide: Mammals of North America north of Mexico*, and then started a massive *Handbook of North American Birds*. The first volume *Loons through flamingos* (1962) included valuable reviews of the petrels and peleceniformes with much new data, and also introduced the documentation with concise references now standard in such works, but he did not receive the support he deserved and failed to get beyond the raptors. Among many other things he was also second in command of a landing craft in the third wave arriving in Normandy on D-day. He was a tubby, modest, knowledgeable, humorous, highly-respected character with many abilities, interests, and friendships who travelled widely before retiring to his beloved Maine. He leaves a wife, two sons and a daughter.

W.R.P. Bourne, Scotland

24TH INTERNATIONAL ORNITHOLOGICAL CONGRESS 2006

The Scientific Program Committee (SPC) for the 24th International Ornithological Congress 2006 invites you to submit symposium proposals. Symposia are aimed at the general ornithologist and provide up-to-date coverage of current ornithological research. Each symposium will include 5 speakers: 2 of these will be invited by the conveners to provide keynote addresses that summarize the global progress of ornithological science in the field over the last four years and to address priorities for future research. The other 3 speakers will be chosen by conveners, with guidance from the SPC, from abstracts of accepted contributed papers. This is intended to increase global participation and/or allow new researchers to contribute to symposia. The call for contributed papers (which will come in autumn 2004) will include a

box that a contributor can check if they wish to be considered for a specific symposium. In cases where 3 additional speakers cannot be found for a symposium topic, conveners will be allowed to invite additional speakers.

Each symposium should have 2 co-conveners. Since this is an international congress, the SPC will give preference in choosing symposium topics to symposia with co-conveners from different continents, and, failing this, from different countries. If it is not possible to meet these criteria, a brief explanation should be given under 'Justification of symposium' on the application form. Conveners may choose themselves as keynote speakers. Conveners can organize only one symposium. Also note that symposium speakers cannot give another oral presentation during the congress, but can apply to organize a round table discussion or present a poster.

Proposals for symposia must be received on or before 1 April 2004.

We urge you to use the submission form available on the IOC meeting web site <http://www.i-o-c.org>. If you cannot submit your proposal by email, please mail it directly to the program chair: Susan Hannon, Dept of Biological Sciences, University of Alberta, Edmonton, Alberta, Canada, T6G 2E9.

Please provide a title of symposium, names, institution or affiliation, addresses, phone, fax, e-mail of principal organizer, co-organizer, first and second keynote speakers, and describe (400 words maximum) goals, objectives, importance of the symposium and outline briefly what each keynote speaker will cover, giving a preliminary title if possible. Justify (250 words maximum) why this symposium is important and timely and why it will be of interest to IOC congress participants. If you cannot find a co-convener from another continent or country, explain why. The justification will not appear in the program or on the web site. All proposals will be reviewed by the SPC in August 2004 and symposium organizers will be notified as to whether their proposal has been accepted shortly thereafter.

We ask that symposium organizers have a firm commitment from keynote speakers to attend the meeting before listing them in their proposal. Once a proposal has been accepted and the speakers finalized, we will request abstracts for each of the keynote talks. Summaries of accepted symposia will be posted on the IOC website. We also ask that symposium conveners inform speakers that the conference proceedings will be published, so that speakers must be willing to submit a paper on their presentation.

We also call for **pre-registration** if you like to receive all further information about the congress. Please use the electronic submission form available on the IOC meeting web site <http://www.i-o-c.org>. If you are unable to use the electronic form, please contact us by e-mail at info@i-o-c.org or mail it to: IOC 2006, Institute of Avian Research, An der Vogelwarte 21, 26386 Wilhelmshaven, Germany.