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The migration of European Sandwich Terns *Sterna s. sandvicensis. II**)

By Anders Pape Møller

Content

*) Part I is published in issue 1/1981, p. 74—94.

13. Migration at European bird observatories

Additional information on the migration of the Sandwich Tern has been collected from various bird observatories in Northern Europe. The first birds arrive at the north European bird observatories in the middle or the end of March (Blåvandshuk, Denmark 17.iii, Portland, Great Britain 21.iii) (Table 8). During April they reach the rest of the observatories within the breeding range, whereas Revtangen, Norway, where only prolonged migration is observed, has its earliest observation on 11.v. Peak spring migration is reached in the southwest at the end of April (Portland, Great Britain 22.iv, Dungeness, Great Britain 23.iv). Further north at the Skaw, Denmark peak passage occurs on 5.v, and at Revtangen, Norway on 17.v. Migration seems to cease early June.

Table 8: Average dates of first observation, spring maximum, autumn maximum and last observation of Sandwich Terns at northern European bird observatories. Numbers in brackets indicate the number of seasons of observation.

Bird observatory	First observation	Spring maximum	Autumn maximum	Last observation
Revtangen (11)	11.v	17.v	17.viii	30.viii
Ottenby (10)	—	—	8.viii	6.ix
Skaw (5)	1.iv	5.v	27.viii	2.x
Hanstholm (4)	30.iii	1.v	28.viii	6.x
Blåvandshuk (7)	17.iii	26.iv	26.viii	18.x
Helgoland (4)	29.iii	4.v	31.viii	9.x
Skegness (5)	23.iv	—	21.viii	22.x
Man (10)	16.iv	—	2.ix	26.ix
Dungeness (15)	28.iii	23.iv	3.ix	5.x
Sandwich Bay (5)	26.iii	1.v	28.viii	12.x
Portland (5)	21.iii	22.iv	21.ix	17.x

In conclusion, Sandwich Terns return to north European waters from the middle of March reaching areas near the breeding grounds in large numbers at the end of April. Most birds are present at the colonies during May. This pattern is borne out by the pattern of ringing recoveries.

On dispersal from the breeding colonies Sandwich Terns are seen at the bird observatories from the end of June. Peak numbers are reached in the eastern Baltic at Ottenby, Sweden as early as 8.viii and at Revtangen, Norway on 17.viii. At the bird observatories in the Danish, German and northern British waters peak numbers are recorded at the end of August, and at the southern British observatories in September (Isle of Man, Great Britain 2.ix, Dungeness, Great Britain 3.ix, Portland, Great Britain 21.ix). The last Sandwich Terns are seen in the eastern Baltic at the beginning of September (Ottenby, Sweden 6.ix), at Revtangen, Norway at the end of August (30.viii) and elsewhere they are recorded until the beginning or middle of October with the latest records at Portland, Great Britain (17.x), Blåvandshuk, Denmark (18.x) and Skegness, Great Britain (22.x).

To summarise, autumn migration is seen from June with maximum numbers at the end of August and the beginning of September leaving only small numbers in October in northern European waters. Generally higher numbers are seen in British waters in September compared to nearby continental areas due to a slow movement of British and Irish birds and accumulation of continental birds in the Channel zone in August and especially September.

14. Migration speed

Thomson (1943) has criticised Marples & Marples (1934) for the calculation of migration speeds from ringing recoveries. However, if a large number of speeds are available, they can be used for calculating average speeds in different months or different populations.

Speeds of migration for 1y birds have been calculated up to December (Table 9). In July and August speeds are low, with averages ranging from 2.3 to 11.1 km day^{-1} and a maximum of 83.6 km day^{-1}. These speeds are hardly influenced by migration and therefore indicate the speed of dispersal. In September British-Irish birds reach a maximum of 21. 5 km day^{-1} compared to 8.5—11.5 km day^{-1} for the birds from other countries. British and Irish birds still move at a very high speed (average 41.9 km day^{-1}, the highest recorded) in October bringing most birds to the winter quarters in Africa. Sandwich Terns from the other countries speed up their migration more slowly, reaching a maximum speed of 32.0—34.4 km day^{-1} in November. In December average values decrease to 29.6—31.8 km day^{-1}, most birds now being present in the winter quarters.

Table 9: Migration speeds of Sandwich Terns in km per day. Average values and standard deviations with numbers in brackets.

Month	Denmark	West Germany	Netherlands	Great Britain, Ireland
July	4.2 ± 3.1 (30)	7.3 ± 15.6 (28)	5.8 ± 0.5 (44)	2.3 ± 1.4 (7)
August	6.3 ± 7.5 (107)	4.2 ± 0.9 (172)	11.1 ± 8.9 (143)	3.7 ± 5.6 (50)
September	11.5 ± 13.4 (77)	10.9 ± 16.6 (93)	8.5 ± 12.1 (54)	21.5 ± 21.4 (51)
October	25.8 ± 20.8 (41)	28.1 ± 19.0 (48)	27.5 ± 17.4 (20)	41.9 ± 14.3 (73)
November	32.0 ± 13.5 (41)	34.4 ± 12.2 (49)	33.3 ± 34.5 (28)	36.7 ± 9.6 (94)
December	31.0 ± 7.7 (24)	29.6 ± 9.4 (31)	30.5 ± 32.3 (31)	31.8 ± 5.1 (78)

High average speeds in Dutch birds in August and in British and Irish birds in September-October bring these populations further away from the breeding grounds compared with Danish and West German birds. Maximum migration speeds, of course, are much higher in the different months. The highest speed at all is reached as early as August. The two highest values are as follows:

Helgoland 6222206	27. VI. 1964	Norderoog (54.30 N, 08.30 E), West Germany
	x 5. VIII. 1964	Agadir (30.30 N, 09.24 E), Morocco
		83.6 km day^{-1}
Helgoland 6238896	16. VII. 1967	Trischen (54.06 N, 08.42 E), West Germany
	x 22. IX. 1967	Joal (14.12 N, 16.48 W), Senegal
		72.6 km day^{-1}

15. Geographical distribution of the age classes

The distribution of birds from different age classes in different parts of the range of the Sandwich Tern has been analysed by grouping the recoveries from Denmark, West Germany, Netherlands and Great Britain and Ireland. This procedure was necessary because so few recoveries are reported in certain months. The geographical range was divided into four main areas, viz. Europe, West Africa, Guinea Gulf and Southern Africa.

15.1. Europe

Most birds of all ages are recovered in the months May—October with a maximum of 820 in August. During the rest of the year less than 40 birds have been recovered in any single month. Recoveries of 1y birds seem to be most frequent July—October with a maximum in

August, 2—3y birds a little earlier, June—September with a maximum in August and 4y+ birds even earlier, May—October with a maximum in July—August (Fig. 15). The 1y birds make up 65—69% of all recoveries in August—October but decrease to a minimum value (2%) in May (Fig. 15). Recoveries of 2—3y birds are at a maximum (20—25% of all recoveries) in January-March and reach a later maximum in June with 16%.

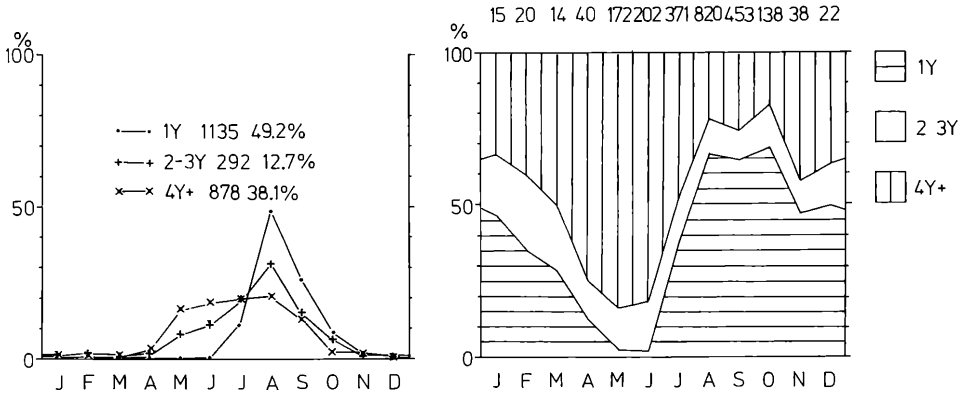

Fig. 15: Occurrence of age clases (left) and age distribution of Sandwich Terns in Europe (right) throughout the year. Numbers at the top indicate the numbers of recoveries.

15.2. West Africa

Nearly two thirds of all birds recovered in West Africa are 1y leaving one fifth for 2—3y and one tenth for 4y+ birds (Fig. 16). That is comparably more immatures and juveniles and fewer adults compared to the age distribution of all European recoveries ($\chi^2 = 18.9$, $P < 0.001$). The 1y birds reach a peak in October to February with 10—17% of all recoveries in each month, and apparently decrease steadily from January to May. The 2—3y birds occur extremely regularly and represent 5—12% of all 2—3y recoveries in each month throughout the year. The adults (4y+) reach a maximum in October and November with 23—25% of all adult recoveries. During the months June—August only very few birds are recovered.

The 1y birds comprise some 62—76% of all recoveries in each month from October to May (Fig. 16). The 2—3y birds reach a maximum from June to August accounting for 93—96% of all recoveries. The adults reach a maximum in September—November with 17—28% of the recoveries.

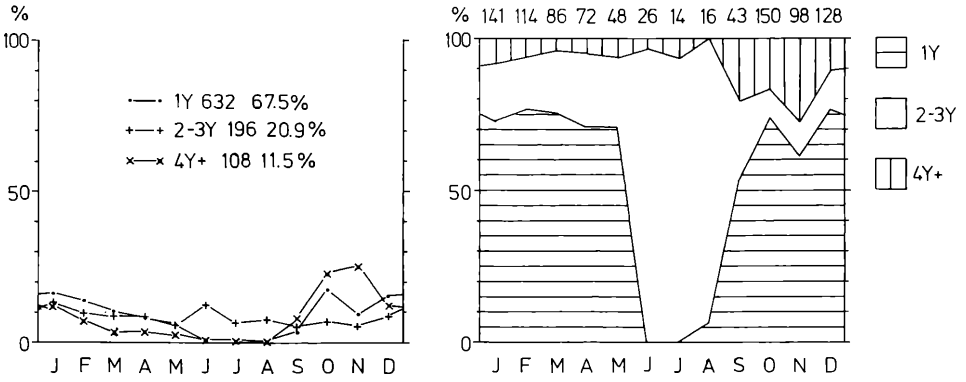

Fig. 16: Occurrence of age classes (left) and age distribution of Sandwich Terns in West Africa (right) throughout the year. Numbers at the top indicate the numbers of recoveries.

15.3. Guinea Gulf

The age distribution of recoveries is very similar to the situation in West Africa with two thirds 1y birds, a quarter 2—3y birds and one tenth 4y+ birds (Fig. 17). It is still significantly fewer adults compared to European recoveries and more 1y and 2—3y birds ($\chi^2 = 21.9$, $P < 0.001$). Recoveries of ly birds are at a maximum in December and January (21—24% of the 1y recoveries), but the proportion decrease steadily from December to May (Fig. 17). Immatures (2—3y) account for 4—13% of the 2—3y recoveries in each month. Adults reach a maximum in October—December (11—16% of the adult recoveries) and a minimum in July. The 1y birds comprise some 72—81% of all recoveries in each month from December—May. The 2—3y birds are at a maximum in June—September with 71—100% of the recoveries and adults (4y+) are most frequent between August and November with 16—22% of the recoveries (Fig. 17).

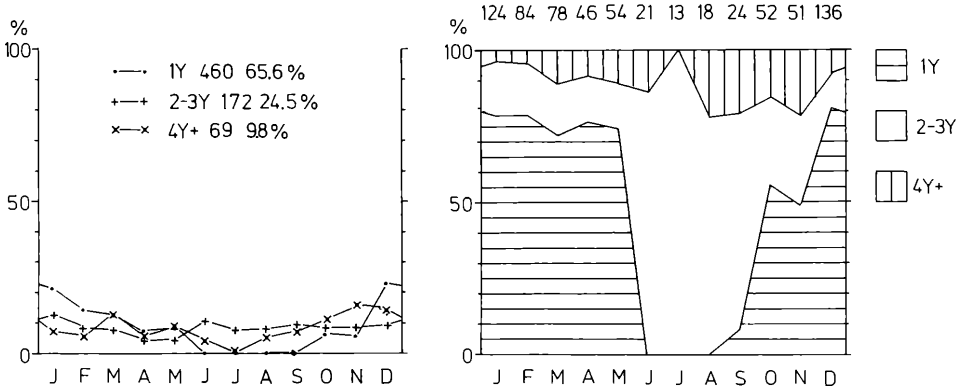

Fig. 17: Occurrence of age classes (left) and age distribution of Sandwich Terns in Guinea Gulf (right) throughout the year. Numbers at the top indicate the numbers of recoveries.

15.4. Southern Africa

The age distribution of recoveries from this area differs from other areas with 45% 1y, 38% 2—3y and 17% 4y+ (Fig. 18), comparatively fewer adults are recovered than in Europe ($\chi^2 = 10.9$, $P < 0.001$), and fewer 1y birds than in West Africa and Guinea Gulf ($\chi^2 = 10.0$, $P < 0.01$, $\chi^2 = 8.3$, $P < 0.01$). The 1y birds reach a maximum (15%) in December and in March (20% of all the 1y recoveries). The 2—3y birds are regular in their occurrence with 3—17% in each month and a peak in November. Adults (4y+) occur in highest numbers between October and March with 12—19% (Fig. 18). The proportion of 1y recoveries in each month seems to increase during the winter to a maximum of 75% in May. Immatures (2—3y) dominate recoveries during the months June—September with 78—100%. Adults (4y+) have peaks in October (33%) and in February (35%) and account for more than 20% of recoveries between October and February (Fig. 18).

16. Upwelling

Upwelling phenonema are the ascending motion by which water from subsurface layers is brought to the surface and then removed by horizontal flow. The water from the subsurface layers is cool and very nutrient-rich leading to a high primary production (Ashmole 1971). The extremely abundant occurrences of crustaceans and fish caused by upwelling phenomena serve as food for seabirds in different areas of the oceans. The Sandwich Tern is to some extent dependent on such occurrences during its stay in Southern Europe and Africa and may be found in huge numbers in these areas. The most important areas (Fig. 19) are the Canarian Stream upwelling north of Cap Blanc, Senegal to Morocco (north of it upwellings are found in Portugal), the Senegal upwelling from Cap Blanc to Guinea, the Gold Coast upwelling from the Ivory Coast to Lagos, Nigeria and the two southern areas in Gabon to Loanda, Angola

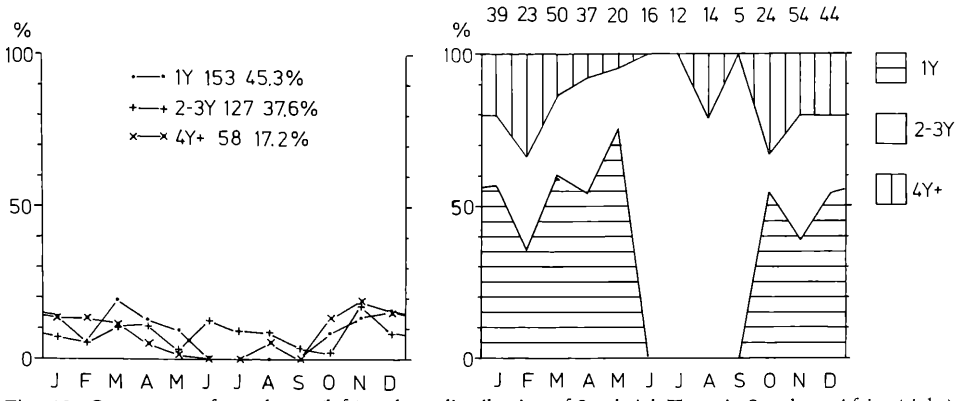

Fig. 18: Occurrence of age classes (left) and age distribution of Sandwich Terns in Southern Africa (right) throughout the year. Numbers at the top indicate the numbers of recoveries.

and Benguela, Angola to Cape Town, South Africa (Ashmole 1971, Ingham 1970, Grimes 1977, Brown 1979). Most fish catches from fishing vessels come from these areas, too (Fig. 19).

In the upwelling areas the Sandwich Tern is found nearly exclusively on the main continental shelf and only to a very limited extent further offshore on the slope (Brown 1979). Grimes (1977) indicates that large numbers of Common Terns *Sterna hirundo* and Little Terns *Sterna albifrons* exploit fish shoals in the Guinea Gulf during the months January to May, although it is not clear whether or not the Sandwich Tern exploit these food resources, too. This needs to be checked in the future.

The exploitation of these upwelling areas by Sandwich Terns varies (Table 10), the Senegal upwelling is most heavily utilized, 37% of the birds being within this area during the upwelling season with an especially high number of 1y birds (Fig. 16). The Gold Coast upwelling is used by 18% of the birds during the season, especially by immatures and, later in the season, adults (Fig. 17). The Benguela upwelling is utilized by 7% of the birds (Table 10). Adults are found in high numbers during the winter season November to January whereas immatures peak during both the winter and the summer seasons (Fig. 18). The Canarian Stream and the Portugal upwellings are used by small numbers of Sandwich Terns, as shown by the 5.3% and 2.9% of the recoveries recorded there during the upwelling seasons (Table 10).

There are marked differences in the ages of birds recovered from each upwelling area (Table 10). The Senegal and the Gold Coast upwellings are especially utilized by 1y birds and to a lesser degree by 2—3y birds, whereas the Benguela upwelling is utilized by 2—3y and especially 4y+ birds. The Portugal and Canarian Stream upwellings are utilized by 4y+ birds on their migration.

The separation of the different age classes in the upwelling areas seems to indicate comparatively more immatures and adults at the most southerly areas. The immatures can spend much time here because they do not need to return to the breeding grounds, whereas the adults with their superior fishing and flying abilities are able to reach these distant areas in considerable numbers. On the other hand, 1y birds can spend their first winter in West African waters and in the Guinea Gulf moving southwards rather slowly to reach the Southern African waters in their second year of life. The migration period thereby becomes longer, and furthermore, they are able to spend more time fishing and practising fishing.

17. Winter quarters

All recoveries from December to February come from the winter quarters. In November migration is still recorded along the Iberian Peninsula and off Morocco. By March some adults have already arrived at the European breeding grounds marking the onset of spring migration. The winter quarters have been divided into different areas as before.

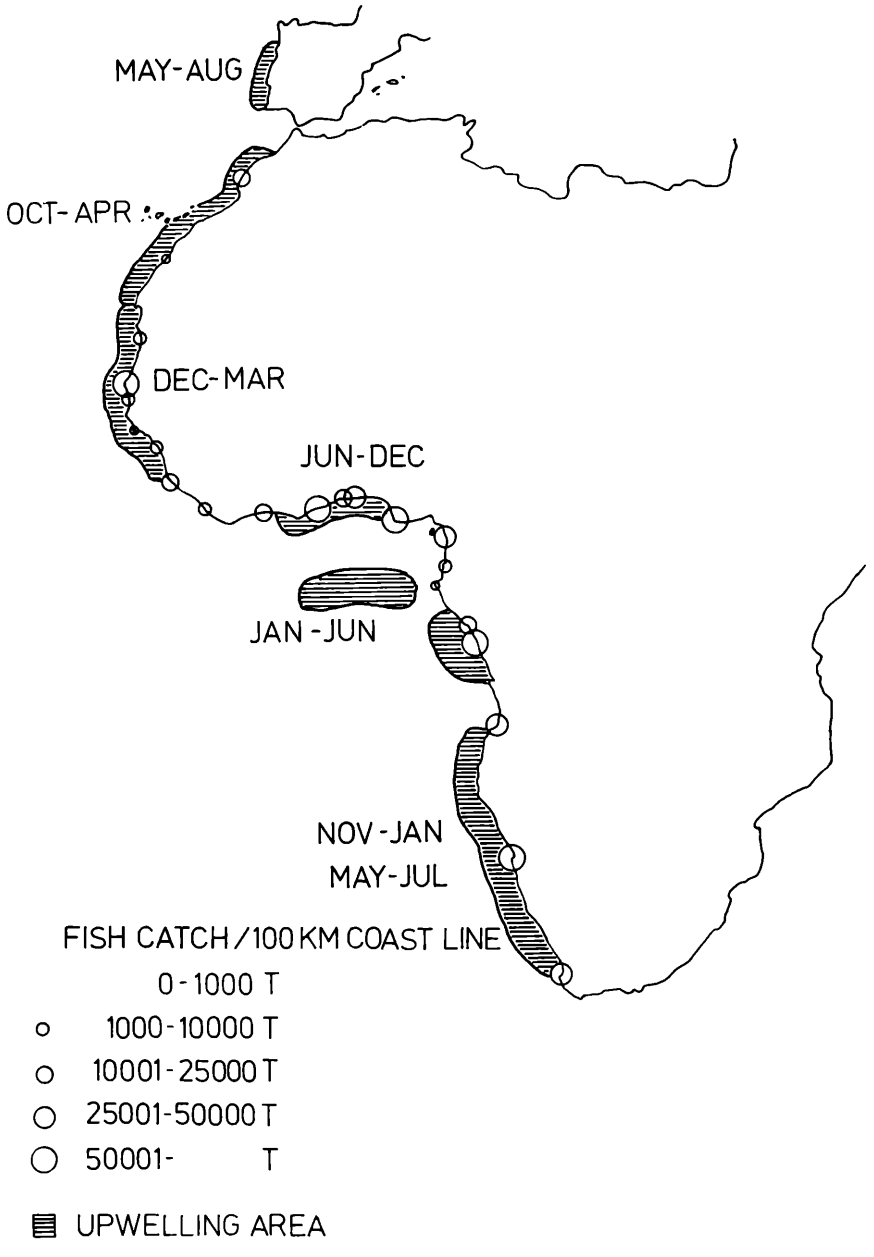

Fig. 19: Upwelling areas in Europe and Africa together with the upwelling seasons (partly from INGHAM 1970, ASHMOLE 1971 and others). Fish catches/100 km coast line are shown for each country (partly from FAO 1977).

Table 10: Utilization of upwelling areas by Sandwich Terns indicated by recovery rates within the areas. The upwelling season is indicated in brackets. When an age class only occurs in a limited part of the season, it is indicated in brackets. See Fig. 19 for the location of the areas.

Age class	Recoveries within area	Total recoveries	Percentage within area
Portugal upwelling (May—August)			
1y	13 (Aug)	550 (Aug)	2.4
2—3y	8	365	2.2
4y+	11 (Aug)	186 (Aug)	5.9
1y+	32	1101	2.9
Canarian Stream upwelling (October—April)			
1y	54	1450	3.7
2—3y	20	344	5.8
4y+	36	296	12.2
1y+	110	2090	5.3
Senegal upwelling (December—March)			
1y	312	797	39.1
2—3y	66	197	33.5
4y+	33	126	26.2
1y+	411	1120	36.7
Gold Coast upwelling (June—December)			
1y	228 (Sep—Dec)	1162 (Sep—Dec)	19.6
2—3y	110	546	20.1
4y+	40 (Sep—Dec)	380 (Sep—Dec)	10.5
1y+	378	2088	18.1
Benguela upwelling (November—January, May—July)			
1y	32 (Nov—Jan)	843 (Nov—Jan)	3.8
2—3y	44	392	11.2
4y+	20 (Nov—Jan)	136 (Nov—Jan)	14.7
1y+	96	1371	7.0

17.1. 1y birds

Large numbers of recoveries of first year Sandwich Terns are reported in the winter quarters from all four countries (Fig. 20, 21). Many Danish and West German birds are recovered in West Africa (44% and 60% of all Danish and West German recoveries from the winter months), whereas many Dutch and British and Irish birds are in the Guinea Gulf (52% and 48%). The percentage of Danish-West German and Dutch-British-Irish birds within and outside the Guinea Gulf area differs significantly ($\chi^2 = 7.3$, $P < 0.02$). In Southern Africa few Dutch (2%), more West German and British-Irish (8% and 7%) and many Danish birds (13%) occur. Significantly more Danish birds are in Southern Africa compared to the other countries ($\chi^2 = 6.4$, $P < 0.02$). Few birds (3—8%) are in Europe (Table 11).

There have been changes in Sandwich Tern winter quarters during the present century (Table 12). The most marked change is in Southern Africa, where the proportion of recoveries of Danish birds decreased from 53% to 13% between 1941 and 1960, to 3% in recent years. Recoveries of West German birds have also fallen from 40% to 11% (1941—60) and to 4% (1960—76) whilst British-Irish birds recovered declined from 21% to 11% (1941—60) and then to 4%. Recoveries of British-Irish Sandwich Terns in West Africa increased from 21% (1900—1940) to 42% (1941—60) and to 45% (1960—76). In the Guinea Gulf, concurrent increases in the number of recoveries from 1941—1960 to 1961—1976 occurred for West German birds (from 11% to 28%), Dutch birds (from 29% to 59%) and British-Irish birds

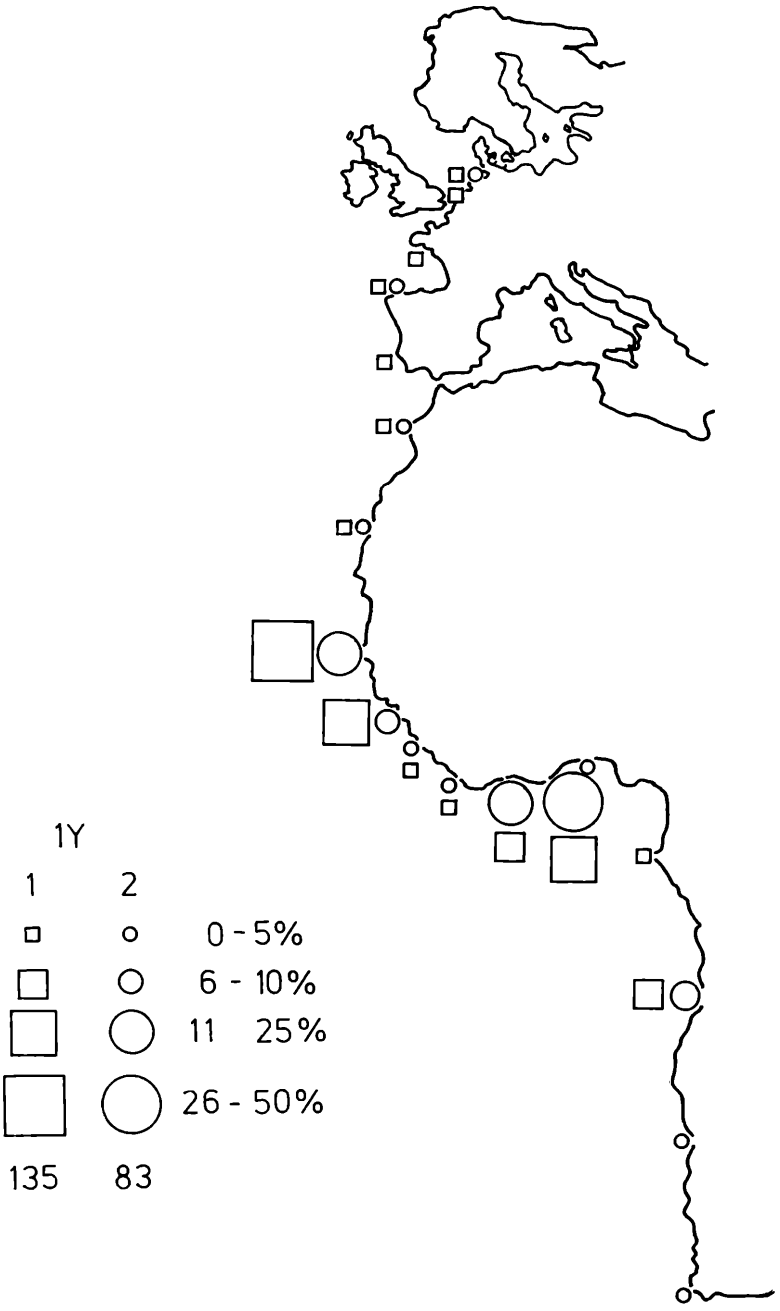

Fig. 20: Winter (December—February) distribution of Danish (2) and West German (1) 1y birds. Numbers indicate recovery totals. Recoveries are distributed on countries.

(from 38% to 49%). However, the cause of these changes in the pattern of recoveries remain obscure as several factors affecting recovery rates may also have altered. Different increases in human population levels, educational levels etc. in different areas may have affected the number of recoveries for example.

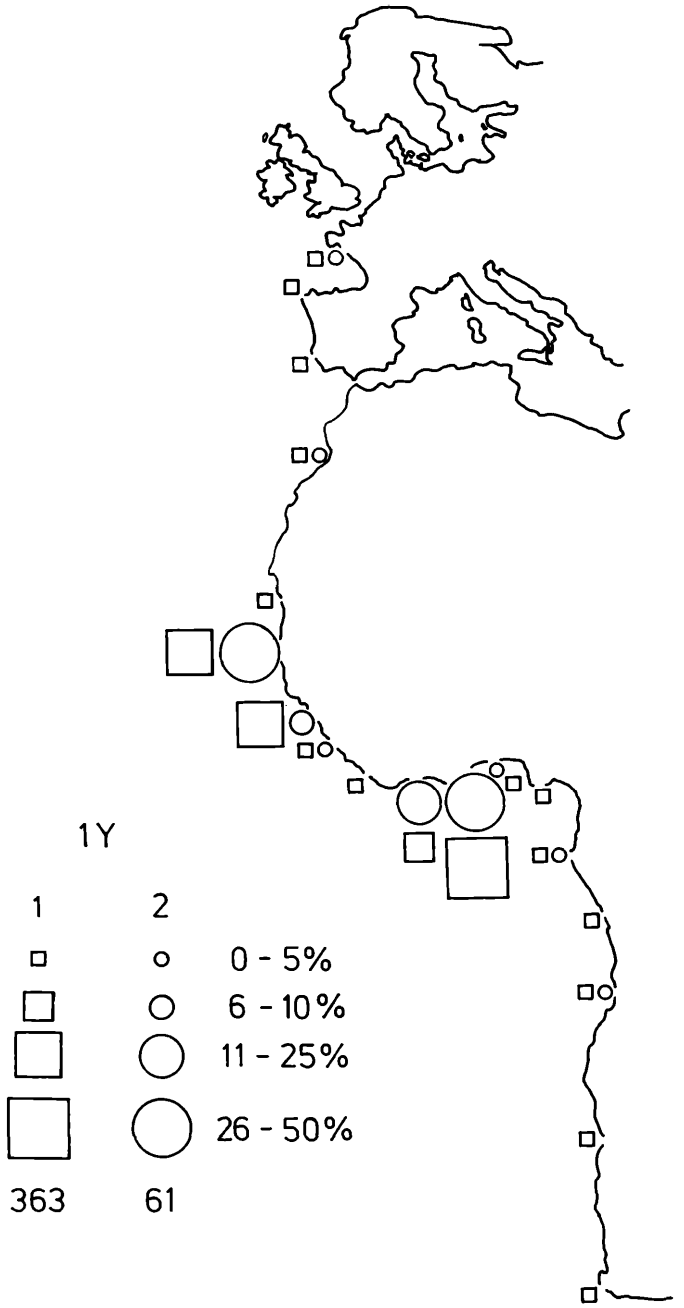

Fig. 21: Winter (December—February) distribution of Dutch (2) and British-Irish (1) 1y birds. Explanations as in Fig. 20.

Table 11: Winter (December-February) distribution of Sandwich Terns from Denmark, West Germany, Netherlands and Great Britain. Percentage in four areas.

Denmark	1y	2—3y	4y+
Europe	8	18	12
West Africa	60	47	46
Guinea Gulf	25	6	12
Southern Africa	8	29	31
N	142	17	26
West Germany			
Europe	5	3	46
West Africa	44	48	39
Guinea Gulf	39	21	0
Southern Africa	13	28	15
N	85	29	13
Netherlands			
Europe	5	7	18
West Africa	42	67	36
Guinea Gulf	52	27	9
Southern Africa	2	0	36
N	60	15	11
Great Britain, Ireland			
Europe	3	6	19
West Africa	42	35	26
Guinea Gulf	48	46	32
Southern Africa	7	13	23
N	392	95	53

17.2. 2—3y birds

There are few recoveries of West German and Dutch birds in this age class. Danish, West German and Dutch birds dominate in recoveries in West Africa (Denmark 48%, West Germany 47%, Netherlands 67%), while British-Irish birds are most frequently recovered in the Guinea Gulf (46%) (Fig. 22). Significantly more British-Irish birds were found in the Guinea Gulf compared to the other populations ($\chi^2 = 18.4$, $P < 0.001$). More Danish and West German birds are in Southern Africa (28% and 29%) compared to Dutch and British-Irish birds (0% and 13%) ($\chi^2 = 9.6$, $P < 0.01$).

When the recoveries from the four countries are grouped, the proportion of records in Southern Africa has decreased from 56% (1900—40) over 22% (1941—60) to 10% (1960—76) as in the 1y birds. The proportion of birds recovered in the Guinea Gulf has increased from 13% to 22% to 40% in the same time periods. The numbers of birds recovered in Europe have decreased from 19% to 9% to 4%, although numbers are small for the first two periods (Table 12).

17.3. 4y+ birds

There are very few recoveries of Danish and Dutch birds. Many West German birds are recovered in West Africa (46% of total), whereas recoveries of birds from Great Britain and Ireland reaches a maximum in the Guinea Gulf (46%). The birds seem to be distributed as the 1y and 2—3y birds (Fig. 23). There are too few recoveries to enable changes in winter quarters during this century to be examined (Table 12).

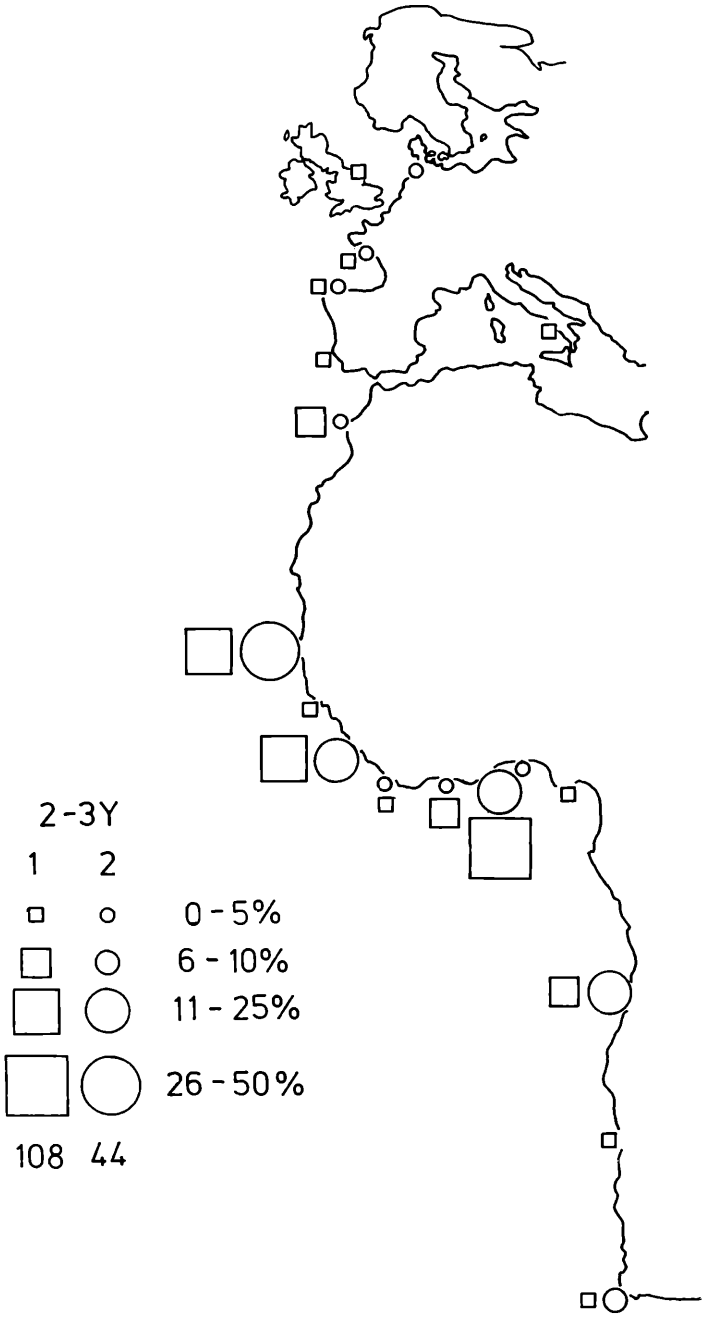

Fig. 22: Winter (December—February) distribution of Danish-West German (2) and Dutch-British-Irish (1) 2—3y birds. Explanations as in Fig. 20.

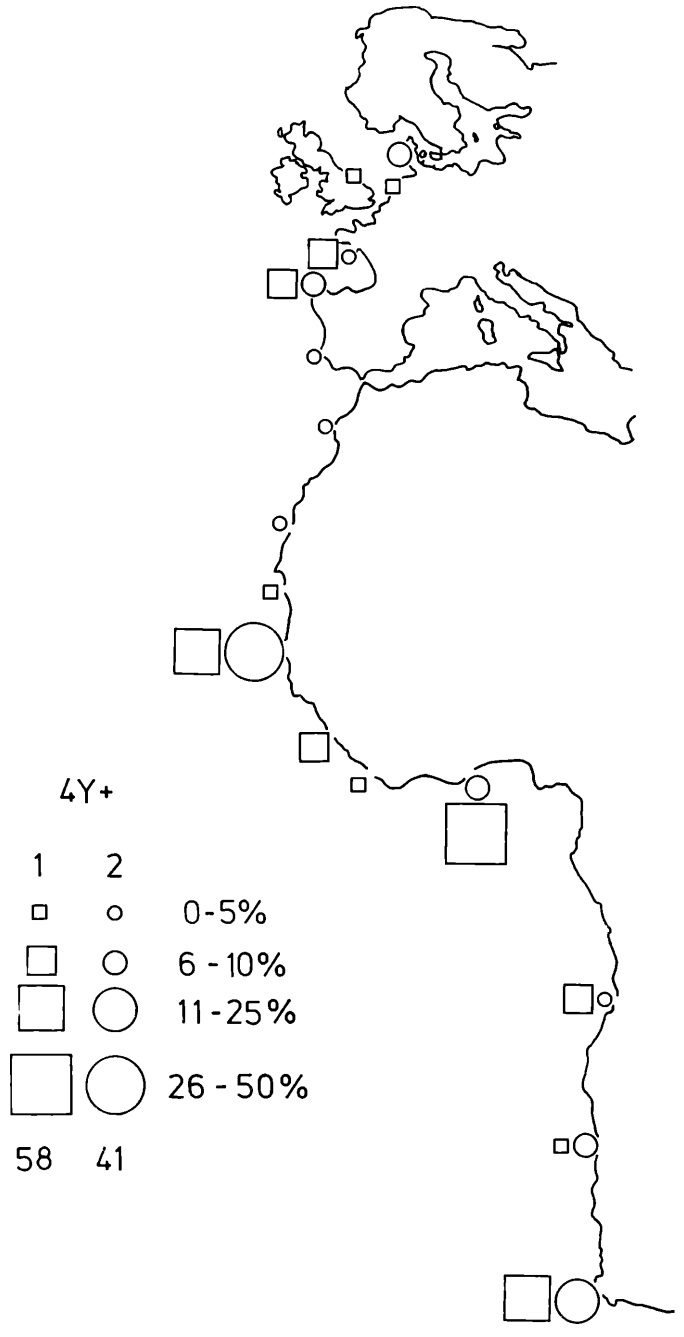

Fig. 23: Winter (December—February) distribution of Danish-West German (2) and Dutch-British-Irish (1) 4y+ birds. Explanations as in Fig. 20.

Table 12: Changes in winter distribution from 1900—1940, 1941—1960 to 1961—1976. Percentage in four areas, with 2—3y and 4y+ recoveries grouped.

Denmark 1y	1900—1940	1941—1960	1961—1976
Europe	7	13	3
West Africa	20	75	45
Guinea Gulf	20	0	48
Southern Africa	53	13	3
N	15	8	62
West Germany 1y			
Europe	20	0	8
West Africa	30	78	60
Guinea Gulf	10	11	28
Southern Africa	40	11	4
N	10	18	114
Netherlands 1y			
Europe	50	7	2
West Africa	0	64	36
Guinea Gulf	50	29	59
Southern Africa	0	0	2
N	2	14	44
Great Britain, Ireland 1y			
Europe	0	9	2
West Africa	21	42	45
Guinea Gulf	58	38	49
Southern Africa	21	11	4
N	43	55	294
Northern Europe 2—3y			
Europe	19	9	4
West Africa	13	48	46
Guinea Gulf	13	22	40
Southern Africa	56	22	10
N	16	23	114
Northern Europe 4y+			
Europe	20	50	17
West Africa	10	10	40
Guinea Gulf	10	30	20
Southern Africa	60	10	23
N	10	10	83

17.4. Wintering in Europe

Ouweneel (1975) reported Sandwich Terns wintering in the Netherlands and suggested an increase in the tendency for the birds to winter in Europe during the 1970's. Campredon (1978) reports some 50 birds wintering at Bassin d'Arcachon, West France, whereas 65 Sandwich Terns have been recorded in northern Portugal and 700 terns in southern Portugal (E. K. Dunn in litt.).

Isolated recoveries in Europe between December and February cannot be taken to indicate birds trying to winter in Europe, especially since some 1y birds stay near the breeding grounds and die there, unable to survive their first winter.

However, a total of 62 birds have been recovered in Europe between December and February. Of these, 48% were 1y birds, 18% were 2—3y birds and 34% were 4y+ birds. They include significantly fewer ly birds (73%) compared with other areas ($\chi^2 = 13.3$, $P < 0.001$) but more 4y+ birds (9%) ($\chi^2 = 18.0$, $P < 0.001$). There is no ev8dence that the number of Sandwich Terns wintering in Europe has changed recently. European winter recoveries account for 10.3% of the 97 winter recoveries reported between 1900 and 1940, 10.9% of the 128 winter recoveries from 1941 to 1960 and 5.3% of 711 winter recoveries in more recent years. It is possible that the proportion of African winter recoveries has increased due to the human population explosion and a general increase in the level of education, especially since 1960. The proportion of European winter recoveries has remained more or less stable during the present century.

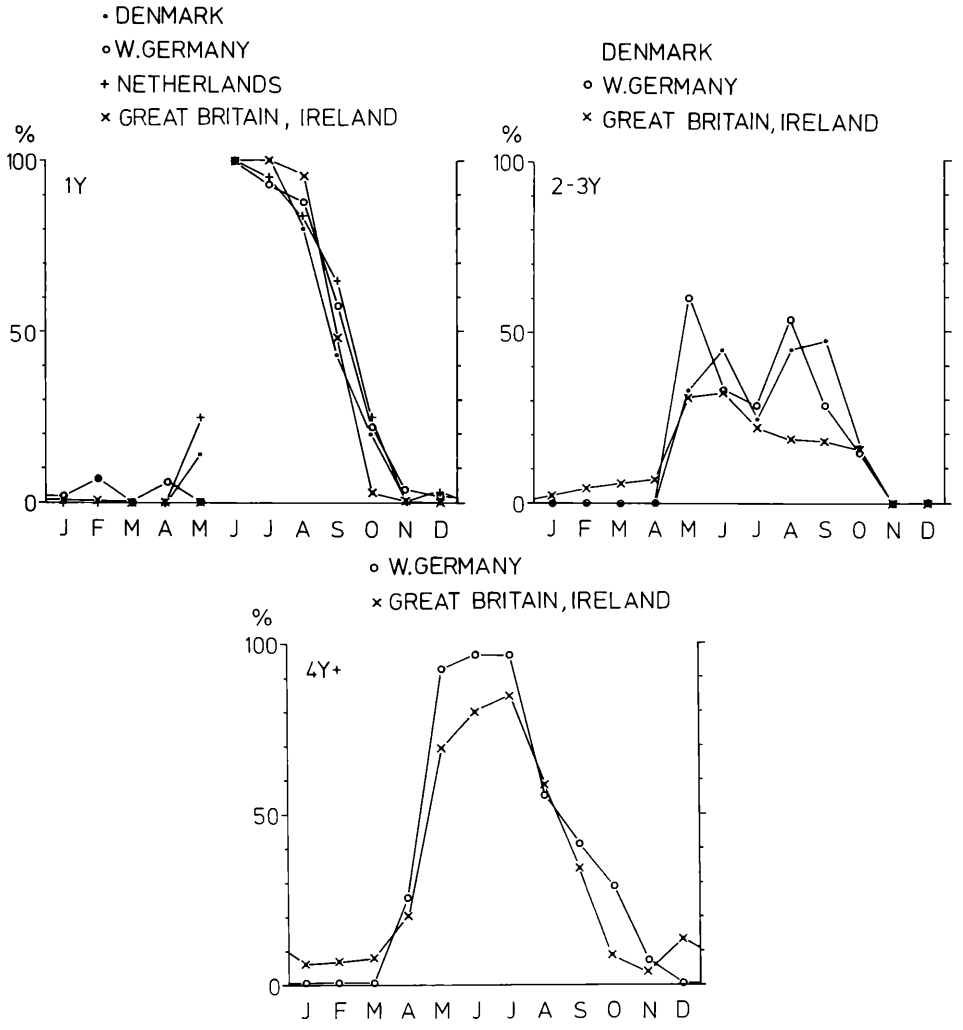

Fig. 24: Percentage of 1y, 2—3y and 4y+ birds within the 500 km limit in different months. Dutch and Danish birds are excluded due to few recoveries, respectively.

18. Return to the breeding grounds

It is well known that many 1y Sandwich Terns spend their first summer in the winter quarters, and that an unknown proportion of the 2—3y birds stay there during summer, too (THOMSON 1943, MÜLLER 1959 and others). Although Sandwich Terns are rarely faithful to their natal colony, only very few birds move more than 500 km from their birth place. The pattern of return to the natal colony is shown by the proportion of ringing recoveries reported within the 500 km.

Few 1y birds return to the vicinity of their natal colony (Fig. 24). A total of 4.5% of the recoveries are reported there in May (Table 13). Among the 2—3y birds, most recoveries from the natal area are reported between April and June (birds attempting to breed?) and from July to September (non-breeding immatures?) (Fig. 24); 31.8—45.2% of the recoveries from the four areas are within the 500 km limit in June (Table 13) which is the only month when no migration of breeding birds occurs. Among the 4y+ birds, most are found within the 500 km limit between May and July (Fig. 24), with a maximum of 79.7—100.0% of the recoveries reported there in June (Table 13). Apparently more West German and Dutch birds are found near their natal colonies compared to Danish and, especially, British-Irish birds. Some birds of the 4y+ age class may even be away from the breeding grounds in June. Two British 7y birds, recovered in Senegal and Ghana are the only birds reported in Africa at this time. All other birds are probably near Sandwich Tern breeding grounds somewhere. LANGHAM (1971) states that few 4y birds breed. Danish investigations show that most birds have bred once when 4y old.

In conclusion, some 1y birds, more 2—3y birds and nearly all 4y+ birds return to their breeding grounds in the summer months, but birds as old as 7y may be far away at this time. Ringing recoveries give no indication of the birds' breeding status.

19. Implications of the results for protection

This analysis of European Sandwich Tern ringing recoveries has several implications for the conservation of the species. Although c. 41.000 pairs breed in Western Europe and the species seems not to be threathened, the large size of colonies make the birds particularly vulnerable to disturbance. Several thousand birds died in the Netherlands in the 1960's due to toxic chemical poisoning (KOEMAN et al. 1967), although numbers have increased again since. The trapping of large numbers of Sandwich Terns in West Africa and the Guinea Gulf (DUNN

Table 13: The timing of Sandwich Tern arrivals at the breeding grounds. Percentage within and outside the 500 km limit from the natal colony.

Sandwich Tern 1y May	Denmark	West Germany	Netherlands	Great Britain, Ireland
0—500 km	14	0	25	0
501— km	86	100	75	100
N	14	15	4	48
Sandwich Tern 2—3y June				
0—500 km	45	33	40	32
501— km	55	67	60	68
N	31	12	5	44
Sandwich Tern 4y+ June				
0—500 km	88	96	100	80
501— km	12	4	0	20
N	68	52	17	74

1981) may also threathen the species, especially when trapping seems to be increasing (C. MEAD in litt.). British and Irish birds are apparently more vulnerable to this trapping, and most birds from Britain and Ireland are recovered there. However, British and Irish birds are less often recovered in Europe during migration allowing a higher mortality in the winter quarters and especially in the Guinea Gulf, where trapping is common. Ringing recoveries show a decrease in the proportion of birds wintering in Southern Africa and an increase in the percentage of birds wintering in the Guinea Gulf which may have caused increased mortality, especially in the British-Irish population. However, the changes in the winter distribution indicated in the present paper may be due to just a change in recovery rates in the different areas. Such a change will furthermore affect the total number of different populations simultaneously.

Anyhow, Sandwich Tern breeding populations in all European countries should be monitored carefully and the mortality in Africa kept under observation. Protection in the winter quarters must be considered a possibility, especially if the breeding populations decrease due to mortality from trapping on the wintering grounds.

20. Summary

1. European recoveries of Sandwich Terns have been analysed to describe the spatial and seasonal distribution of the species. A total of 5099 recoveries have been considered.

2. Recovery rates ranged from 1.07 to 3.04%.

3. Recoveries are biased in a number of ways, but comparisons of different populations or age groups may minimize these biasing factors.

4. A total of c. 41.000 pairs of Sandwich Terns breed in Europe with large numbers founds in Denmark, West Germany, Netherlands, Great Britain and France.

5. The post-fledging dispersal of some colonies has been shown in Figs. 1—3. No preference for dispersal in the opposite direction to the migrational one exists. The colonies most distant to the winter quarters have high dispersal rates. Local differences in the occurrence and amount of fish are suggested to account for the different dispersal patterns.

6. A post-breeding dispersal seems to exist.

7. Migration is outlined in Figs. 4—14.

Juveniles. British-Irish and Dutch 1y birds cover short distances during their first autumn migration. During the rest of the year the distribution of Danish, West German, Dutch and British-Irish birds seems to be very similar. More British-Irish 1y birds are recovered in Africa compared with continental Sandwich Tern populations. More West German 1y birds are recovered in West Africa and fewer West German birds are recovered in the Guinea Gulf compared with the other populations.

Immatures. The northward return of 2—3y birds during summer shows temporal differences between countries, Dutch and British-Irish birds returning later and to a lesser extent than Danish and West German ones. Few British-Irish birds are recovered in Europe and West Africa, whereas many are recovered in the Guinea Gulf.

Adults. Few British-Irish birds are recovered in Europe. Few Dutch Sandwich Terns are recovered in West Africa and many are recovered in Southern Africa. Many Danish birds are recovered in the Guinea Gulf.

Swedish and East German birds have a distribution similar to the other continental populations. French Sandwich Terns are similar to British-Irish and Dutch birds in their distribution.

8. The western European populations are totally synhiemic; the Black Sea population is partially synhiemic with the western European Sandwich Terns performing a leap-frog migration. The Caspian Sea population is totally allohiemic to the other populations.

9. At northern European bird observatories migration patterns are borne out by the pattern of ringing recoveries (Table 8).

10. Average migration speeds of 1y birds peak during October-November (Table 9).

11. In Europe 1y birds are recovered later in summer compared with 2—3y birds and especially with 4y+ birds (Fig. 15).

In West Africa and the Guinea Gulf two thirds of the recoveries are 1y birds, one fifth 2—3y birds and one tenth 4y+ birds (Figs. 16, 17).

In Southern Africa few juveniles and adults are recovered (Fig. 18).

12. In the upwelling areas along the coasts of Europe and Africa age classes are separated, the Senegal and the Gold Coast upwellings being utilized by 1y and to some extent 2—3y birds, whereas the Benguela upwelling is utilized by 2—3y and especially 4y+ Sandwich Terns (Fig. 19, Table 10).

13. Winter quarters are shown in Figs. 20—23 and Tables 11—12.

Juveniles. More Danish-West German birds are in West Africa compared to Dutch and British-Irish birds. More Dutch and British-Irish birds are in the Guinea Gulf compared with Danish and West German Sandwich Terns. The proportion of birds recovered in Southern Africa has apparently decreased.

Immatures. More British-Irish birds are in the Guinea Gulf compared with Danish, Dutch and West German birds, and more Danish and West German birds are in Southern Africa compared with Dutch and British-Irish ones. Southern African recoveries have decreased in proportion.

Adults. The distributional pattern appears to be similar to that of 1y and 2—3y birds.

The percentage of birds wintering in Europe has not increased.

14. Few juveniles, more immatures and most adults return to their breeding grounds during summer. Two 7y birds did not return.

21. Zusammenfassung

1. Die räumliche und jahreszeitliche Verbreitung der Brandseeschwalbe wurde untersucht. 5099 Wiederfunde in Europa beringter Vögel wurden berücksichtigt, von denen 4915 ausgewertet wurden.

2. Die Wiederfundrate liegt je nach Beringungszentrale zwischen 1,07 und 3,04%.

3. Bei der Auswertung von Ringfunden gibt es eine Reihe von Fehlerquellen. Durch den Vergleich bestimmter Populationen oder Altersgruppen konnte eine Reihe Fehlerquellen ausgeschaltet werden.

4. Etwa 41000 Paare der Brandseeschwalbe brüten in Europa, vor allem in Dänemark, Nordwestdeutschland, den Niederlanden, Großbritannien und Frankreich.

5. Zwischenzugartige Bewegungen (Dismigration) von Jungvögeln sind für einige Kolonien in Abb. 1—3 dargestellt. Die von einigen Autoren behauptete Bevorzugung nördlicher Richtungen gibt es nicht. Die Kolonien, die am weitesten von den Winterquartieren entfernt sind, zeigen hohe Anteile an diesen Bewegungen. Es wird angenommen, daß örtliche Unterschiede in Vorkommen und Häufigkeit von Fischen für das unterschiedliche Dismigrationsverhalten verantwortlich sind.

6. Es gibt offenbar auch ähnliche Bewegungen bei Altvögeln.

7. Zugbewegungen sind in Abb. 4—14 dargestellt. Jungvögel im ersten Winterhalbjahr: Vögel aus Großbritannien, Irland und den Niederlanden legen im ersten Herbst nur kurze Entfernungen zurück. Besonders niederländische Vögel finden sich im September noch nahe den Kolonien. Später im Jahr ist die Verbreitung von Vögeln aus Dänemark, Westdeutschland, den Niederlanden, Großbritannien und Irland sehr ähnlich. Mehr Brandseeschwalben aus Großbritannien und Irland als vom Kontinent werden in Afrika wiedergefunden. Verglichen mit anderen Populationen werden mehr westdeutsche Vögel in Westafrika bzw. weniger westdeutsche Vögel im Golf von Guinea wiedergefunden.

Immature: Die Rückkehr zwei- bis dreijähriger Vögel nach Norden variiert zeitlich nach Herkunftsländern. Vögel aus Großbritannien, Irland und den Niederlanden kehren später und in geringerem Umfang zurück als dänische und westdeutsche Vögel. Wenige Vögel aus Großbritannien und Irland werden in Europa und Westafrika wiedergefunden, viele dagegen im Golf von Guinea.

Adulte: Wenige Vögel aus Großbritannien und Irland werden in Europa wiedergefunden. Wenige Vögel aus den Niederlanden werden in Westafrika wiedergefunden, viele dagegen im südlichen Afrika. Viele dänische Vögel werden im Golf von Guinea wiedergefunden. Schwedische und ostdeutsche Vögel sind in ihrer Verbreitung den anderen Populationen vom Kontinent ähnlich. Vögel aus Frankreich ähneln in ihrer Verbreitung Vögeln aus Großbritannien, Irland und den Niederlanden.

8. Die westeuropäischen Populationen sind vollständig synhiem. Die Schwarzmeer-Population ist teilweise mit den westeuropäischen Populationen synhiem, doch reicht die Winterverbreitung dieser weiter nach Süden. Die Population des Kaspischen Meeres ist gegenüber den anderen Populationen vollständig allohiem.

9. Beobachtungsdaten von Stationen im nördlichen Europa vermitteln zusammen mit Ringfunddaten ein genaues Bild vom Ein- und Abzug der Art in ihren Brutgebieten (Tab. 8).

10. Jungvögel erzielen im ersten Winterhalbjahr höchste durchschnittliche Wandergeschwindigkeiten im Oktober/November (Tab. 9).

11. In Europa werden Vorjährige zur Brutzeit später wiedergefunden als zwei- bis dreijährige oder besonders vierjährige Vögel und ältere (Abb. 15). In Westafrika und im Golf von Guinea sind zwei Drittel der Wiederfunde Vögel im ersten Lebensjahr, ein Fünftel zwei- bis dreijährige und ein Zehntel vierjährige oder ältere Vögel (Abb. 16, 17). Nur wenige Jung- und Altvögel werden im südlichen Afrika wiedergefunden (Abb. 18).

12. Die Altersklassen der Brandseeschwalbe sind mit unterschiedlichen Schwerpunkten an den Auftriebswässern entlang der Küsten Europas und Afrikas verbreitet. Die Senegal- und Goldküstenströmung wird von den einjährigen und in gewissem Umfang von den zwei- bis dreijährigen Vögeln genutzt. Die Benguela-Strömung nutzen die zwei- bis dreijährigen und besonders die vierjährigen und älteren Vögel (Abb. 19, Tab. 10).

13. Abb. 20—23 und Tab. 11—12 zeigen die Winterquartiere der Art.

Jungvögel: In Westafrika finden sich relativ mehr dänische und westdeutsche Vögel als Vögel aus Großbritannien, Irland und den Niederlanden. Umgekehrt ist es im Golf von Guinea. Offensichtlich hat der Anteil von Vögeln, die im südlichen Afrika wiedergefunden werden, abgenommen.

Immature: Im Golf von Guinea finden sich relativ mehr Vögel aus Großbritannien und Irland als dänische und westdeutsche Vögel. Im südlichen Afrika finden sich relativ mehr dänische und westdeutsche Vögel als Vögel aus Großbritannien, Irland und den Niederlanden. Wiederfunde aus diesem Überwinterungsgebiet haben abgenommen.

Adulte: Ihre Verbreitung scheint der Verbreitung der beiden vorhergehenden Altersgruppen zu entsprechen.

Der Anteil in Europa überwinternder Vögel hat im Beringungszeitraum (seit etwa 1910) nicht zugenommen.

14. Wenige Vorjährige, mehr Immature und die meisten Adulten kehren im Frühjahr/Sommer an ihre Geburts- bzw. Brutplätze zurück. Zwei siebenjährige Vögel wurden zu dieser Zeit im Winterquartier wiedergefunden.

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Die Vogelwarte 31, 1981: 168—174

Trauerschnäpper *(Ficedula hypoleuca* PALLAS) orientieren sich nichtvisuell mit Hilfe des Magnetfeldes

Von Willy Beck und Wolfgang Wiltschko

Einleitung

Viele Vögel verlassen jährlich ihre Brutgebiete, um Perioden mit schlechten Lebensbedingungen wie Kälte, Trockenheit und Nahrungsknappheit auszuweichen. Neben der Orientierung nach der Sonne, den Sternen und vielen anderen Faktoren (Zus. EMLEN 1975) bestimmen besonders nachtziehende Vögel auf den gerichteten Wanderungen ihre Richtung mit Hilfe des Erdmagnetfeldes, wie MERKEL & WILTSCHKO (1965, WILTSCHKO 1968) durch Versuche mit zugaktiven Rotkehlchen zeigen konnten: In einem künstlichen Magnetfeld, dessen Nordrichtung je nach Stromrichtung in den Spulen nach geographisch ESE oder geographisch W wies, bezogen die Vögel ihre Zugrichtung sowohl im Frühjahr als auch im Herbst auf die entsprechende Nordrichtung des Feldes.

Bis heute konnte bei vier weiteren nachtziehenden Vogelarten eine nichtvisuelle Orientierung nach dem Magnetkompaß nachgewiesen werden: Dorngrasmücke *Sylvia communis*