PELAGIC DISTRIBUTION, MOULT AND (SUB-)SPECIFIC STATUS OF CORY'S SHEARWATERS *CALONECTRIS [D.] DIOMEDEA/BOREALIS* WINTERING OFF SOUTHERN AFRICA

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SUMMARY

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Newly described field characters are used to separate Cory's Shearwaters of the east Atlantic population (*Calonectris diomedea borealis*, or *C. borealis*) from those of the Mediterranean population (*C.d. diomedea*, or *C. diomedea*) in their wintering areas off southern Africa. It is shown that *borealis* outnumbered *diomedea* in most areas, which contradicts the current consensus that the majority of Cory's Shearwaters wintering of southern Africa belong to the Mediterranean population. *Borealis* outnumbered *diomedea* on average by a factor of 6:1 on the continental shelf, but over deep ocean waters north of 34°S both varieties were equally scarce. In the offshore areas influenced by recently shed Agulhas Rings (39°–34°S), *borealis* was 10 times more numerous than *diomedea*, with foraging flocks concentrating at the edges of the rings. Off Cape Town, where *borealis* predominated, east-/south-eastbound migratory movements were observed. Cory's Shearwaters deployed a variety of feeding techniques and were occasionally attracted to fishing vessels and foraging dolphins. Most birds had nearly finished their primary moult, which is in accordance with expectation for breeding birds that normally complete primary moult around March.

Keywords: Cory's Shearwater, *Calonectris diomedea*, distribution, moult, taxonomic status

INTRODUCTION

Cory's Shearwaters *Calonectris* spp. are common non-breeding visitors off the west and south coasts of southern Africa (Ryan 1997). Most are present during the austral summer, arriving off Namibia and the Western Cape Province in October and November. Until recently, Cory's Shearwater was generally considered polytypic, with *C.d. diomedea* in the Mediterranean, *C.d. borealis* breeding in the east Atlantic, from the Berlengas in Portugal to the Azores and the Canary Islands, and a third subspecies *C.d. edwardsii* endemic to the Cape Verde Islands (Cramp & Simmons 1977, del Hoyo *et al.* 1992, Thibault *et al.* 1997). The Cape Verde subspecies was considered distinctive (smaller, bill more slender and black instead of yellow, tail relatively longer; Bourne 1955, Cramp & Simmons 1977, Porter *et al.* 1997) and Hazevoet (1995) treats this race as a separate species: *C. edwardsii*. The two other subspecies were considered indistinguishable in the field (Cramp & Simmons 1977). Both subspecies were known as trans-equatorial migrants (Cramp & Simmons 1977, del Nevo 1994, Thibault *et al.* 1997) and *C.d. diomedea* has been described to move south to the Benguela Current, whereas *C.d. borealis* should concentrate off South America after visiting the eastern seaboard of the United States (Mougin *et al.* 1988). Most southern African specimens originate from the Mediterranean population, but at least three specimens of *C.d. borealis* have been found (Ryan 1997, Oschadleus *et al.* 2001).

Sangster *et al.* (1999) consider the Atlantic and Mediterranean varieties of Cory's Shearwater as specifically distinct (Cory's Shearwater *C. borealis* and Scopoli's Shearwater *C. diomedea*, respectively) based on phylogeographic analysis of allozymes (Randi *et al.* 1989) and mitochondrial DNA (Heidrich *et al.* 1996, 1998), qualitative differences in vocalisations (Bretagnolle & Lequette 1990) and analysis of morphological characters (Granadeiro 1993, Gutiérrez 1998). Irrespective of whether this treatment should be followed, it is of significance that useful field characters have been recently published, on the basis of which both (sub-)species can often be separated in the field (Gutiérrez 1998). For practical reasons, we will refer to *borealis* and *diomedea* in this paper, while 'unidentified' individuals will be mentioned as 'Cory's Shearwaters' (*Calonectris [d.]* spp.).

Recent systematic ship-based seabird surveys off Namibia and the Western Cape Province of South Africa were used to evaluate the specific status of 'Cory's Shearwaters' in southern African waters using these newly described characteristics, enabling a much larger sample of specifically identified individuals. Seabird cruises were part of the NIOZ Mixing of Agulhas Rings Experiment Programme (MARE), meant to determine the proportion of Agulhas leakage that contributes to the northward branch of the oceanic thermohaline circulation (THC). Through a process of eddy detachment and associated entrainment from the Agulhas Retroflection, pulses of warm and salty water ('rings') enter the Atlantic (Gordon 1985, Garzoli *et al.* 1996). As part of MARE, a selected Agulhas Ring was examined at different stages of its nonlinear decay over a period of one year. The MARE oceanographic research enabled ornithologists to investigate and interpret interactions of seabirds with physical processes simultaneously.

This paper reports on the offshore distribution and primary moult of *diomedea* versus *borealis* in the second half of the austral summer, providing additional insight into the relative abundance, foraging behaviour, habitat choice and moult stages of both types off southern Africa.

METHODS

Distribution at sea

The analysis includes sightings of Cory's Shearwaters during cruises on board the R.V. *Pelagia* off southern Africa in February 2000 and January–March 2001 (Table 1). Methods of observation were similar to standards developed for ship-based seabird surveys in north-west European waters (Tasker *et al.* 1984), but with extra attention to and systematic coding of primary moult stages, foraging behaviour and interactions between species (Camphuysen & Webb 1999, Camphuysen & Garthe 2001). Following Tasker *et al.* (1984), a 300-m wide transect was operated on one side and in front of the vessel, including a snap-shot count for flying birds and using 10-minute period intervals, from which densities could be calculated ($n.km^{-2}$). Simultaneously, a 180° scan was performed, but these data were not used to calculate densities, but for numbers of birds per km travelled ($n.km^{-1}$).

Habitats

The study area was subdivided into five regions (Fig. 1). Continental shelf waters are coastal waters immediately adjacent to the mainland, up to a depth of 2000 m. Namibian Continental Shelf waters (1; north of 27°S) were separated from Cape Continental Shelf waters (2; south of 32°S), because a large area between the two was not investigated. Deep Ocean waters (3) were between the shelf break (at 2000-m depth) up to the Walvis Ridge area (4; 2000–3700-m depth), and these were further separated from an area with recently shed Agulhas Rings with a clear 'surface signature' (great differences in surface salinity at the ring edges), the Agulhas Ring area (5), which was generally to the south of 35°S.

Agulhas Rings were characterised by a relatively high surface salinity and their anti-clockwise rotating velocity, and could be found and best followed by altimetry from a satellite (Sea Surface Height Anomaly analysis from the Colorado Center for Astrodynamics Research). These data, in combination with continuous recordings of surface salinity (‰), surface temperature (°C), and water depth (m; analysed at 500-m intervals), measured at one-minute intervals and automatically logged on board the ship, were used to describe and classify habitats at sea in broad terms. Shifts of surface salinity within 10-minute transects of over 0.099‰ were categorised as steep gradients (2.9%, n = 1964 10-minute counts), shifts between 0.049 and 0.099‰ as medium gradients (8.9%) and shifts <0.049‰ as (near-) stable situations (88.2%) (similar to a method proposed by Haney & McGillivray 1985a). Similarly, surface temperature shifts within individual transects of >0.2°C were considered strong gradients (10.0%), 0.1 > 0.2°C as medium gradients (16.1%), and <0.1°C as (near-) stable situations (73.9%). Steep salinity gradients were encountered most frequently in the Agulhas Ring area (5.6%, n = 550) and on the Cape Continental Shelf (8.2%, n = 159). Steep temperature gradients were relatively frequently encountered at the Namibian Continental Shelf (14.6%, n = 213), in the Agulhas Ring area (10.2%, n = 550), and particularly at the Cape Continental Shelf (42.1%, n = 159). Observed numbers of shearwaters in each situation were compared with expectation based on the frequency of encountered gradients (G-test with Williams's correction; Sokal & Rohlf 1995).

(Sub-)specific identification

Gutiérrez (1998) listed three characters that should be noted to separate Cory's Shearwaters from either population at sea: size and structure, upperside colouration and underwing pattern. On average, *borealis* is 46% larger than *diomedea* and the former type usually looks 'heavier' than the latter. Again on average, the upperside of *borealis*, especially head and upperparts, is noticeably darker than in *diomedea*. The underwing pattern, however (also cited by Cramp & Simmons 1977), is the only diagnostic character: *diomedea* has pronounced white wedges on the inner webs of the primaries which project well beyond the underwing coverts, *borealis* has completely black primaries, contrasting sharply with the rounded shape of the white primary coverts (see Gutiérrez 1998 for further details and illustrations). The latter character was found to be most useful and was used throughout. The size of a lone bird is very hard to judge, and subtle differences in colouration are easily misleading in variable light conditions. These two characters were only used to confirm that initial identifications based on the underwing pattern were probably correct. The underwing pattern was easy to check in most nearby encounters, except with very strong light from behind the observer (glossy feathers), or when the birds failed to turn sufficiently on their side during flight near the vessel. *Borealis* and *diomedea* were only separated in cases where there was no doubt on the basis of the relevant characters. One setback was the fact that many shearwaters were moulting primaries. Single missing feathers introduced at least the suggestion of a white inner web. In case of any doubt moulting birds were not (sub-)specifically identified.

Moult

During cruises in 2001 primary moult was scored to separate birds with complete sets of primaries (not moulting) from birds with missing or growing primaries in the inner section (P1–5; moult just started), birds with central primaries missing or growing (full progress), and birds that were about to finalise their moult (only the last two or last feathers not shed or growing; end of moult).

RESULTS

Distribution at sea

Cory's Shearwaters were most abundant on the Namibian and Cape Continental Shelf areas, occurred in low densities in the open ocean and were virtually absent over the Walvis Ridge (Table 1). Overall numbers fell considerably in waters over 1500 m in depth (Figs 2 & 3). The situation in the Agulhas Ring area was slightly more complicated, with rather low densities overall, but with local concentrations of birds (Fig. 2). At the Cape Continental Shelf, south of False Bay and Cape Agulhas, South Africa, extensive easterly (71.4%, n = 175) and south-easterly (12.6%) movements were observed, indicating displacements towards the Indian Ocean. Cory's Shearwaters occurred in flocks of 2.6 ± 5.5 individuals (mean ± SD; maximum flock observed was 82 individuals in the Agulhas Ring area).

(Sub-)specific identification

Of 1642 Cory's Shearwaters observed, 32.4% were (sub-)specifically identified (Table 2). On the Namibian Continental Shelf, Cory's Shearwaters from both populations occurred in equal numbers (48.1% *borealis*). Over deep oceanic waters, equal (low) numbers occurred in 2001, but *borealis* outnumbered *diomedea* in 2000 by five to one (2000/01 73.2% *borealis*). At the Walvis Ridge only a single Cory's Shearwater (*diomedea*) was observed. On the Cape Continental Shelf and in the Agulhas Ring area, *borealis* predominated, comprising 96.1% and 92.0%, respectively.

TABLE 1

Observer effort (number of 10-minute counts, km² surveyed and km travelled) and numbers of Cory's Shearwaters recorded (number in transect and total number of birds observed) in February 2000 and January–March 2001 (see Fig. 1 for subregions)

Region	Year	Counts (n)	Area (km²)	Distance (km)	Cory's Shearwaters			
					n in transect	n (all)	$n.km^{-2}$	$n.km^{-1}$
Namibian Continental Shelf	2000	137	104.0	346.6	207	368	1.99	1.06
Deep Ocean		413	352.2	1173.9	33	106	0.09	0.09
Walvis Ridge		52	50.5	168.5			0	0
Cape Continental Shelf		27	24.4	81.3	108	202	4.43	2.49
Namibian Continental Shelf	2001	76	57.7	192.4	23	71	0.40	0.37
Deep Ocean		464	405.4	1422.1	16	69	0.04	0.05
Walvis Ridge		113	108.5	360.8		1	0	0.00
Cape Continental Shelf		132	118.4	394.7	272	558	2.30	1.41
Agulhas Ring area		550	481.1	1630.5	43	267	0.09	0.16
Total		**1964**	**1702.2**	**5770.7**	**702**	**1642**		

TABLE 2

Cory's Shearwaters observed in January–March 2000 and 2001, including Mediterranean (*C. diomedea*), east Atlantic (*C. borealis*) and unidentified individuals

Region	Year	*diomedea*	*borealis*	Unidentified	Totals	% *borealis*
Namibian Continental Shelf	2000	9	12	347	368	57.1
	2001	31	25	15	71	44.6
Deep Ocean	2000	9	46	51	106	83.6
	2001	17	25	27	69	59.5
Walvis Ridge	2001	1			1	0
Cape Continental Shelf	2000		42	160	202	100.0
	2001	10	205	343	558	95.3
Agulhas Ring area	2001	8	92	167	267	92.0
Total		**85**	**447**	**1110**	**1642**	**84.0**

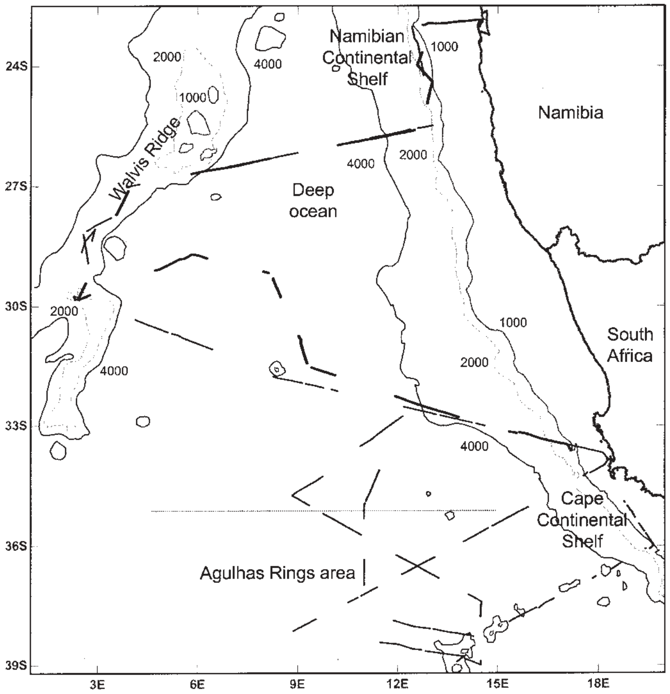

***Fig. 1.** Study area off southern Africa, regions mentioned in this paper and transects sailed in February 2000 and January–March 2001. The 1000, 2000, and 4000-m depth contours are illustrated.*

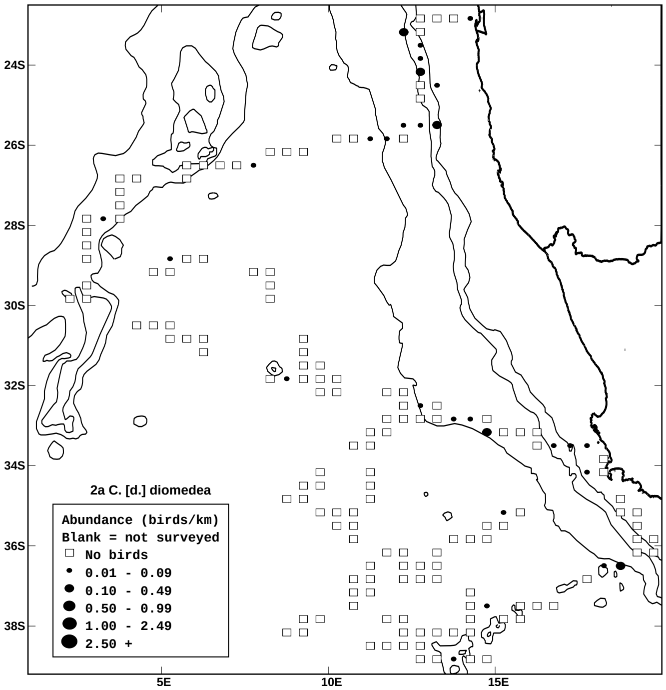

***Fig. 2a.** Distribution of* C. [d.] diomedea *off southern Africa, as number of birds per km travelled (n.km^{-1}).*

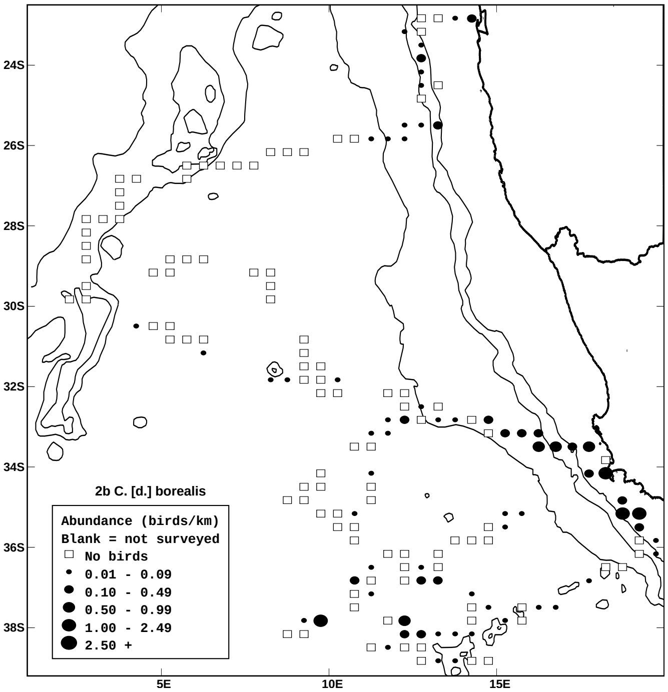

***Fig. 2b.** Distribution of* C. [d.] borealis *off southern Africa, as number of birds per km travelled (n.km^{-1}).*

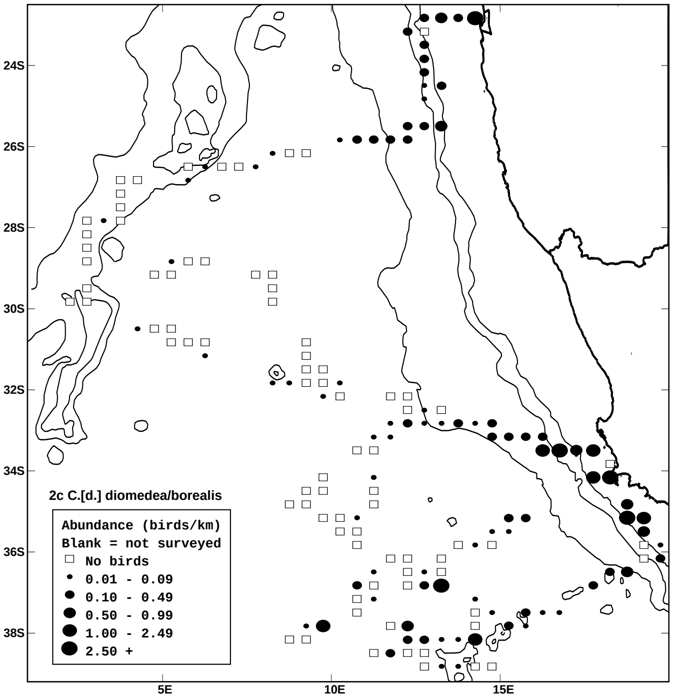

***Fig. 2c.** Distribution of* C. [d.] diomedea *and or* C. [d.] borealis, *including 'unidentified' Cory's Shearwaters, off southern Africa, as number of birds per km travelled (n.km^{-1}).*

Moult

During the first half of the cruises in 2001 (<14 February), 28 of 47 recorded individuals of *diomedea* were actively moulting primaries, whereas only 28 of 71 *borealis* shearwaters showed wing moult (G_{adj} 4.56, df = 1, $P < 0.05$). During the second halves of the cruises too few *diomedea* could be checked to obtain a reliable sample (three moulting, four not moulting). After 14 February, 23 of 86 *borealis* showed wing moult, a similar fraction as during the first half of the trips ($G_{adj} = 2.82$, df = 1, n.s.). The stage of wing moult was similar in both types (*diomedea* two just starting, five halfway, four finishing moult; *borealis* 6, 11, 27, respectively; $G_{adj} = 2.11$, df = 2, n.s.).

Habitats

Overall, Cory's Shearwaters occurred in far greater numbers than expected in areas with steep surface salinity gradients and in slightly larger than expected numbers in areas with medium gradients ($G_{adj} = 56.2$, df = 2, $P < 0.001$). Steep salinity gradients were most pronounced at the edges of Agulhas Rings. Similarly, Cory's Shearwaters were considerably more abundant than expected in transects with steep surface temperatures gradients and slightly more numerous than expected in situations with medium gradients ($G_{adj} = 175.7$, df = 2, $P < 0.001$). Temperature gradients were steepest in shelf waters, particularly off Cape Town. For *borealis*, the results were exactly the same (salinity $G_{adj} = 53.1$, df = 2, $P < 0.001$; temperature $G_{adj} = 61.0$, df = 2, $P < 0.001$), but not for *diomedea* (salinity $G_{adj} = 2.04$, df = 2, n.s.; temperature $G_{adj} = 4.79$, df = 2, n.s.). Because *diomedea* was almost absent in the Agulhas Ring area and scarce on the Cape Continental Shelf, the tests were repeated for a combination of Deep Ocean and Namibian Shelf areas (northern half of the study area). Neither taxon was significantly more abundant during transects with the steepest surface salinity or temperature gradients. Slightly more than average *diomedea* were encountered around the 1500–2000-m depth contour (Fig. 3), whereas *borealis* were most frequently in shallower waters (<1000 m), consistent with the overall higher numbers of Cory's Shearwaters in these waters. Neither type was very numerous close inshore.

Foraging behaviour

Of 439 Cory's Shearwaters encountered on the Namibian Shelf (Table 3), 1% were observed resting or apparently asleep, 7% actively foraging by surface-seizing prey (occasionally in association with or near South African Fur Seals *Arctocephalus pusillus*), five birds (1%) were observed shallow plunging, one bird (0.2%) was pursuit-plunging, and 32% were actively searching for prey (circling over and occasionally nearly plunging down). Of 175 Cory's Shearwaters over deep ocean waters, one bird was dipping for prey (1%), two were surface-seizing (1%), one was shallow plunging (1%), five were shallow plunging while following a herding pod of Long-snouted Spinner Dolphins *Stenella longirostris*, and 19% were apparently actively searching for prey.

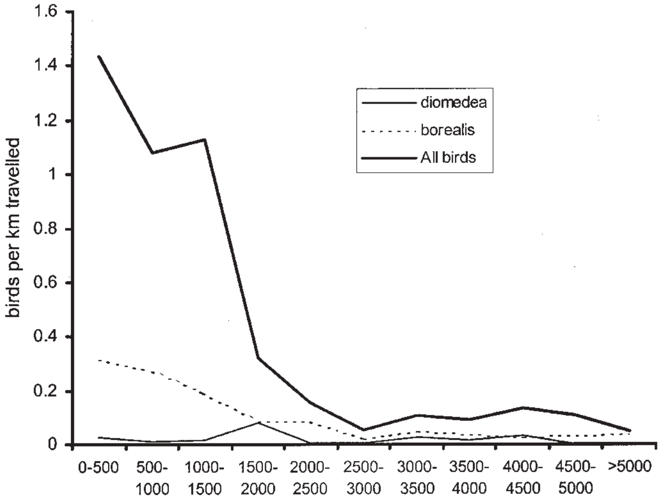

Fig. 3. *Relative abundance of* diomedea *and* borealis *compared with all (including 'unidentified') Cory's Shearwaters, as number of birds per km travelled (n.km^{-1}) in relation to water depth (m).*

In the Agulhas Ring area, of 267 Cory's Shearwaters recorded, 32 birds (12%) were loosely associated with a Korean longline fishing vessel (circling in its wake), 43% were searching for prey, often in groups, and exclusively just beyond ring edges (hence outside the Agulhas Rings). On the Cape Continental Shelf, apart from the directed movements observed south of False Bay and Cape Agulhas (23%, n = 760), 3% occurred near trawlers but were not feeding at the time of the observations, 2% were preening or bathing, and 18% were actively searching for prey. Not a single actively feeding bird was observed in either offshore area (Table 3).

Fishing trawlers at the Namibian and Cape Continental Shelf edges and a line-setting longliner in the Agulhas Ring area attracted small numbers of Cory's Shearwaters among many other scavengers, but the shearwaters were never seen to participate in feeding frenzies. On the Namibian Continental Shelf many Cory's Shearwaters foraged independently from, but near to fishing vessels, in areas extremely rich in foraging seabirds and fur seals.

One Cory's Shearwater was persistently and successfully kleptoparasitized by four Black-browed Albatrosses *Thalassarche melanophrys* and a Yellow-nosed Albatross *T. chlororhynchos/carteri*. On two occasions Cory's Shearwaters were attacked and nearly killed by Subantarctic Skuas *Catharacta antarctica* (drowning attempts).

DISCUSSION

The results suggest that both species of Cory's Shearwaters are common off southern Africa. Rather unexpectedly, the east Atlantic *C. [d.] borealis* outnumbered the Mediterranean *C. [d.] diomedea*, particularly off South Africa (*contra* Ryan 1997). Recently described field characters to identify Cory's Shearwaters from either population seem to have shed new light on the taxonomic status and origin of shearwaters wintering off southern Africa. The results should be treated with caution, however, for field characters such as those used to separate *borealis* shearwaters from *diomedea* will never be the ultimate proof of the (sub-)specific status of a bird. Ringing data or results from satellite telemetry will have to confirm our conclusions that, contrary to the present knowledge, *borealis* shearwaters seem to be common visitors and passage migrants in southern African waters.

Cory's Shearwaters from both populations breed colonially during the northern summer. The Azores probably holds the largest population (50 000–90 000 pairs) of *borealis* (total population *c.* 95 000–150 000 pairs; del Nevo 1994, Thibault *et al.* 1997). Of *diomedea*, the total population amounts to *c.* 60 000–80 000 pairs, most of which breed in Italy (15 000–18 000 pairs) and Tunisia (20 000 pairs; Thibault 1993, del Nevo 1994). Del Nevo (1994) and Thibault *et al.* (1997) describe *borealis* and *diomedea* as trans-Equatorial migrants, with *diomedea* moving south to the Benguela Current off southern Africa and with *borealis* concentrating first off the eastern United States and later in the year off South American waters (see also Mougin *et al.* 1988). However, *borealis* has been found in the southern Indian Ocean and a beach-cast specimen has been reported from New Zealand (Marchant & Higgins 1990, Warham 1990), together with the recoveries of Ryan (1997) and Oschadleus *et al.* (2001) indicating that birds from the east Atlantic population do travel towards or through the Benguela Current as well. Recent satellite telemetry data suggest that at least some Mediterranean breeding birds (*diomedea*) did not cross the Equator but wintered off north-west Africa (Ristow *et al.* 2000).

In an unpublished report, Moerbeek (1982) reconstructed migration routes and Atlantic wintering and non-breeding staging areas of Cory's Shearwaters from a variety of sources (mainly ship-based observations, local bird reports and records of beach-cast individuals of known (sub-)specific identity). In July and August, all records were from the North Atlantic, mainly around the breeding colonies, but with large numbers off North America south of Newfoundland and off the British Isles (Fig. 4). Both *diomedea* and *borealis* were recovered from American beaches. In September–October, numbers increased off north-western Africa and near the Equator while the breeding localities became gradually abandoned, but South American and South African waters were still free of Cory's Shearwaters. In November–December, consistent with the description by Ryan (1997), multiple sightings occurred in the Gulf of Guinea, and the shelf off southern Africa had been reached. Southbound movements off Mauritania were common. Sparse observations off South America indicated that Cory's Shearwaters had now reached these waters, while numbers off the American east coast declined. In January–February, the North Atlantic was virtually abandoned, while Cory's Shearwaters were common off West Africa and the Argentinean coast (cf. Cooke & Mills 1972). In March and April, a return of shearwaters to the breeding grounds was documented, but Cory's Shearwaters were still abundant around South Africa. Some sightings off South America suggested that a wintering population remained in these waters. In May and June, Cory's Shearwaters were becoming less numerous in the South Atlantic, although substantial numbers remained off southern Africa long after breeding birds should have returned to their colonies, indicating a substantial non-breeding population off southern Africa (confirmed by recent at-sea sightings; P.G. Ryan pers. comm.). Very large numbers occurred around the breeding

TABLE 3

Behaviour types of Cory's Shearwaters observed in different sea areas, January–March 2000 and 2001, as a proportion of the total number of birds observed. The difference between 'total number of birds seen' in each area and the sum of birds with a listed behaviour is made up by flying individuals

Region	Type of behaviour observed	*diomedea*	Unidentified	*borealis*	Totals	%
Namibian Shelf	resting or apparently asleep		3		3	0.7
	surface seizing		32		32	7.3
	shallow plunging		5		5	1.1
	pursuit plunging		1		1	0.2
	actively searching for prey	2	129	10	141	32.1
	total number seen	40	362	37	439	
Deep Ocean	resting or apparently asleep	1	9	3	13	7.4
	dipping		1		1	0.6
	surface seizing	1	1		2	1.1
	shallow plunging		5	1	6	3.4
	actively searching for prey	1	12	20	33	18.9
	total number seen	26	78	71	175	
Agulhas Ring area	resting or apparently asleep		2	3	5	1.9
	actively searching for prey near trawler		32		32	12.0
	actively searching for prey		88	29	117	43.8
	total number seen	8	167	92	267	
Cape Shelf	resting or apparently asleep	1	155	47	203	26.7
	preening or bathing		12	5	17	2.2
	actively searching for prey		113	28	141	18.6
	total number seen	10	503	247	760	

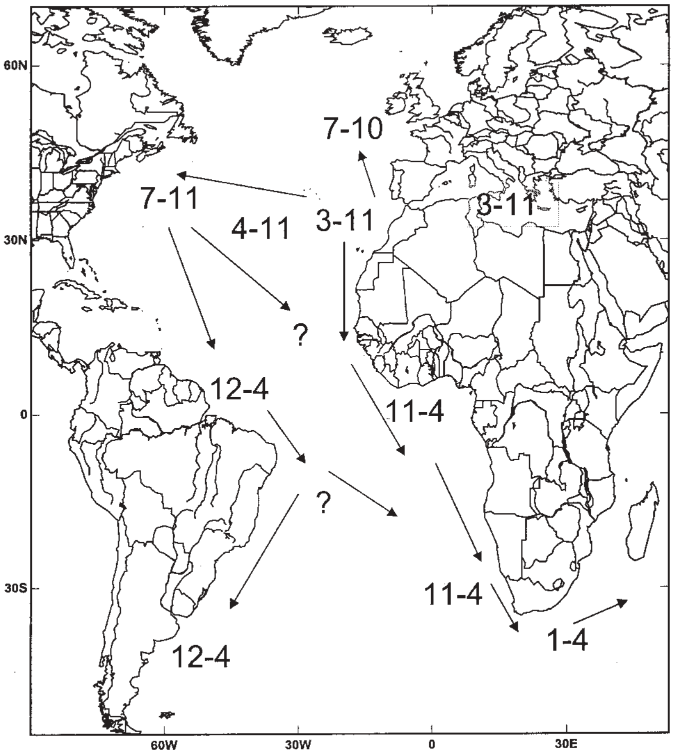

Fig. 4. *Seasonal distribution of Cory's Shearwaters* Calonectris *spp. in the Atlantic Ocean, from a compilation of records by Moerbeek (1982). The indicated periods as numbered months are peak occurrences. Isolated sightings may occur at any time of the year in most areas.*

stations in this period. Moerbeek (1982) had few data for the South American coast, but other publications seem to confirm that Cory's Shearwaters are much more abundant off the entire African west coast (Thibault *et al.* 1997), and therefore most probably including both *diomedea* and *borealis*. It is unclear from Moerbeek's (1982) data whether Cory's Shearwaters could travel from their North American staging areas towards Africa by crossing the North Atlantic, or by crossing the Atlantic around the equator (Fig. 4). Bartle & Stahl (in Marchant & Higgins 1990) estimate ('perhaps overestimate' according to Thibault *et al.* 1997) the number of Cory's Shearwaters occurring in the Indian Ocean at *c.* 250 000. This figure is so high that if anywhere near the truth and given the size of the breeding populations mentioned earlier, such a wintering population has to include *borealis*. It is clear that future observations over the entire non-breeding range of Cory's Shearwaters, using the novel techniques of field identification described by Gutiérrez (1998), will shed more light on the overlap and segregation in migration routes and non-breeding range of east Atlantic versus Mediterranean Cory's Shearwaters.

Cory's Shearwaters off southern Africa utilised various foraging techniques, joined groups of cetaceans and occurred near fishing vessels (whether or not they actually scavenged for prey), and are clearly attracted to the rich feeding opportunities on the continental shelf, including the Benguela upwelling system. Remarkably, in the northern half of the study area, there were no differences in spatial distribution patterns of either (sub-)species, whereas farther to the south, *diomedea* is comparatively scarce (shelf) to near-absent (Agulhas Rings). Also, in the north there were no obvious habitat preferences in terms of salinity or temperature gradients as found by Haney & McGillivray (1985b), but the distribution maps suggest a concentration of sightings at the shelf break (*c.* 1000-m depth contour). In the south, flocks of Cory's Shearwaters were encountered in the more turbulent water masses just outside the edges of the rings, whereas they were nearly absent within the rings. Elevated levels of biological activity at fronts occurred at the ring edges visited off southern Africa in 2001 (unpublished data of multi-net plankton records; Frank Peeters pers. comm.). Observed flocks were highly mobile, settling frequently, and constantly keeping in close contact. Ryan (1997) indicated that Cory's Shearwaters feed primarily on epipelagic fish, such as Saury *Scomberesox saurus*. The wide spectrum of foraging behaviours observed during our cruises, coupled by the diversity of habitats exploited by these shearwaters, suggest that they may have a more catholic diet and more diverse feeding habits, adjusting foraging techniques to the particular area and local prey resource.

Very few other seabirds joined flocks of Cory's Shearwaters, although the occasional *Thalassarche* albatross occurred. Mixtures of *borealis* and *diomedea* within flocks were not seen, although both species shared certain feeding areas, particularly off the Namibian coast. On the Cape Shelf feeding frenzies similar to those on the Namibian Shelf were observed, but farther to the south many birds passed by in an easterly/south-easterly direction, perhaps migrating towards the Agulhas and Mozambique Currents as suggested by Ryan (1997). These migrants comprised many individuals showing characteristics of *borealis*.

Most shearwaters observed off southern Africa had completed their moult, or were in the final stages. This observed moult pattern is consistent with the observations by Monteiro & Furness (1996) of primary renewal (in *borealis*) seeming to be simply descendent and estimated to take a mean 207 days to complete, i.e. by late March. Both *borealis* and *diomedea* return to the colonies gradually from late February to late March (Thibault *et al.* 1997). The observed shearwaters could perhaps still make that, but it is more likely that immatures or potential non-breeders (individual Cory's Shearwaters do skip breeding in some years; Mougin *et al.* 1987) predominate off southern Africa in the late second half of the austral summer.

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