

## POPULATION TRENDS OF LITTLE AND SANDWICH TERNS *STERNA ALBIFRONS* AND *S. SANDVICENSIS* IN BRITAIN AND IRELAND FROM 1969 TO 1998

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*Population trends of Little Terns *Sterna albifrons* and Sandwich Terns *S. sandvicensis* were determined between 1969 and 1998 using counts from sample colonies throughout the UK and Ireland. The Sandwich Tern population increased from c. 12 000 pairs in 1969 to c. 17 000 pairs in 1971, but then fell to c. 13 000 pairs in 1974. It then recovered at a rate of 6% per annum to c. 17 000 pairs in 1979 and fluctuated around 16 000 pairs until 1992. There was a second large population decline of 20% between 1992 and 1995, resulting in a total of c. 13 000 pairs in 1995. This decline appears to have halted up to 1998, when population size remained relatively stable at 13 500-14 000 pairs. The Little Tern population increased from 2000 pairs in 1969 to 2600 pairs in 1971 and then decreased to c. 1800 pairs in 1973. It increased again to a peak of 2800 in 1975 but then entered a long-term decline at an average rate of 1.23% per annum, punctuated by increases in 1988 and 1996. The population of c. 1700 in 1998 was the lowest recorded during the 30 year study and represents a 39% decline compared with 1975. The decline in Sandwich Tern populations appears to be confined primarily to the North Sea, with decreases being associated with events at individual colonies rather than at all colonies within the area. The declines in Little Tern populations appear to have occurred throughout the species range and are probably symptomatic of a chronic, widespread problem. Possible reasons for the declines in these populations are discussed and recommendations are made for further research, monitoring and conservation measures.*

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### INTRODUCTION

The Little Tern *Sterna albifrons* and Sandwich Tern *S. sandvicensis* populations in Britain and Ireland are internationally important, hosting c. 15% and c. 40% of the European population respectively (Lloyd *et al.* 1991). Little and Sandwich Terns are included on the 'Amber' list of Birds of Conservation Concern (Gibbons *et al.* 1996) and listed in Annex 1 of the EC Birds Directive (Batten *et al.* 1990). All tern populations are sensitive to an array of threats, including disturbance (Lloyd *et al.* 1975), predation (Craik 1997; Becker 1998), flooding (Haddon & Knight 1983; Becker 1998), food availability (Monaghan *et al.* 1989;

Suddaby & Ratcliffe 1997; Stienen & Brenninkmeijer 1998), pollutants (Becker 1991) and trapping during winter (Dunn & Mead 1982, Stienen *et al.* 1998). This potential for tern populations to undergo rapid declines is exemplified by the crash of Roseate Terns *S. dougallii* in Britain and Ireland during the 1970s (Cabot 1995), of all tern species in the Wadden Sea during the 1960s (Becker 1991) and of Arctic Terns *S. paradisaea* on the Orkney and Shetland Islands between 1980 and 1994 (Bullock & Gomersall 1981; Avery *et al.* 1989; Brindley *et al.* 1999). It is essential that tern populations be monitored so that adverse population trends can be identified and ultimately diagnosed and reversed. Effective monitoring of terns in Britain and Ireland should therefore be regarded as a high priority and an international responsibility.

The low site-fidelity of terns makes census work difficult as they readily abandon sites, form new colonies and move among established ones (Lloyd *et al.* 1991). Therefore changes in numbers at sample colonies may not be representative of trends of others in the region, and the variability of trends among colonies produces wide confidence limits around population estimates. In order to overcome this problem, periodic complete national censuses or an annual sampling strategy that includes a high proportion of the colonies within the nation (and preferably in other countries within the metapopulation) need to be conducted. Data from both these sources are available for Sandwich and Little Terns in Britain and Ireland.

There is a long history of censusing tern colonies in Britain and Ireland that dates back to the beginning of the century (Parslow 1967; Cramp *et al.* 1974). These were generally non-systematic counts of a small sample of individual colonies by amateur ornithologists. The first national Little Tern census was in 1967 (Norman & Saunders 1969) and was followed by the 1969-70 'Operation Seafarer' census (Cramp *et al.* 1974), which censused all tern colonies in Britain and Ireland. Another complete survey was conducted in 1985-87 (Lloyd *et al.* 1991) and incorporated data from the 1984 'All Ireland Tern Survey' (Wilde 1985) for those sites not surveyed in western Ireland. These surveys showed an increase in the population size of both Little and Sandwich terns. The Irish tern survey was repeated in 1995 (Hannon *et al.* 1997), detecting declines in Little and Sandwich Terns since the mid 1980s. A third national tern census of Britain and Ireland is planned for 2000.

In addition to the infrequent national censuses, a sample of tern colonies have been counted annually by reserve wardens and volunteers throughout Britain and Ireland since 1969. These data are a valuable supplement to the national censuses as annual population changes can be described, allowing adverse trends to be detected and diagnosed more quickly and patterns of change between censuses to be studied. The counts have been collated by The Royal Society for the Protection of Birds (RSPB) and the Seabird Group, and total

numbers of breeding terns at monitored colonies between 1969 and 1984 have been reported as population sizes and raw trends (Lloyd *et al.* 1975; Thomas 1982; Thomas *et al.* 1989). This simple analysis produces minimum population estimates and biased trends, because changes in population size reflect temporal patterns in the colonies included in the sample as well as real changes in population size (Sears & Avery 1993).

In 1986, the annual tern monitoring scheme was integrated with the national Seabird Monitoring Programme and trends have since been presented as chain indices (Marchant *et al.* 1990) that compare percentage changes only at those colonies counted in consecutive years. These indices suggest that Little and Sandwich Terns have declined in the UK since 1986 (Thompson *et al.* 1999). Sears & Avery (1993) also used chain indices to describe annual population changes for Little Terns in Britain and Ireland between 1969 and 1989. This showed an increase up to 1972, followed by a sharp fall in 1973. The population then recovered to a peak in 1976 followed by a gradual decline up until 1989.

From the above, it is clear that a holistic interpretation of the annual tern population trends from 1969 to the present day is not feasible because the data are not held centrally and have been analysed using different, non-comparable methods. The evidence that Little and Sandwich Tern populations have decreased since 1986 needs to be investigated more thoroughly in the light of earlier population trends. This paper describes the population trends for Sandwich and Little Terns in Britain and Ireland using data from sample colonies over a 30-year period. Possible reasons for changes in population size are discussed and recommendations are made for further demographic studies, including more analyses of tern population trends.

## METHODS

Counts of tern colonies were made by volunteers and reserve wardens throughout Britain and Ireland between 1969 and 1998 and were submitted to a central co-ordinator for collation. Count units were the number of breeding pairs, derived primarily from counts of nests or Apparently Incubating Adults (Walsh *et al.* 1995). Peak fledgling counts (the maximum number of fledged young counted at a colony, Walsh *et al.* 1995) were also available from many Little Tern colonies and were used to provide a crude measure of productivity. Movements of fledglings among colonies, count errors and sampling bias in the counts create inaccuracies in this measure of productivity, and so it should be regarded at best as a crude index.

Sandwich Terns tend to breed in a few large colonies, most of which are in nature reserves and are counted annually. The 38 regularly censused Sandwich Tern colonies represented approximately 80% of the national population in 1985-

87, so trends described from these colonies should be accurate. These colonies were distributed throughout the Sandwich Tern's British and Irish breeding range, although the small colonies in Orkney, Stroma and some parts of western Ireland were counted neither regularly nor systematically enough to include in the sample. Some of the smaller colonies included in the sample were not counted annually, so gaps occur in these colony histories (6.4% of all cases).

Little Terns tend to nest in small, single-species colonies on beaches and spits, many of which are on nature reserves. Survey coverage was not as comprehensive as it is for Sandwich Terns because smaller, declining colonies and abandoned colonies were rarely monitored (Sears & Avery 1993); this tends to result in conservative estimates of downward trends. The total number of Little Terns at the 110 sampled colonies represented around 65% of the national total during 1985-87 complete survey. Sampled colonies were distributed throughout the species breeding range in the North and Irish Seas. The consistency of counting at the monitored colonies is far lower than for Sandwich Terns and so there are more gaps in colony histories (32.2% of all cases). Estimates of Little Tern population trends will therefore be less robust than for Sandwich Terns, but are likely give a reasonably accurate index of long-term population changes.

Due to the gaps in the colony census histories, simple summation of annual totals would result in biased population trends that are influenced by the temporal pattern of missing counts. Chain indices (Marchant *et al.* 1990) have been used to assess changes in population size at colonies counted in consecutive years (Sears & Avery 1993; Walsh *et al.* 1994). However, this method makes poor use of the available data as any counts at a colony that are not repeated in the following year are discarded. The program TRIM (Pannekoek & van Strien 1996), a log-linear model specifically designed to model trends in data with missing counts, was used to produce indices of population change with 95% confidence limits.

The TRIM indices give changes in population size relative to that in the first year measured (1969), which is scaled to an arbitrary value of 1. In order to derive annual population sizes rather than merely indices of change, all index values for both species were multiplied by the total British and Irish population sizes during the 1969-70 'Operation Seafarer' survey. The population estimates for the entire period are therefore dependent on the 1969-70 survey being comprehensive and accurate.

Regional trends were also computed in order to compare them with national trends. Studies of Roseate Tern natal fidelity and inter-colony movements suggest that sub-populations of the NW European metapopulation occur in the Irish Sea, the English Channel and the North Sea (Ratcliffe 1997). Population trends for Sandwich and Little Terns were therefore examined within

these regions on the assumption that their metapopulation structures were similar. The small number of colonies monitored in western Scotland and Ireland were pooled with the counts from the Irish Sea. The trends were analysed using TRIM, and the results presented as indices rather than population sizes.

Productivity of Little Terns was determined by summing the total number of pairs and total number of fledged young at colonies for each year of available data. Productivity may be calculated by dividing the total number of chicks fledged by the total number of pairs and trends investigated by regressing these values against year. However, analysis of trends using these summary statistics would result in uneven weighting of cases due to variation in sample sizes among years (Crawley 1993). Instead, a code of 1 was assigned to denote successes and 0 to denote failures. The value for successes was weighted by the total number of fledged chicks and the value for failures was weighted by the total number of pairs minus the total number of fledged chicks. Thus if 100 pairs produced 25 chicks, there would be 25 successes and 75 failures. This scheme produces identical annual estimates of productivity to the simple division of fledged young by number of pairs providing the overall annual productivity does not exceed one chick per pair, as was always the case for Little Terns. A logistic regression was used to determine the significance of productivity trends by testing the effect of year on success as a continuous covariate. The square of year was fitted in addition to year in order to test for Gaussian (bell-shaped) trends in productivity through time. The logistic models were fitted using the maximum likelihood ratio.

## RESULTS

The British and Irish Sandwich Tern population during the last 30 years has been highly variable, with annual fluctuations and notable peaks and troughs (Fig. 1). The population increased from c. 12 000 pairs in 1969 to c. 17 000 pairs in 1971, an increase of 42%. This was followed by a sharp decline of 23% to c. 13 000 pairs in 1974. It then recovered at a rate of 6% *per annum* to c. 17 000 pairs in 1979 and fluctuated around 16 000 pairs until 1992, with a notable peak of 18 000 pairs in 1988. There was a second population crash of 20% between 1992 and 1995, with a total of c. 13 000 pairs in 1995. The population has been relatively stable from 1995-98 at 13 500-14 000 pairs. The population size in 1986 was estimated at c. 15 500 pairs using the modelled trend since 1969, whereas the complete census in 1985-87 (with most counts in 1986) was 18, 400 pairs (Lloyd *et al.* 1991). This suggests either that the colony trends were negatively biased or that the 1969 survey was an underestimate.

Analyses of regional trends show that the 1992-95 population crash was sustained primarily on the British North Sea coast (Fig. 2) where the population

during 1996-98 was lower than previously recorded. The North Sea hosted 73% of the British and Irish Sandwich Tern population in 1969, so it is not surprising that trends here have a large influence on the national population size. Examination of trends at individual colonies show the Sands of Forvie (Grampian, *c.* 1000 pairs in 1992) and Firth of Forth (473 pairs in 1991) declined and were ultimately abandoned between 1992 and 1995 without commensurate increases occurring at other colonies along the British North Sea coast. There was also a net loss of 1500 pairs from Northumberland between 1992 and 1995 due to declines at the Farne Isles that were not fully compensated for by observed increases at nearby Coquet Island. The colonies at Foulness and Havergate Island in Suffolk, which collectively contained 580 pairs in 1995, also declined and were abandoned in 1998.

In the English Channel (2% of the British and Irish population in 1969) the Sandwich Tern population was stable until 1980, but doubled in the following year (Fig. 2) due to increases at Dungeness and the Solent. The population has since fluctuated around this new level, with no notable changes during the period of the national population decline (Fig. 2).

In the Irish Sea (25% of the 1969 population) numbers increased by 50% in 1970 due to colony growth at Ravenglass (Cumbria), Green Island (Co. Down) and Tern Island (Co. Wexford) and then fluctuated around this level until 1986. The population then increased by a further 50% due to increases at Green Island, Strangford Lough (Co. Down) and Lady's Island Lake (Co. Wexford). There followed a decline of 25% between 1989 and 1992, which occurred at colonies in Strangford Lough and Cumbria (Fig. 2).

The Little Tern population increased from 2000 pairs in 1969 to 2600 pairs in 1971 and then decreased to *c.* 1800 pairs in 1973 (Fig. 3). It increased to a peak of 2800 in 1975 but then entered a long-term decline at an average rate of 1.23% *per annum*, punctuated by increases in 1988 and 1996 (Fig. 3). The population of *c.* 1700 in 1998 was the lowest recorded during the 30-year study and represents a 39% decline compared to 1975. The 1986 population estimate using the modelled trend since 1986 was *c.* 2300 pairs which again is lower than the complete census total of 2800 in Lloyd *et al.* (1991).

Analysis of regional trends show that declines have occurred throughout Britain and Ireland over the last two decades. The numbers in the English Channel (23% of the 1969 population) have decreased most and are approximately half of what they were in 1969 (Fig. 4). Numbers in the North Sea and western coasts (46% and 31% respectively of the 1969 population) have shown a less severe decline after the 1970s and are now at levels similar to those in 1969 (Fig. 4).

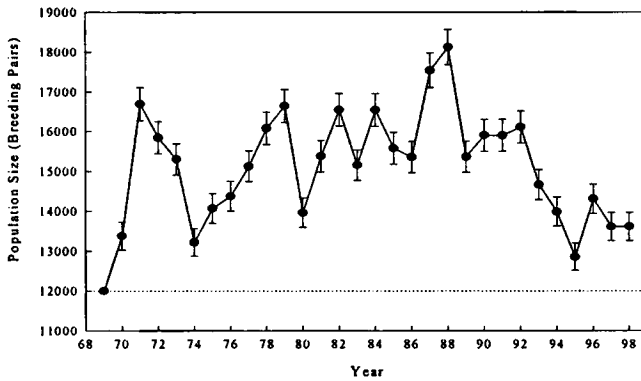


Figure 1. Population size and trends of Sandwich Terns in Britain and Ireland between 1969 and 1998. Error bars represent 95% confidence limits of the population estimates.

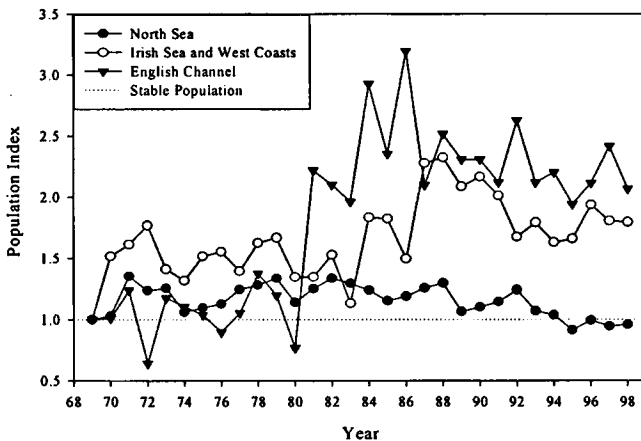


Figure 2. Population trends of British and Irish Sandwich Terns in the North Sea, Irish Sea and English Channel. Values are index values scaled as proportional change in population size compared with the population in 1969, which is given an arbitrary value of 1. The dotted reference line represents a stable population trajectory.

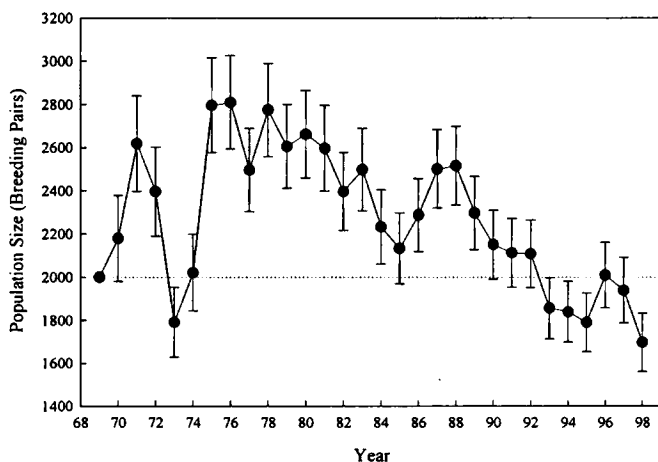


Figure 3. Population size and trends of Little Terns in Britain and Ireland between 1969 and 1998. Error bars represent 95% confidence limits of the population estimates.

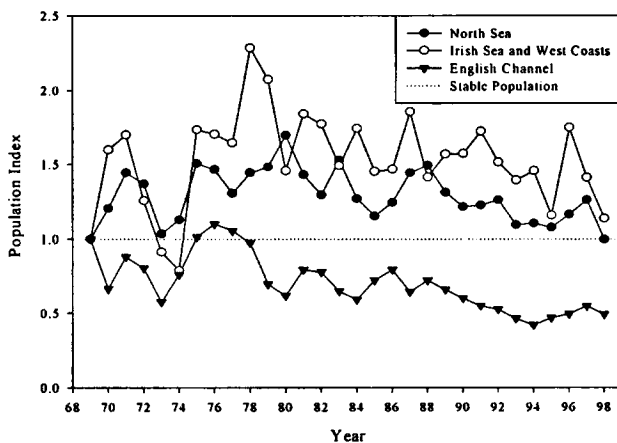


Figure 4. Population trends of British and Irish Little Terns in the North Sea, Irish Sea and English Channel. Values are index values scaled as proportional change in population size compared with the population in 1969, which is given an arbitrary value of 1. The dotted reference line represents a stable population trajectory.



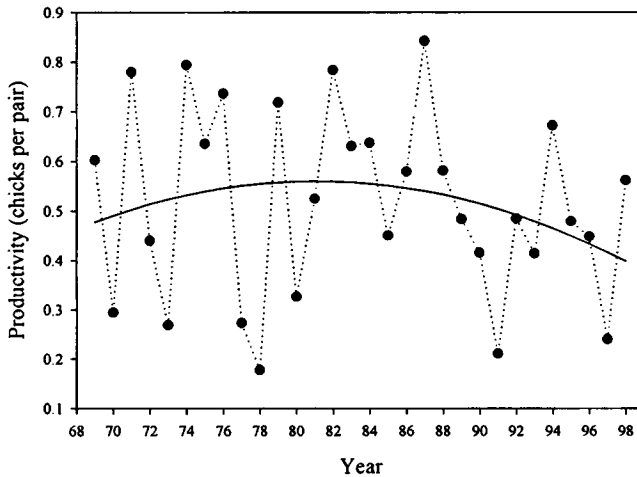


Figure 5. Trends in productivity of Little Terns between 1969 and 1998. Productivity estimates represent the number of chicks per breeding pair pooled over all colonies for which data were available in each year. The solid line represents the best fit logistic regression line.

A logistic regression showed that productivity increased significantly up to the early 1980s and then declined subsequently ( $G_2 = 280.35$ ,  $P < 0.0001$ ; Fig. 5), this Gaussian curve being a significantly better fit than the logistic one (improvement of fit from adding year<sup>2</sup> to model including year:  $G_1 = 103.43$ ,  $P < 0.0001$ ). However, the overall fit of the trend is poor ( $r^2 = 0.01$ ) due to the large annual fluctuations in productivity.

## DISCUSSION

Monitoring of sample colonies of Little and Sandwich Terns has revealed population declines in both these species that are of conservation concern. These downward trends may have been exaggerated because the modelled trend underestimated the size of the population compared with the national census estimates in 1986 (Lloyd *et al.* 1991). This may be because the sample colonies declined at a faster rate than the population as a whole or because the 1969 counts were underestimates. However, since the proportion of the populations of

both species that is monitored annually is large, it is unlikely that the trends are wholly unrepresentative and so the declines were probably real. The complete census of British and Irish tern populations planned for 2000 is timely so that long-term population trends can be determined with complete confidence and any bias in the sample monitoring programme can be investigated more thoroughly.

Detecting a decline only instructs conservationists that a problem exists, not what that problem is nor how to mitigate it. Identifying the factors responsible for tern population trends is difficult as terns are migratory and spend much of their lives at sea, so direct assessment of threats in declining colonies can be problematical. Effective interpretation of tern population trends depends on long-term monitoring of productivity (Becker 1998), survival (Croxall & Rothery 1991; Wendeln & Becker 1998), an understanding of inter-colony movements (Spendelov *et al.* 1995) and knowledge of migratory routes and wintering areas.

Unfortunately, data on tern demography and movements are few compared with those on population trends. Productivity data tend to be collected using peak counts of fledglings, but these are prone to errors due to inter-colony movements of juveniles; collection of these data also tends to be *ad hoc* rather than systematic. Analysis of dead recoveries is unlikely to yield precise estimates of survival rates because most birds are ringed as chicks, which confounds estimation of age-specific survival and reporting rates (Green *et al.* 1990). There are also few studies in Britain and Ireland that have estimated survival from resightings of colour-ringed terns. Therefore, a robust analysis of demographic parameters that have changed and precipitated the population declines described in this paper is not possible. However, several factors are likely to have affected Sandwich and Little Tern population trends at the breeding colonies.

The decline in the Sandwich Tern population in the 1990s appears to be due to localised events at individual colonies rather than widespread declines across its range. The abandonment of colonies at the Sands of Forvie (Grampian), Foulness and Havergate (Suffolk) and Foulney (Cumbria) during the early 1990s appears to have been in response to several years of Fox *Vulpes vulpes* predation that caused breeding failures in previous years (Thompson *et al.* 1996, 1997, 1998). All these sites are on mainland beaches or islets in lagoons, and so are vulnerable to mammalian predation. The reasons for the complete abandonment of the Forth colonies are more obscure since they are on offshore islets and inaccessible to mammalian predators. The main colony at Inchmickery was abandoned after several years of breeding failure and may have been due to encroachment of the increasing gull population onto the breeding area (D. Fairlamb, pers. comm.). Sandwich Terns attempted to breed on Long Craig islet between 1991 and 1996, but the Firth of Forth was completely abandoned by

1997. The reasons behind declines on the Farne Islands, which are also offshore and free from mammalian predators, are also obscure. Increases on nearby Coquet Island partially explain this decline, but there was still a net loss of 1500 pairs from Northumberland.

While abandonment of colonies by Sandwich Terns has been documented in the past, these have usually been followed by commensurate increases at other nearby sites (Lloyd *et al.* 1991). In the recent series of colony abandonment this appears not to have occurred. The birds must either have died, deferred breeding or emigrated to colonies outside Britain. Since the declines have been confined to the North Sea, emigration to the large colonies in the Netherlands and Germany might explain decreases in Britain. The populations there have indeed increased (Fleet *et al.* 1994; van Dijk & Meininger 1995; Südbeck & Hälterlein 1997) following catastrophic declines due to organochloride poisoning (Rooth 1981). However, the population growth has been at a steady rate and there is no evidence of sudden increases during the early 1990s that could explain the disappearance of over 2000 pairs from Britain, so emigration to eastern North Sea coasts appears not to explain the decline. Sandwich Tern populations experienced declines of similar magnitude in the early 1970s but rapidly recovered, so it is possible that the current population crash is another short-term perturbation in the longer term population trend. Further monitoring is clearly necessary to ensure that future recovery or further decline is recorded.

Concerns about decline in the Little Tern population predate 1969 (Parslow 1967) and prompted the first complete survey in 1967 (Norman & Saunders 1969). Little Terns prefer to nest on mainland beaches; increased use of the coast for human recreation probably led to increased breeding failure through disturbance and trampling (Norman & Saunders 1969). In the 1970s and 1980s many Little Tern colonies were designated as nature reserves and measures were taken to reduce disturbance, including wardening and sign-posting (Haddon & Knight 1983). Following a decline in the early 1970s, the Little Tern population increased, possibly due to improved breeding success of birds accorded protection from disturbance in nature reserves (Sears & Avery 1993).

Despite this protection there has been a long-term decline in the population since 1975, culminating in the lowest population recorded in Britain and Ireland during the 30 years of study in 1998 (see Results). Elsewhere in Europe, the fortunes of Little Terns have been mixed. The Netherlands population has declined from 400-500 pairs in the early 1980s to 350 pairs in 1992 (van Dijk & Meininger 1995). Numbers in the German Wadden Sea increased through the late 1970s and early 1980s before declining sharply during the mid 1980s (Fleet *et al.* 1994). There is some evidence of a recovery in the 1990s (Flore 1998) but the population is still below previous levels.

Population decline in Britain and Ireland has been associated with a downward trend in productivity since the early 1980s (see Results) and the resultant lower recruitment into the breeding population probably explains the decline. While the rate of decline may have been steeper had colonies not been protected from disturbance, it is clear that Little Tern reserves are not meeting their objectives of maintaining or increasing the population size. Factors other than disturbance are clearly responsible for the decline in productivity of Little Terns within these reserves.

Predation is listed as a major problem at many colonies, with foxes, Carrion Crows *Corvus corone* and Kestrels *Falco tinnunculus* being listed as the main predators (Norman & Saunders 1969; Lloyd *et al.* 1975; Haddon & Knight 1983; Thompson *et al.* 1998). Increased predation at colonies could be due to increases in fox and corvid populations (Tapper 1992; Gregory & Marchant 1996), or to the terns breeding in fewer, larger and fixed colonies that predators can exploit more easily (Sears & Avery 1993). Complete surveys are required to examine trends in the number and size of colonies; the only such survey to include the years of the decline in Little Terns was in Ireland (Whilde 1985; Hannon *et al.* 1997), which showed that the number of colonies halved from 40 in 1984 to 20 in 1995.

Efforts have been made to guard against mammalian predation at many colonies by erecting electric fencing (Haddon & Knight 1983; Brindley 1995, 1996, 1998; Behmann 1998; Pickerell 1998). Electric fencing reduces the likelihood of fox incursion, but occasionally foxes can avoid them and cause significant damage (Patterson 1977; Haddon & Knight 1983; Brindley 1995, 1996, 1998; Pickerell 1998). Nocturnal patrols of the colony perimeter by wardens appear to be the most effective way of deterring fox predation (Brindley 1998; Pickerell 1998). Other methods of reducing mammalian predation at colonies include use of chemical deterrents (Haddon & Knight 1983) and ultrasonic scaring devices (Brindley 1998), which appear to be ineffective. Attempts to counter avian predation have included provision of chick shelters (Brindley 1998) and supplementary feeding of Kestrels (Durdin 1992). Methods of controlling predation are generally applied in an *ad hoc* manner rather than experimentally and the limited monitoring of their effects on predation rates does not allow assessment of their efficacy in improving productivity (Sears and Avery 1993).

Flooding during spring tides is also a problem at many colonies (Lloyd *et al.* 1975; Haddon & Knight 1983; Pickerell 1998) and this may have increased due to long-term rises in sea levels (Norris & Bussion 1994). Sea level rise is likely to be a particular problem in the Little Tern stronghold of East Anglia, where rates of rise are likely to be highest and strong sea defences prevent reformation of natural coastal profiles further inshore (Norris & Bussion 1994).

This could reduce breeding habitat for Little Terns and render remaining sites more vulnerable to flooding. Attempts to counter flooding at Little Tern colonies have included major restructuring of a few colonies and removal of eggs from marked scrapes just prior to an incoming spring tide and replacing them afterwards (Haddon & Knight 1983).

Further studies of tern demography are required to monitor survival rates, interpret effects of varying productivity on population changes and to assess inter-colony movements. Survival rate estimates could be obtained for Sandwich Terns by integrating ring-recovery analyses with count and productivity data (Green *et al.* 1990), but this is unlikely to yield precise estimates for Little Tern survival due to the low number of recoveries (Toms *et al.* 1999). Accurate estimates of survival and inter-colony movement rates for both Little and Sandwich terns are likely to depend on colour-ringing or field-readable metal rings (Casey *et al.* 1995) or PIT tags (Wendeln & Becker 1998) that allow live adults to be re-sighted in consecutive years (Massey *et al.* 1992; Renken & Smith 1995; Spendelow *et al.* 1995; Ratcliffe 1997; Wendeln & Becker 1998). This demands capture of adults in order to produce a representative age structure for the population within a short time; problems with disturbance should be minimal if established protocols are followed (Brubeck *et al.* 1981; Nisbet 1981; Massey *et al.* 1988; Hill & Talent 1990). Such studies require a great deal of effort to be successful and should be initiated only in a few accessible colonies.

Further research into management of tern colonies is also required. The efficacy of the various methods employed in tern reserves to reduce predation needs to be tested experimentally by comparison of clutch and chick survival rates under different treatments. Recommendations for effective anti-predator management may then be formulated.

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#### SAMENVATTING

##### POPULATIEONTWIKKELINGEN VAN DWERGSTERN *STERNA ALBIFRONS* EN GROTE STERN *S. SANDVICENSIS* IN GROOT-BRITANNIË EN IERLAND VAN 1969 TOT 1998

*Van 1969 tot en met 1998 werden de aantallen broedende Dwergsterns *Sterna albifrons* en Grote Sterns *Sterna sandvicensis* in Groot-Brittannië en Ierland steekproefsgewijs geteld. De Grote Stern nam toe van c. 12 000 paren in 1969 tot c. 17 000 paren in 1971, maar nam vervolgens af tot c. 13 000 paren in 1974. Sindsdien groeide de populatie met 6% per jaar tot c. 17 000 paren in 1979,*

waarna tot aan 1992de populatie schommelde rond 16 000 pairs. Een tweede opmerkelijke afname in de populatie (20%) werd waargenomen tussen 1992 en 1995, zodat in 1995 nog maar c. 13 000 paren tot broeden kwamen. Deze afname lijkt nu tot stilstand te zijn gekomen, aangezien de populatie zich gestabiliseerd heeft op een niveau van ongeveer 13 500-14 000 paren.

De Dwergstern nam toe van 2000 paren in 1969 tot 2600 paren in 1971, om vervolgens af te nemen tot ongeveer 1800 paren in 1973. Een korte periode van herstel tot liefst 2800 broedparen in 1975 werd gevolgd door een langdurige periode van gestage neergang met gemiddeld 1.2% per jaar, afgewisseld met korte perioden van herstel in 1988 and 1996. De in 1998 gemeten populatiegrootte, c. 1700 broedparen, was het laagste gedurende de 30 jaren van onderzoek en betekent een afname van 39% sinds 1975. De neergaande trend bij de Grote Stern blijkt zich vrijwel geheel te hebben beperkt tot de Noordzee en bovendien werd de afname veroorzaakt door teleurstellende resultaten in een klein aantal kolonies. In tegenstelling daarmee lijkt de afname bij de Dwergstern een structureel en wijdverbreid probleem te zijn. Mogelijke oorzaken van de teruggang worden besproken en aanbevelingen worden gedaan voor toegepast beheer, toekomstig onderzoek en een voortgezet monitoringprogramma.

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