A PILOT STUDY OF BREEDING TERN FORAGING RANGES IN NW ENGLAND AND EAST ANGLIA IN RELATION TO POTENTIAL DEVELOPMENT AREAS FOR OFFSHORE WINDFARMS

RSPB/WWT/JNCC

Authors

R Allcorn[1], MA Eaton[1], PA Cranswick[2], M Perrow[3], C Hall[2], L Smith[2], JB Reid[4], A Webb[4], KW Smith[1], RHW Langston[1] & N Ratcliffe[1]

[1] RSPB, The Lodge, Sandy, Beds SG19 2NR
[2] WWT, Slimbridge, Glos GL2 7BT
[3] ECON, School of Biological Sciences, UEA, Norwich, Norfolk NR4 7TJ
[4] JNCC, Dunnet House, 7 Thistle Place, Aberdeen AB10 1UZ

Report to DTI

September 2003

Published by:

Royal Society for the Protection of Birds
The Lodge
Sandy
Beds
SG19 2NR
T: 01767 680551
F: 01767 692365
W: www.rspb.org.uk
Reg. charity no. 207076

The Wildfowl & Wetlands Trust
Slimbridge
Gloucestershire
GL2 7BT
T: 01453 890333
F: 01453 890827
W: www.wwt.org.uk
Reg. charity no. 1030884

Joint Nature Conservation Committee
Dunnet House
7 Thistle Place
Aberdeen
AB10 1UZ
W: www.jncc.gov.uk

This publication should be cited as:

Allcorn, R, MA Eaton, PA Cranswick, M Perrow, C Hall, L Smith, J Reid, A Webb, KWS Smith, RHW Langston & N Ratcliffe. 2003. A pilot study of breeding tern foraging ranges in NW England and East Anglia in relation to potential development areas for offshore windfarms. RSPB/WWT/JNCC, Sandy. 27 pp.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

SUMMARY

1. The distributions of Little, Common and Sandwich terns around their breeding colonies in the Greater Wash and Liverpool Bay Round 2 Development Areas have been investigated using combinations of land, boat and aircraft based surveys.

2. This preliminary report describes the survey methods and gives an overview of the results obtained in 2003 and their interpretation.

3. Maps are presented for the distributions of the three tern species.

4. Land and boat-based data indicate that Little Terns were only found close to their breeding colonies and near to the shore. Ninety per cent of all boat-based observations were within 2.5 km of the breeding colony and 99.5% were within 2 km of the shore.

5. Boat-based surveys found Common Terns were more widely distributed than Little Terns but were still only recorded out to a maximum distance of 4.5 km from the shore.

6. Sandwich Terns were recorded out to the maximum range of the boat-based surveys (5 km).

7. Aerial surveys found large terns (Common or Sandwich) present out to the maximum range of the survey (15 km form the shore) although numbers declined with distance from the shore.

8. Land-based surveys of inshore habitats such as tidal creeks and estuaries found that they could be important at times for Little and Common terns but were less used by Sandwich terns.

9. Further analyses are required to combine the counts from the three survey platforms to determine the relative importance of the different areas.

These results are based on data from one breeding season. At least another year's data collection will be needed in order to confirm the conclusions.

1 INTRODUCTION

The UK government is committed to a target of 10% of its energy use being generated from renewable sources by 2010. It is intended to achieve this target with a substantial contribution from both onshore and offshore wind energy. It is estimated that between 60 and 70% of wind-generated electricity could come from turbines sited offshore (DTI 1999). This industry must be developed in a sustainable way that avoids adverse effects on the environment, but assessing the potential environmental effect is complicated. Baseline information on the distribution and numbers of seabirds and water birds in the marine environment is limited and patchy, especially for inshore waters, as are relevant environmental data for many of the marine areas targeted by developers. This information is fundamental to inform the optimal siting of offshore windfarms in relation to conservation requirements for seabirds and waterbirds.

This report presents the results of the surveys of tern distribution within two of the proposed Round 2 Development Regions (the Greater Wash and the North West strategic areas, the latter extending from Liverpool Bay to the Solway) that are necessary to meet the requirements of the Strategic Environmental Assessment (SEA). It also reviews literature on tern foraging ecology and possible effects of offshore windfarms on terns. Preliminary recommendations are made for siting opportunities and constraints within the Greater Wash and North West areas (subject to site-specific Environmental Impact Assessments and to JNCC marine SPA designation proposals). Recommendations for further survey work are also made.

1.1 Possible effects of offshore windfarms on terns

Owing to offshore windfarms being relatively new development, little information concerning their effects on seabirds and waterbirds is currently available. The possible effects of windfarms on seabirds and waterbird populations are to cause elevated mortality owing to collision with turbine rotors or other structures, and loss of habitat owing to physical alteration of habitat characteristics or disturbance effects that cause birds to avoid utilising an otherwise suitable area (ICES 2002, Birdlife International 2002). However, it is possible that there could be positive benefits from sediment accretion around windfarms creating or enhancing shallow sandbank habitat.

Collisions with turbines have been studied at a number of onshore windfarms. Most European studies have produced a mortality rate of between 0 and 40 birds killed per turbine per year (Clausager & Nøhr 1995). The rate will depend largely on the abundance of birds in the area, their size, the proportion that fly within the span of the rotor blades and their avoidance behaviour. Terns are aerial foragers, and only contact the water briefly during plunge dives to capture prey, and so it is possible that they could be more vulnerable to collision with turbines than species that spend most of their time swimming. However, terns generally forage at altitudes of below 15m (Cramp 1985) and so are usually in the airspace beneath the span of the rotor blades. During inclement weather conditions or strong tailwinds terns may fly at higher altitudes (Kruger & Garthe 2001) and their manoeuvrability may also be reduced by tailwinds. Terns may also commute to feeding grounds at heights greater than those they forage from. As such, terns may be at risk of collision with rotors during certain weather conditions and activities.

Both during construction and throughout the life of the windfarms there will be changes to the surrounding habitat. Turbines are often constructed on sandbanks, and these are important foraging habitat for terns. Sandeels are an important prey species for terns and only occur at sandbanks with specific particle size and waterflow characters (Wright & Bailey 1993). Upwelling produced by currents at the edge of sandbanks can also be important in advecting prey to the sea surface where they become available to terns (Gochfeld *et al.* 1998, Nisbet 2002). If windfarm construction altered the sediment composition or profile of a sandbank or the flow of water over it, there could be a reduction in prey availability to terns and consequent changes in distribution or population size. If terns avoid wind turbines owing to the disturbance they cause, loss of foraging habitat could also occur (ICES 2002). In such instances, windfarms could also act as physical barriers between the colony and foraging areas, hence increasing the distance terns have to travel to obtain prey.

From this review, it is plausible that windfarm developments could have sufficient adverse effects on terns to affect their population size or distribution. While little direct evidence of effects is available, the risks to the different tern species breeding within the development regions can be inferred from information on their foraging habitats, ranges and flight altitudes.

1.2 Tern foraging behaviour

Terns are summer migrants to Britain and nest colonially during June and July. Colony size varies from a handful to thousands of pairs, and at the larger colonies the densities of birds can be extremely high owing to birds being constrained to forage from a central place and the foraging ranges of terns being relatively small compared to other seabirds (see review below). Developments within the foraging range of a large tern colony therefore have the greatest potential to have adverse effects on tern distribution or population size.

The tern species that occur in nationally important numbers within the proposed windfarm development areas (see Fig 1 for locations of these) are Sandwich Tern *Sterna sandvicensis*, Common Tern *Sterna hirundo* and Little Tern *Sterna albifrons*. Each has different habitat requirements and foraging strategies and this will affect their vulnerability to windfarm developments.

Little Terns predominantly forage over inshore or nearshore areas. They feed by plunge diving from a height of 5-7m to a maximum depth of 30cm or dip for floating prey (Cramp 1985). They prey mainly on small fish and invertebrates such as shrimp (Davies 1981, Cramp 1985). They often fish in very shallow inshore water only a few centimetres deep, frequently over the advancing tide line (Davies 1981), but will fish much further out to sea, especially over sandbank, if conditions or prey availability dictate. At high tide, they also utilise intertidal estuarine or saltmarsh channels, harbours and marinas or brackish lagoons. The maximum foraging range from the colony is thought to be 6 km, though most foraging trips are within within 3 km of the colony and within 1.5 km of the shore (Cramp 1985, Davies 1981, Fasola & Bogliani 1990).

Common Terns are generalist foragers and take a wider range of prey than other tern species. The diet usually comprises mainly sandeels and clupeids, but other fish prey such as gadoids, sticklebacks and small flatfish and invertebrates are also taken (Pearson 1968, Cramp 1985, Uttley *et al.* 1989, Robinson 1999, Newton & Crowe 2000). Common Terns are shallow plunge divers, diving from a height of between 3-8 m, or surface dipping for insects, crustaceans or offal (Kirkham & Nisbet 1987). Common Terns generally forage within 10-15 km of their colonies (Cramp 1985, Becker *et al.* 1993, Wanless *et al.* 1998, Newton & Crowe 1999, Nisbet 2002), although distances of over 30 km from colonies have been recorded. Common Terns will forage over a wide range of habitats, including offshore sandbanks and tide-rips, inshore along the coast, in estuaries, saltmarsh creeks or lagoons and inland at lakes, gravel pits, reservoirs or rivers.

Sandwich Terns are specialised foragers and feed almost exclusively on clupeids and sandeels (Stienen *et al.* 2000, Stienen and Brenninkmeijer 2002). These are caught near the surface by plunge diving from a height of 5-10m (Cramp 1985). Studies have found the average distances for foraging trips for Sandwich Terns were 13.1 km (Fasola & Bogliani 1990) and 16 km (Brenninkmeijer & Stienen 1994), although exceptionally they may travel 67 km from the colony in search of food (Cramp 1985). Sandwich terns are primarily offshore foragers, utilising habitats such as sandbanks, immersed gullies, reefs or tide-rips (Brenninkmeijer & Stienen 1994, Newton & Crowe 1999, Shealer 1999).

Windfarms constructed following Round 2 are likely to be situated at least 8 and 13km offshore and may therefore overlap with the foraging range of SandwichTerns and Common Terns. It is unlikely that they will overlap with the range of Little Terns owing to the bird's inshore distribution, although more nearshore developments such as that at Scroby Sands in North Norfolk are potentially within their foraging range. These generalisations need to be confirmed by area-specific studies in order to site windfarms in areas where densities of foraging terns are low. This precautionary approach would minimise any possible adverse effects on terns.

Tern breeding colonies tend to form on the same sites each year, but colonies may relocate in response to adverse conditions such as food shortage, nesting habitat loss, predation or disturbance (Cabot 1995, Ratcliffe *et al.* 2000). Changes in distribution of colonies will also have a large influence on the at-sea distribution of terns. Consequently, windfarm developments placed in areas where terns are currently scarce could cause collision mortality in the future if birds colonised a nearby stretch of coast. Windfarms might also reduce the number of potential sites that terns are able to utilise if they cause loss of foraging habitat around otherwise suitable sites. Any such effects could be avoided by locating windfarms beyond the foraging range of suitable tern nesting habitat, although this may impose excessive restrictions on development areas.

2 METHODS

2.1 Survey Methods

Terns have broad foraging habitat selection, including offshore sandbanks, estuaries and salt marsh creeks. Spatial overlap between terns and windfarm developments are most likely to occur in the offshore component of tern foraging ranges. However, surveys inshore are also required to understand the relative importance of the offshore component of the foraging range. A combination of survey techniques were utilised in this study to ensure comprehensive coverage of available foraging habitats.

2.1.1 Aerial surveys

Aerial surveys are an efficient method for surveying large areas of sea within a short space of time. The whole foraging range of Sandwich and Common Terns can be covered in a single day and the rapidity with which the survey platform travels ensures that a snapshot of distribution is obtained. However, this technique – developed primarily for seaducks – has not been applied to terns previously. Use of aerial surveys to survey terns during this project was therefore experimental.

The same basic methods used for aerial survey of seaducks (Kahlert *et al.* 2000) were employed for terns. The aircraft flew at an altitude of 75 m at a speed of approximately 200 kmh^{-1}, and transects were flown at 1 km separation. Observers recorded all birds seen on either side of the aircraft, and located observations into three distance bands: A 44-162 m, B 162-282 m and C 282-426 m. Terns beyond this distance were ignored.

The aerial survey covered 76% of the survey area owing to the 88 m strip that was invisible beneath the aircraft and the 148 m gap between the outer limit of adjacent transects. Terns outside the transect boundaries will therefore have been missed. Terns are also likely to be overlooked within transects, especially in the outer distance bands. The total number of terns counted during aerial surveys will be lower than the actual number present. The data have been collected in such a way that analyses absolute densities can be estimated using Distance models (Buckland *et al.* 2001) and these can be extrapolated to the survey area to provide absolute numbers. In this report, count data are presented without corrections for these biases. These provide information on relative densities and distribution of terns within the survey area, but estimates of absolute numbers of terns using different areas must await further analyses.

The transects were flown north-south to minimise problems of glare and, in most cases, fly across major environmental gradients, covering all of the sea area within a 15 km radius of the colony. Because of restrictions on minimum flying altitude over land, transects perpendicular to the coast ended approximately 1 km from the shore. An additional transect was flown parallel to the shore to survey those birds occurring within 1km of the shore.

2.1.2 Boat surveys

As Little Terns are small, have short foraging ranges and an inshore distribution, boat surveys are the preferred option for monitoring them. Aerial surveys will tend to underestimate their numbers in key inshore habitats and birds may be overlooked more often than Sandwich and Common Terns due to their small size. The use of boats also allows information on behaviour for all tern species to be collected, including whether they are carrying food and, if birds are close to the vessel, the identification of the prey type (Komdeur *et al.* 1992).

All terns seen from the boat were recorded within a transect that extended for 500m on both sides of the boat at right angles to the direction of travel. Range-finders were calibrated to provide three distance bands: A <=100m, B 101–300m and C 301–500m following the method of Heinmann (1981). Birds are likely to have been overlooked during the course of the survey especially in outer distance bands, such that counts are underestimates. As with the aerial surveys, further analyses are required to estimate densities and numbers at sea using Distance models (Buckland *et al.* 2001). However, the data presented here provide information on relative densities and distribution of terns within the survey areas.

The survey vessels steamed along the transect lines at a speed of approximately 10 kmh^{-1}. Terns were counted in 500m blocks along the transect, with the positions at which the counts were taken being determined by the ship's GPS. Additional sightings were recorded between the instantaneous snapshot counts along the transect. The number of birds counted during the snapshot counts was small, and so all sightings of birds are presented in the

maps and graphs. These counts overestimate density owing to flux, whereby additional birds fly into the count block between instantaneous snapshot counts. Such a measure assumes that there is no net flow of birds within or through the study area, which might lead to different relative abundance estimates between transects oriented in different directions to the net flow. Consequently, this measure cannot be used to estimate absolute density of terns or for comparing relative abundance between transects but provides an indication of their distribution and relative abundance within each study site.

The transects were parallel and spaced at 1 km intervals, such that complete coverage of the survey area was obtained. The boat transects ran perpendicular to the stretch of coast on which the colony was sited and extended 5 km out to sea, starting as close to the shore as the ship's draught would allow (20 to 500m, depending on water depth). Although boat surveys were designed to provide data on Little Tern foraging behaviour, data were also collected on the other two larger tern species. These data are presented for the North Norfolk area in order to complement the more extensive aerial surveys of this area.

In addition to counts, data on behaviour of terns was recorded, including flight direction and whether the birds were actively foraging (e.g. diving or dipping) or carrying food, with the type of prey that was being carried also being noted where this was possible.

Boat surveys were typically conducted over a 10-12 hour period during the hours of daylight, typically beginning in mid-morning. However, access to Wells harbour, the base used for the North Norfolk surveys, was only possible at high water. Owing to times of the tides during the later of the two surveys counts commenced in early morning.

2.1.3 Land-based surveys

All three tern species forage in estuarine and salt marsh creeks or coastal lagoons as well as on the open coast. These habitats are inaccessible to both aerial and boat-based surveys, and so were covered by land-based observers. Suitable watch points were identified to provide complete coverage of all these habitats within a 5km foraging range of each Little Tern colony selected for survey. Counts were made in a single scan of the area visible from a watch point with binoculars in order to provide an instantaneous count of terns. The positions of any terns at the time that they were first detected were plotted on a 1:50,000 OS map.

2.2 Areas surveyed

Terns nest colonially in discrete sites that are generally used year after year. There were too many tern colonies within the proposed development regions to survey them all within a single breeding season. The most important colonies (those hosting at least 1% of the national breeding population) and with significant offshore components to their foraging ranges were therefore selected for survey. These are shown in Figure 1 and summarised in Table 1.

The Round 2 development area in Liverpool Bay provides foraging habitat for six nationally important tern colonies (Fig. 1, Stroud *et al.* 2001). Between July and September Liverpool Bay is one of the main post-breeding areas for terns in Great Britain, hosting at least 5.8% of the Sandwich Tern passage population, whilst 2.3% of the Great Britain Common Tern population uses the Dee Estuary and its surroundings (Stroud *et al.* 2001).

Norfolk is of greater significance for breeding terns. During the summer, the various colonies from Scolt Head to Blakeney Point hold approximately 25% of the Great Britain breeding population of Sandwich Terns, 15.7% of the breeding Little Terns and at least 3.7% of Common Terns (Stroud *et al.* 2001). Great Yarmouth North Denes/Winterton is of national threshold importance for Little Tern. Almost 10% of the Great British breeding population uses one or both of these two sites each year (Stroud *et al.* 2001). Offshore from Great Yarmouth and Winterton, areas such as Caister Shoal and Scroby Sands are used for foraging by the inland colony of Common Terns breeding at Breydon Water, another colony of national importance, comprising 1.3% of the British population (Stroud *et al.* 2001).

Areas elsewhere in East Anglia and the Thames estuary are of less importance for terns than Norfolk. Important colonies occur at Minsmere/Havergate and Hamford Water (Suffolk), Pewet Island and Maplin Sands/Foulness (Essex) and Medway (Kent) (Stroud *et al.* 2001). In recent years some of these colonies have declined or been abandoned (Seabird Monitoring Programme, unpublished data).

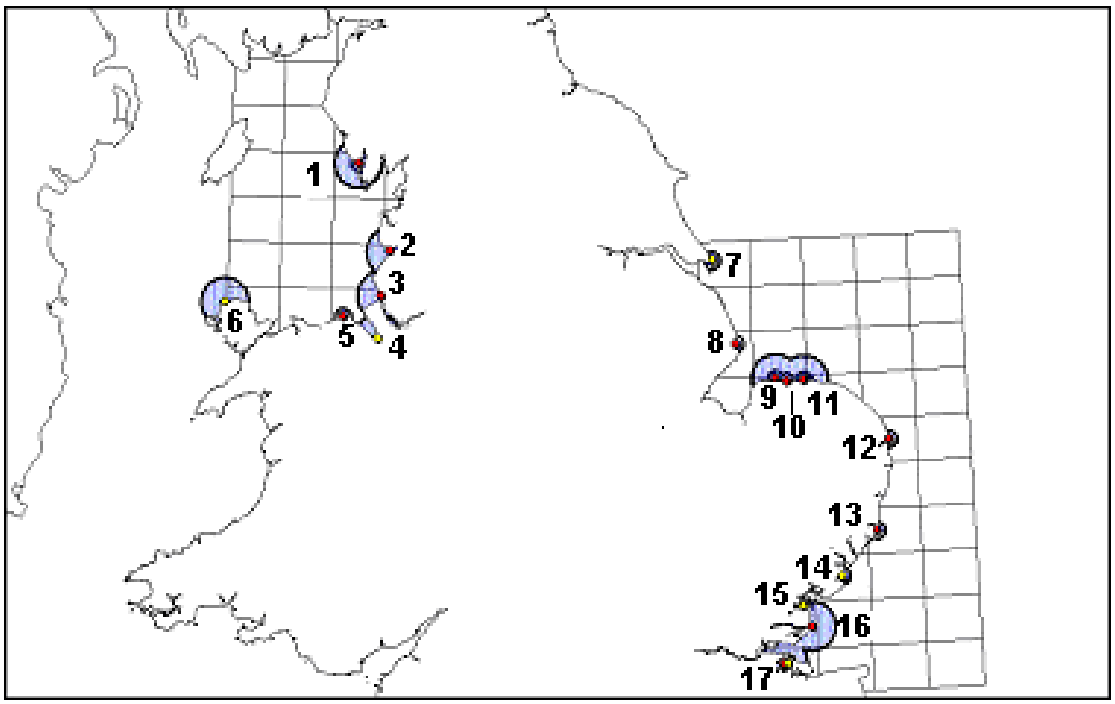

Figure 1. The main Sandwich, Common and Little Tern colonies, showing foraging radii around each colony. The foraging radius is 15 km for Sandwich and Common Terns and 5 km for Little Terns (represented by blue shaded areas). Colonies selected for survey are represented by red dots, others by yellow dots. Numbers denote the names of colonies as follows: 1. Hodbarrow, 2. Ribble, 3. Seaforth, 4. Shotton, 5. Gronant, 6. Cemlyn Bay, 7. Easington Lagoon, 8. Gibraltar Point, 9. Scolt Head, 10. Holkham, 11. Blakeney Point, 12. Great Yarmouth/Winterton, 13. Pewet Island, 14. Minsmere/Havergate Is., 15 Hamford Water. 16. Foulness and Maplin and 17 Burntwick Island (Medway). The areas within the grid pattern are the Round 2 developments areas

The survey work focused on the foraging ranges around specific colonies, rather than attempting to survey all of the sea area within the entire Round 2 development regions. Terns will be absent or at extremely low densities at distances beyond the foraging ranges of their colonies, and so survey work focused on conducting counts within the foraging ranges of important colonies. The foraging ranges of terns vary between species, as described above, with the maximum foraging radii being *c* 5 km for Little Tern and *c* 15 km for Sandwich and Common Terns. Surveys covered an 11 × 5 km grid around Little Tern colonies, and a 30 × 15 km grid around Sandwich and Common Tern colonies. The transects surveyed by boat are shown in Figures 2-4, whilst those covered from the air are shown in maps presented in Figures 5, 7, 8, 10 and 12.

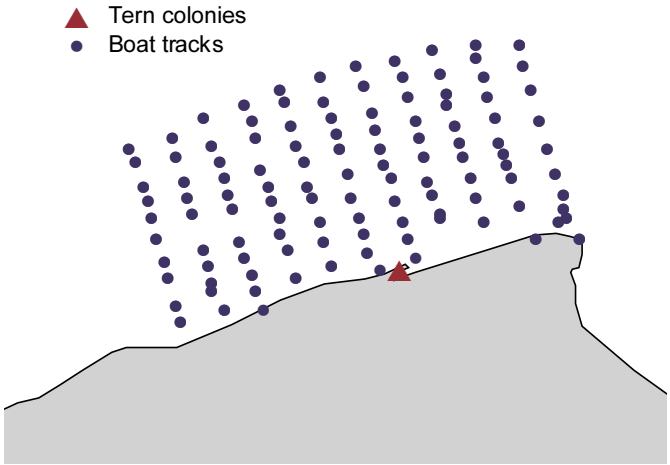

Figure 2. Gronant Little Tern colony boat survey transects (transects are 1 km apart).

Table 1. The main tern colonies for each species, showing their population size and the methods of survey used (A = aerial, B = boat/inshore). Each of these colonies contains at least 1% of the Great Britain breeding population for each of the three species. The figures are based on the preliminary population data from Seabird 2000 (undertaken by JNCC, RSPB, Seabird Group and SOTEAG) during 1998 to 2001, to provide revised British and Irish population estimates and to enable a reassessment of the conservation status of seabird species in the UK (Mitchell *et al*. in prep).

Species	Colony site	Population (Pairs)	SPA	Survey Method
Sandwich tern	Hodbarrow	360	Duddon Estuary	A
Sandwich tern	Scolt Head	3050	North Norfolk Coast	A, B
Sandwich tern	Blakeney Point	750	North Norfolk Coast	A, B
Sandwich tern	Burntwick Island	148	Medway Estuary	A
Sandwich tern	Hodbarrow	360	Duddon Estuary	A
Common tern	Ribble Marshes	126	Ribble & Alt Estuaries	A
Common tern	Seaforth	143	Ribble & Alt Estuaries	A
Common tern	Scolt Head	260	North Norfolk Coast	A, B
Common tern	Blakeney Point	165	North Norfolk Coast	A, B
Common tern	Foulness/Maplin	74	Foulness	A
Little tern	Gronant	60	Dee Estuary	A, B
Little tern	Gibraltar Point	49	Gibraltar Point	A
Little tern	Scolt Head	95	North Norfolk Coast	A, B
Little tern	Holkham NNR	120	North Norfolk Coast	A, B
Little tern	Blakeney Point	85	North Norfolk Coast	A, B
Little tern	Winterton	220	Great Yarmouth	B

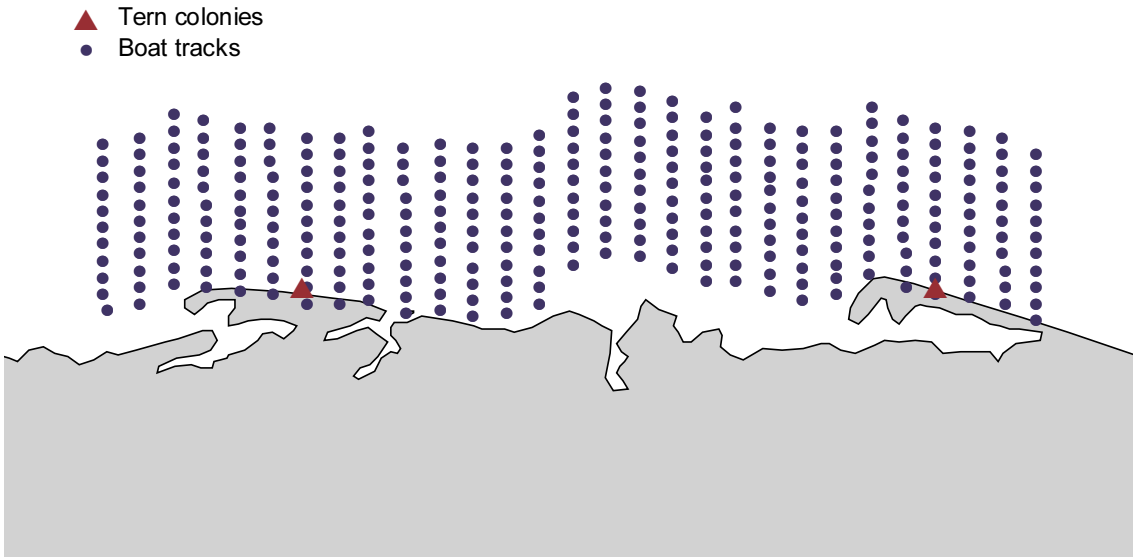

Figure 3. North Norfolk tern colonies boat survey transects (transects are 1 km apart).

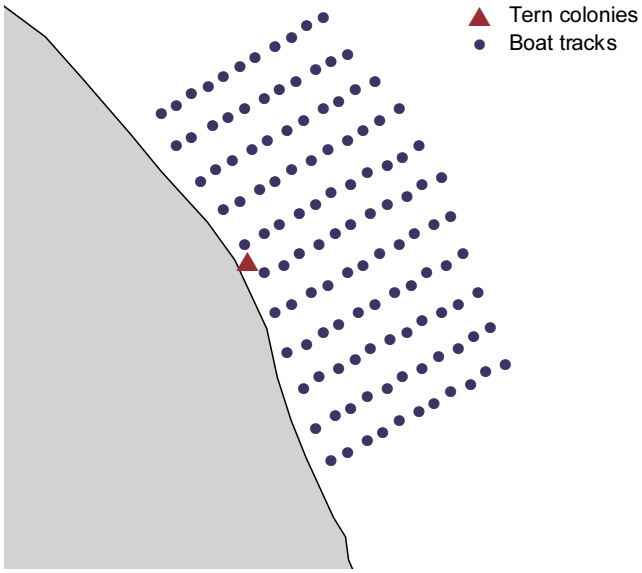

Figure 4. Winterton Little Tern colony boat survey transects (transects are 1 km apart).

2.3 Timing of surveys

Differences in diet, prey distribution and adult time budgets can result in seasonal variation in foraging range, habitat use and distribution of terns (Newton & Crowe 1999). To account for this potential variability, surveys (colony counts, inshore and boat transects) at each colony were undertaken during two time-periods: one during incubation in late June, and another during chick rearing in early July. Aerial surveys were undertaken in mid July, on 15 July for the Ribble, Seaforth and Hodbarrow colonies, and 21 July for Scolt Head and Blakeney Point. These were later than the ideal survey period owing to problems with availability of pilots and observers earlier in July. Some terns will have fledged their chicks by this time, and the possible effects of this on tern densities at sea are outlined in the discussion.

3 RESULTS

3.1 Aerial survey results

3.1.1 Count numbers of birds

The numbers of terns counted during aerial surveys are given in Table 2. These represent the total numbers observed, not the total number present (see methods). It is not possible during aerial survey to distinguish between Common and Arctic Terns and so birds were recorded as 'Commic' tern, indicating that they could have been either species. The vast majority will have been Common as Arctic Terns are very rare breeders within the area surveyed. In many cases, particularly for birds further from the transect line, it was not possible to separate between Commic and Sandwich Terns and, in these cases, birds were simply recorded as 'unidentified tern'.

Table 2. Total numbers of terns counted during aerial surveys in the Round 2 developments areas, July 2003 ('main' transects indicate the majority of surveyed transects, run north-south across the survey area; 'additional' transects represent those run parallel to the coast and/or perpendicular to the 'main' transects).

	'Main' transects				'Additional' transects			
Duddon	Transect band				Transect band			
	A	B	C	Total	A	B	C	Total
Sandwich	4	3		7				
Little						1		1
Unidentified	23	40	23	86	6	15	6	27
Total	27	43	23	93	6	16	6	28
North Norfolk								
	A	B	C	Total	A	B	C	Total
Sandwich	24	16		40	45	44	3	92
'Commic'	7	5		12	4	6		10
Little	2	2		4				
Unidentified	82	80	22	184	53	147	82	282
Total	115	103	22	240	102	197	85	384
Liverpool Bay								
	A	B	C	Total	A	B	C	Total
'Commic'	34	29	3	66				
Unidentified	15	23	12	50	1		2	3
Total	49	52	15	116	1		2	3

3.1.2 Distribution of terns during aerial surveys

The distribution of terns is shown using relative densities (the number of birds seen corrected for area surveyed) in 1 km grid cells for the three surveyed areas in Figures 6, 9 and 11. Due to the relatively high proportion of unidentified birds, maps show observations of all large terns ('Commic', Sandwich and unidentified) combined.

Most birds were located relatively close to the colony, with a marked concentration within c. 5 km of the Hodbarrow colony in particular (Figures 5 and 6). Birds were distributed unevenly throughout the Liverpool Bay area, with a marked absence of terns within the Ribble Estuary and directly around its mouth (Figures 8 and 9) although several of the birds offshore from this area were observed foraging. A marked concentration in the

southwest of the Liverpool Bay survey area, around the mouth of the Dee Estuary, may have related to birds from the Shotton colony situated at the foot of the estuary (S. White pers. comm.). Terns were more evenly distributed through the offshore areas of North Norfolk (Figures 10 and 11) with a concentration in the western part probably reflecting a known feeding area around Sunk Sand (M. Rooney pers. comm.). The transect flown parallel and close to shore at this site recorded over 50% more birds than during all 'offshore' transects combined (Figure 12), suggesting a marked preference for the nearshore area at this site.

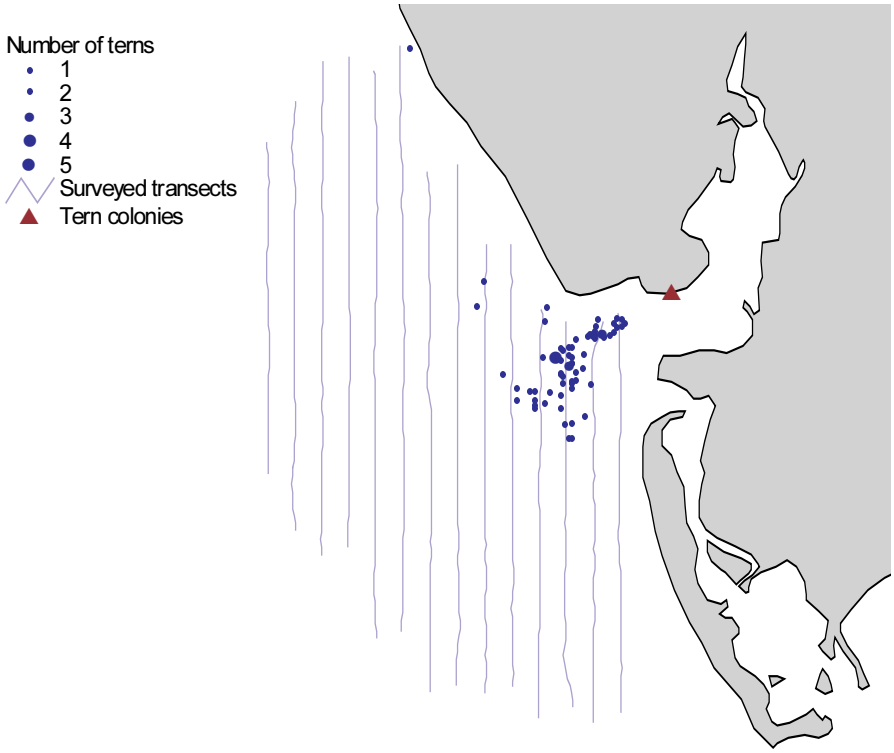

Figure 5. Observations of Sandwich and Common Terns combined, from aerial surveying offshore from the Hodbarrow colony (transects are 1 km apart).

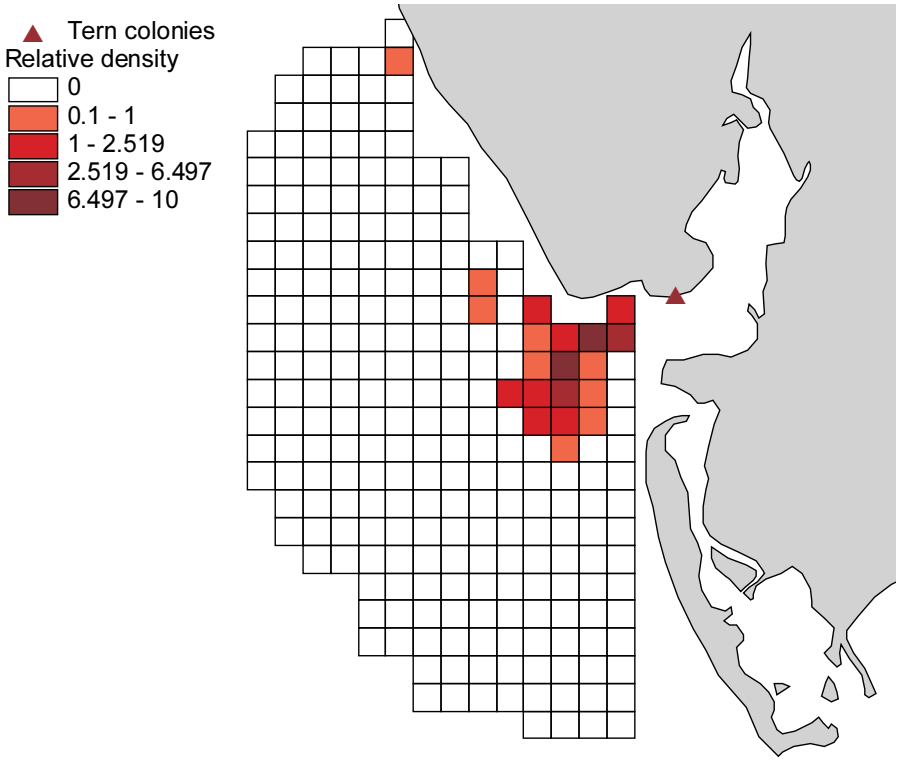

Figure 6. Relative densities of Sandwich and Common Terns combined in 1km^2 blocks, measured by aerial surveys offshore from the Hodbarrow colony.

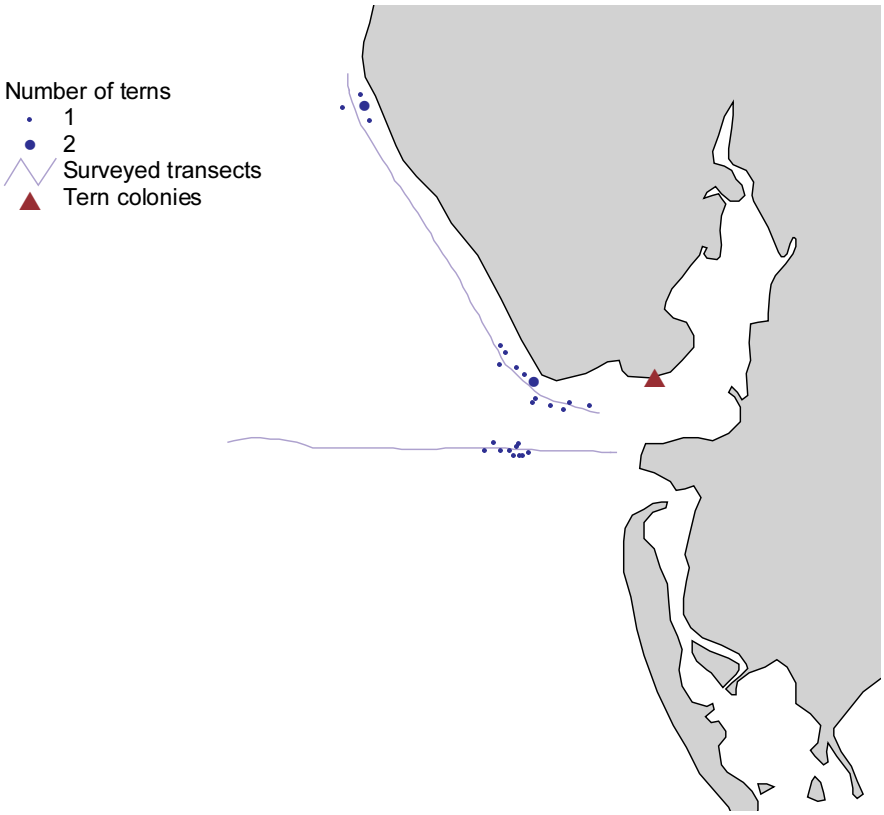

Figure 7. Observations of Sandwich and Common Terns combined from additional aerial survey transects flown offshore from the Hodbarrow colony.

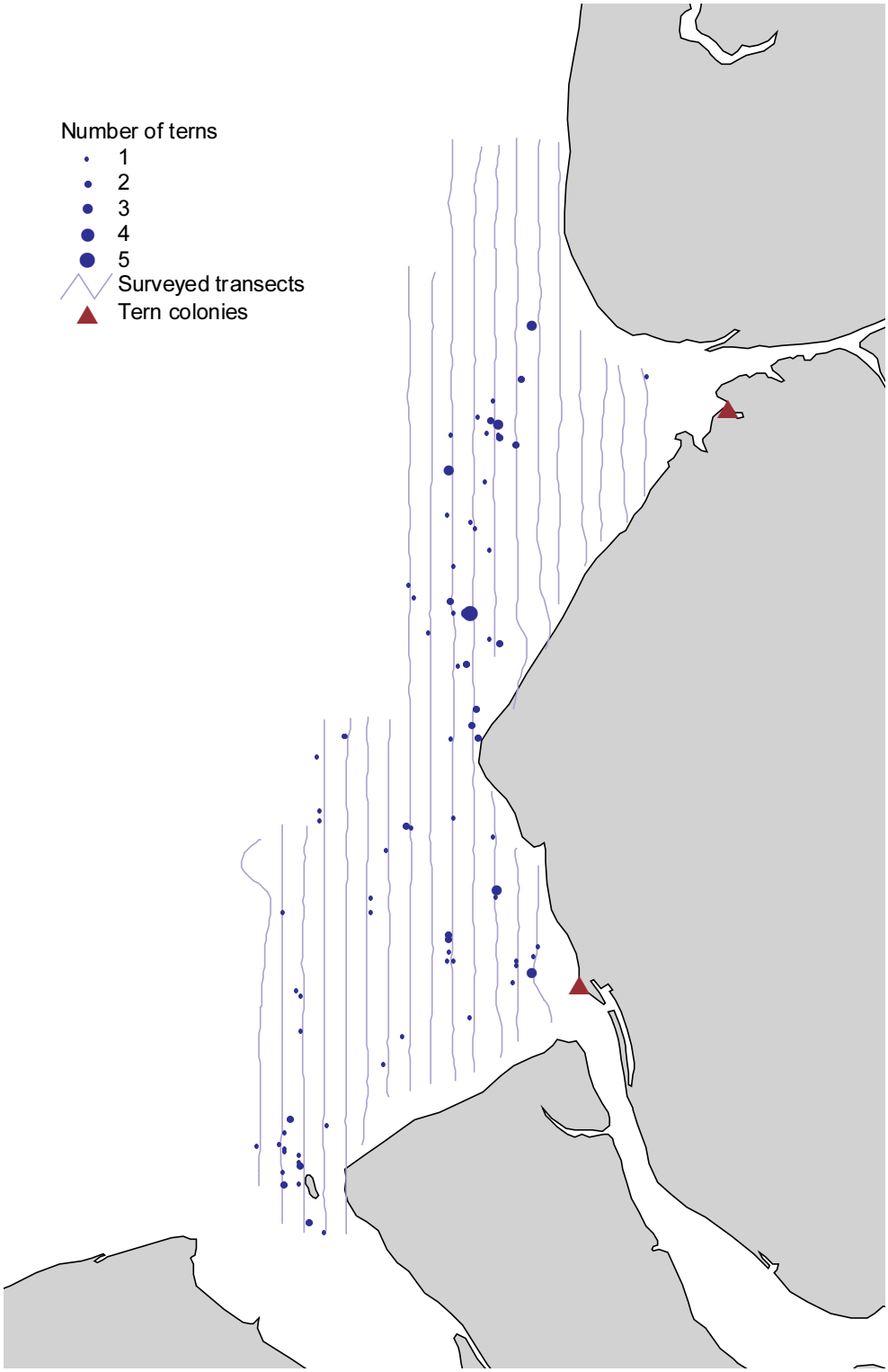

Figure 8. Observations of Sandwich and Common Terns combined, from aerial surveying offshore from the Seaforth and Ribble colonies (transects are 1 km apart).

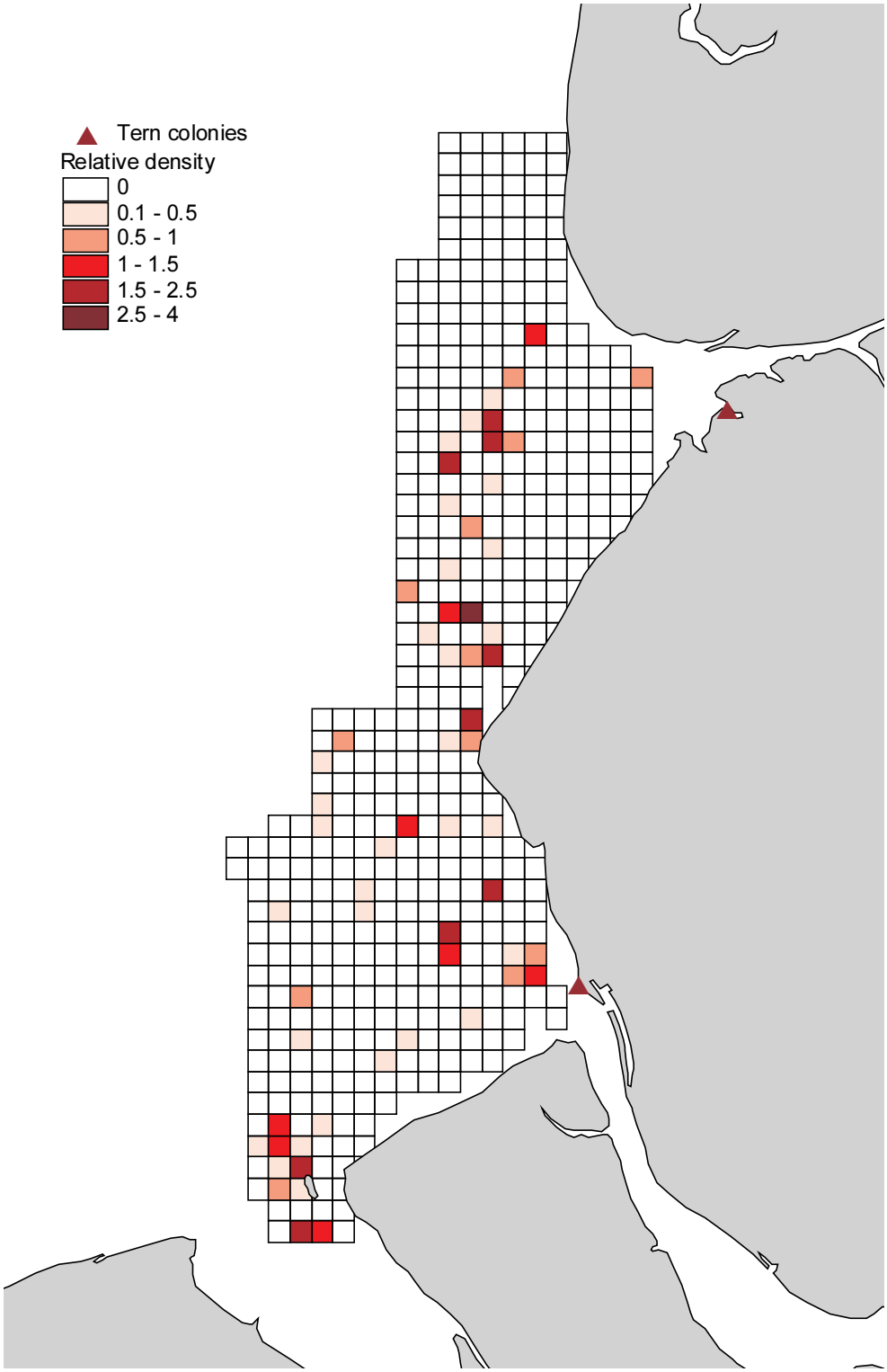

Figure 9. Relative densities of Sandwich and Common Terns combined in 1km^2 blocks, measured by aerial surveys offshore from the Seaforth and Ribble colonies.

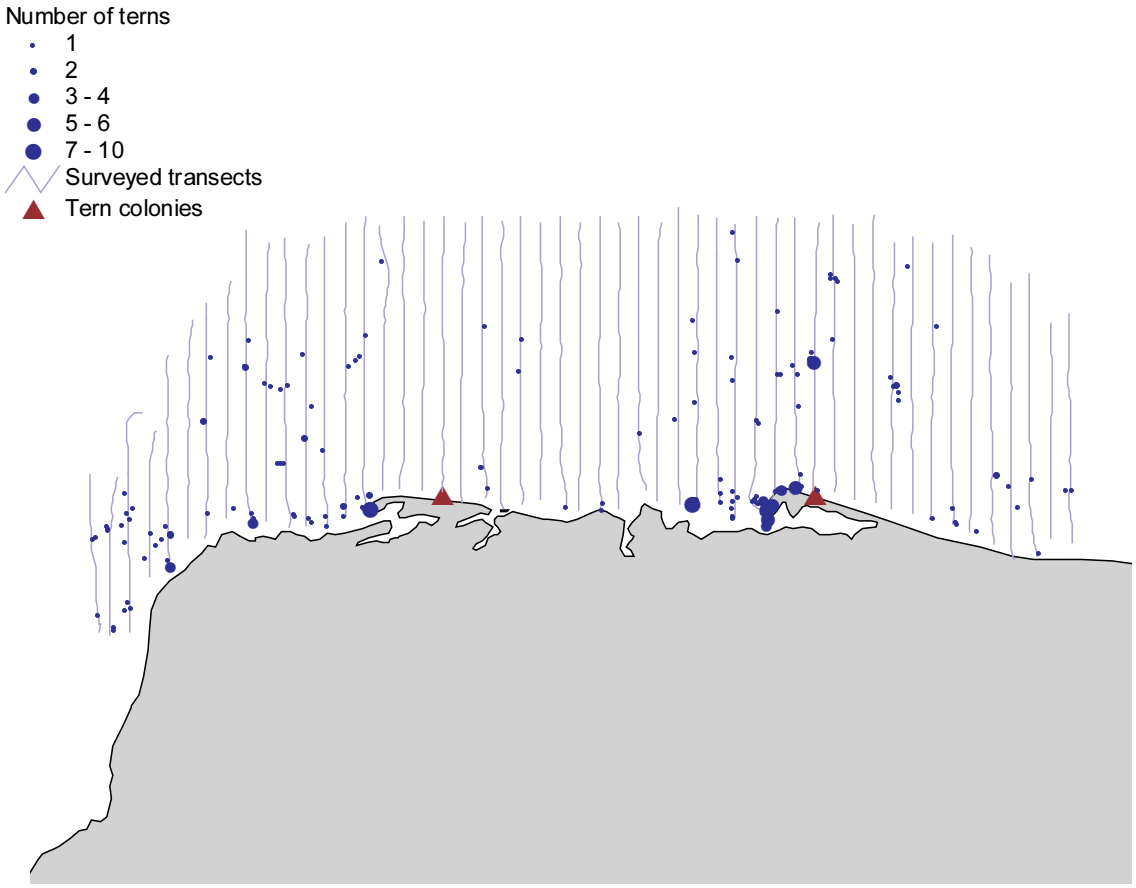

Figure 10. Observations of Sandwich and Common Terns combined, from aerial surveying offshore from the North Norfolk colonies (transects are 1 km apart).

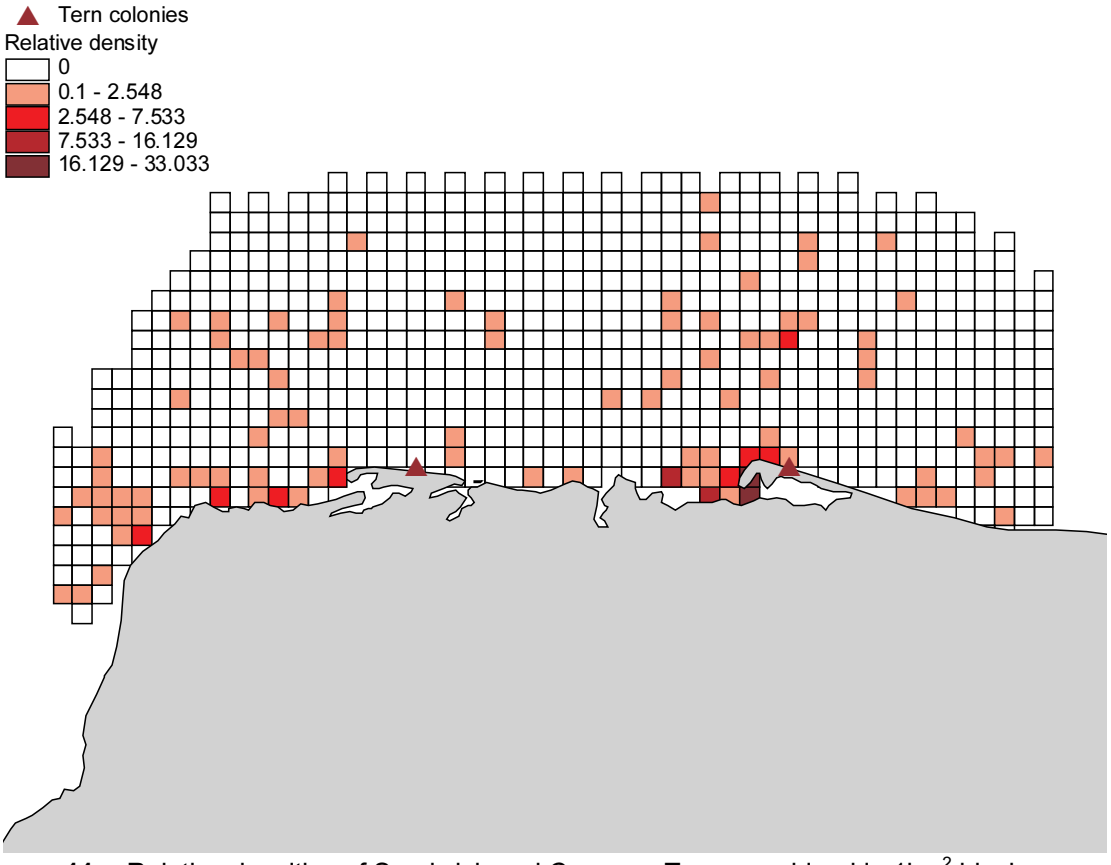

Figure 11. Relative densities of Sandwich and Common Terns combined in 1km^2 blocks, measured by aerial surveys offshore from the North Norfolk colonies.

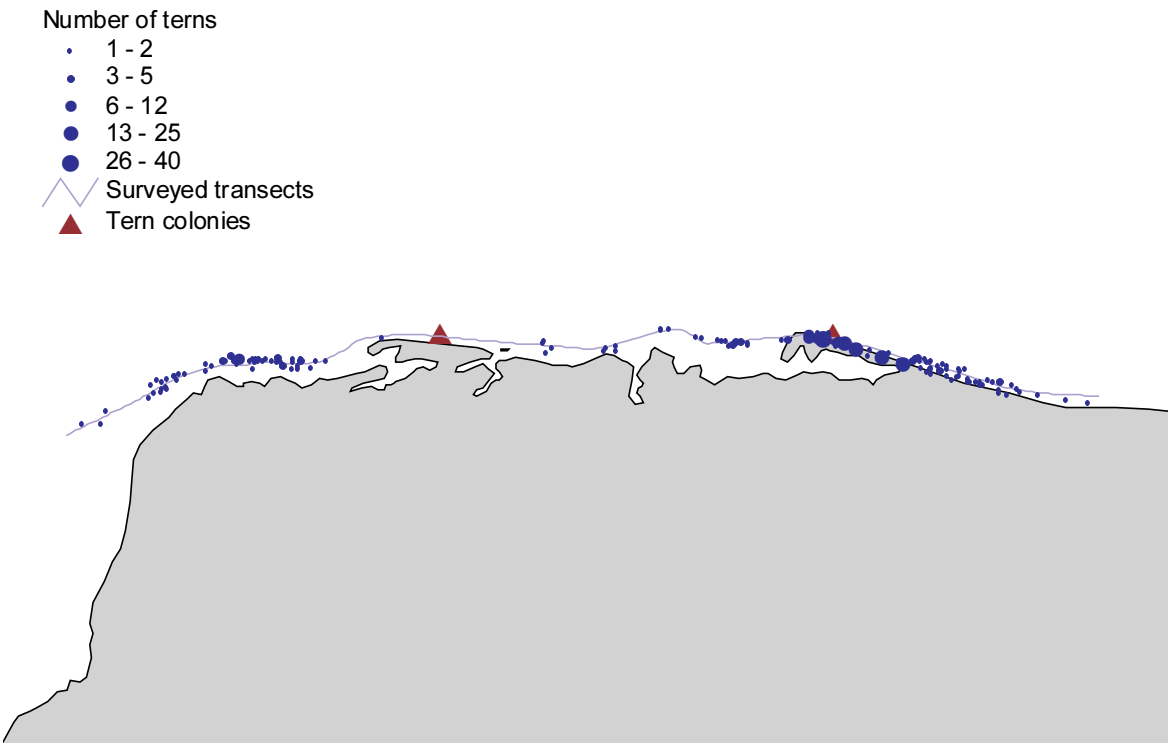

Figure 12. Observations of Sandwich and Common Terns combined from additional aerial survey transects flown offshore from the North Norfolk colonies.

3.2 Results of the boat and inshore surveys and the colony counts

3.2.1 Amendments to the survey coverage

Due to the late arrival or settling of Little Terns at a number of colonies and predation events at a number of sites, boat surveys were not undertaken at all the tern colonies originally proposed. Pewet Island in the Blackwater Estuary usually hosts 36 pairs of Little Terns but as of June 2003, there were only 13 breeding birds present. It was considered that boat surveys were not worthwhile given that only six to seven birds would be expected to be foraging from the colony at any one time (assuming an adult attendance at the colony was 1.5 birds per nest: Bullock and Gomersall 1981). The colony at Gibraltar Point suffered extremely heavy predation, mainly from Foxes *Vulpes vulpes*, and was abandoned early in the season, and so it too was removed from the survey itinerary. The North Norfolk colonies also suffered from predation but not to such a great extent. High tides in both June and July prior to both surveys also affected the colonies by inundating low-lying nests and reducing the number of actively breeding pairs. This may have affected numbers at sea during the survey.

3.2.2 Counted numbers of birds

The total numbers of birds encountered during the boat surveys (and the concurrent inshore counts) are presented in Table 2. Note that these are not the absolute numbers present within the surveyed areas but the numbers detected. Note that no inshore habitats were present at Winterton or Gronant.

Table 3. Numbers of terns seen during the boat and inshore surveys, summer 2003.

Species			North Norfolk	Gronant	Winterton
Sandwich Tern	June	Offshore	591	1	5
		Inshore	48	-	-
	July	Offshore	782	27	95
		Inshore	9	-	-
Common Tern	June	Offshore	84	3	16
		Inshore	381	-	-
	July	Offshore	238	6	38
		Inshore	19	-	-
Little Tern	June	Offshore	34	9	37
		Inshore	20	-	-
	July	Offshore	37	64	73
		Inshore	31	-	-

3.2.3 Ranges of foraging Little Terns

The furthest from the shore that Little Terns were observed was 2.5 km. However, less than 0.5% of all observations were further than 2 km from the beach (Fig. 13) with 75% of observations being within 1 km of the shoreline and the bulk of these were within a few hundred metres from shore. Little Terns were seen more than 3.5 km away from the nearest colony but 90% of observations occurred within 2.5 km. There were variations in range among sites and seasons (Fig 14). Foraging ranges from the colony tended to be shortest at colonies in North Norfolk, intermediate at Gronant and greatest at Winterton. Foraging ranges tended to be higher during the chick period at Gronant and Winterton but not in North Norfolk. The distance from shore was least for the North Norfolk colonies, but on average similar at Winterton and Gronant. Distance from shore tended to be higher during the chick period than the incubation period at Norfolk and Winterton, but the opposite pattern was evident at Gronant.

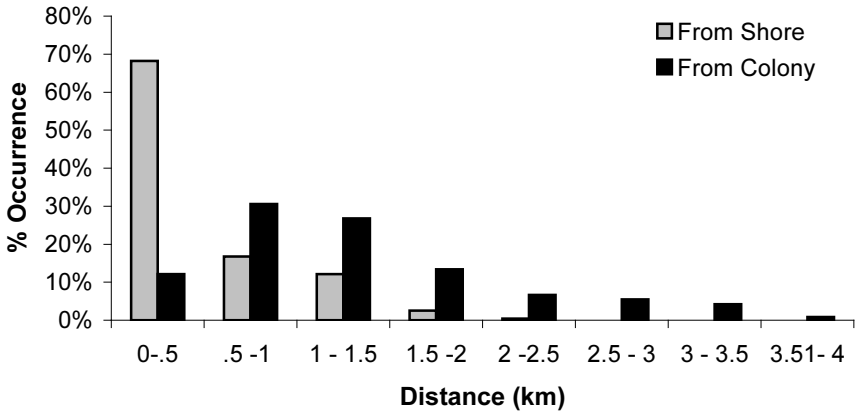

Figure 13. The occurrence of observed Little Terns within 0.5 km bands from the nearest colony or off shore from all boat surveys (all colonies and surveys pooled).

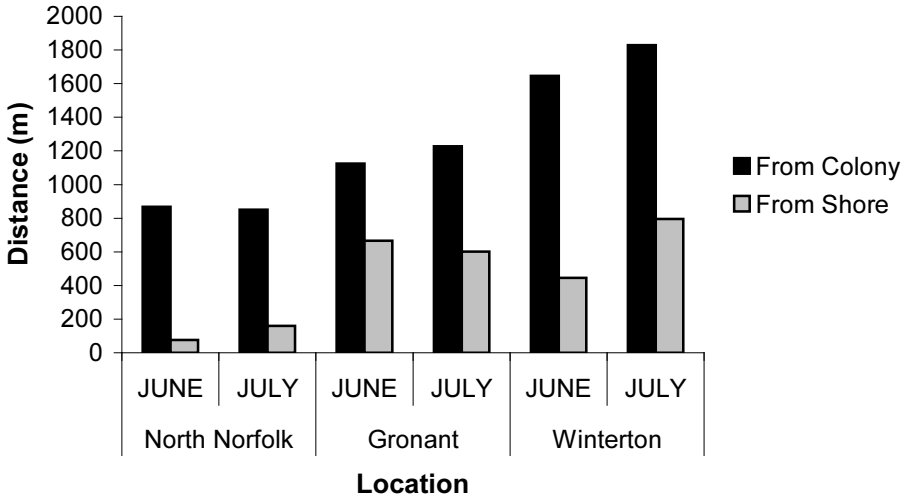

Figure 14. Average foraging distance of Little Terns from the nearest colony and from the shore during boat surveys.

3.2.4 Distribution of foraging areas

3.2.4.1 Little Terns

The distribution of Little Tern observations is shown in Figs. 15-20. Little Terns mostly occur close the colony at all sites, and most of the observations were of terns fishing in the breaking tideline adjacent to their colonies.

In North Norfolk Little Terns at greater distances from the colony also tended to be associated with the tideline or creek mouths, and further offshore they appeared to be associated with shallow sandbanks.

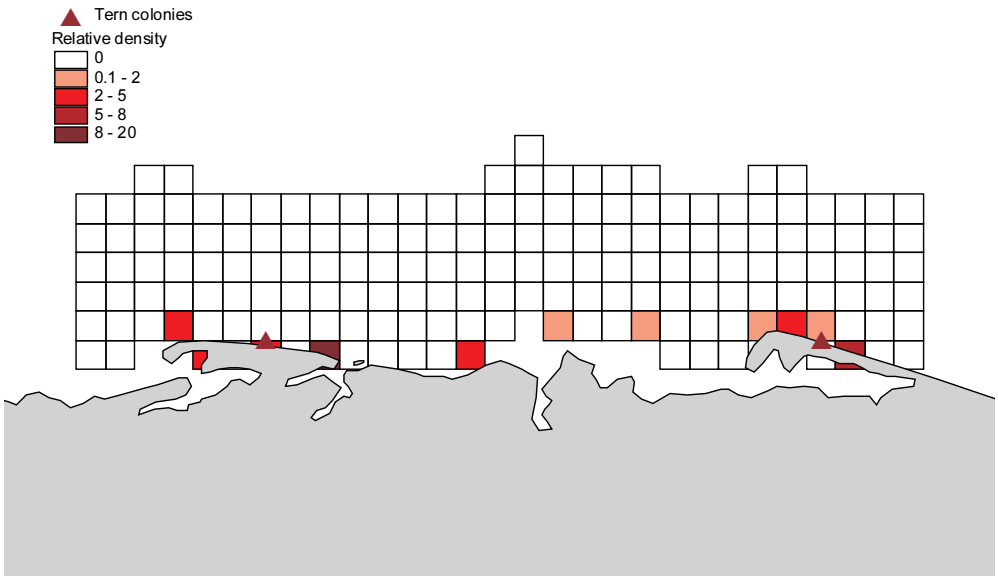

Figure 15. Relative densities of Little Terns in 1km^2 blocks, measured by boat surveys offshore from the North Norfolk colonies, in June.

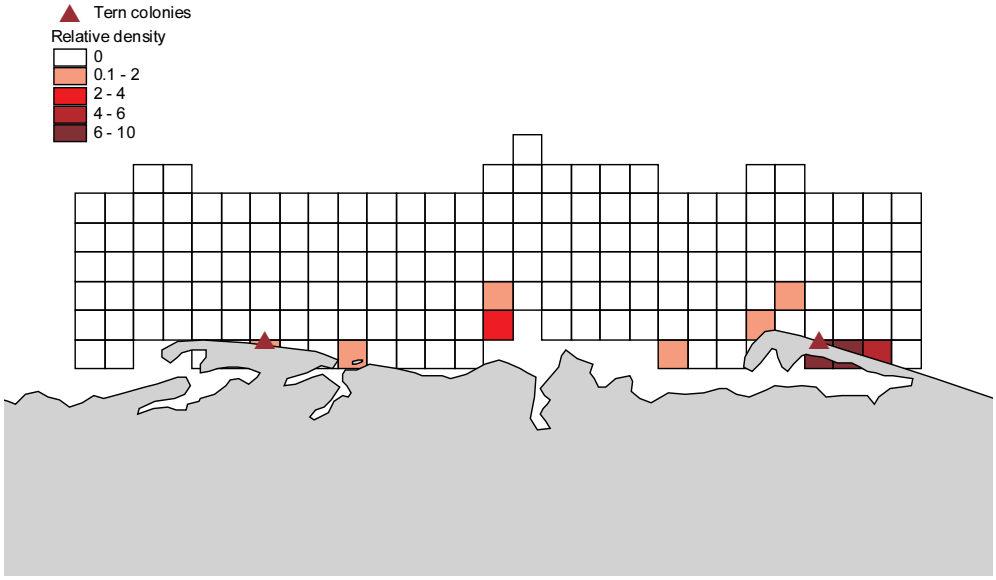

Figure 16. Relative densities of Little Terns in 1km^2 blocks, measured by boat surveys offshore from the North Norfolk colonies, in July.

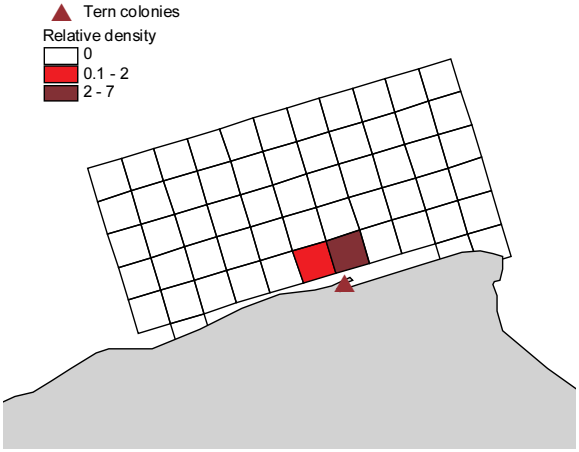

Figure 17. Relative densities of Little Terns in 1km^2 blocks, measured by boat surveys offshore from the Gronant colony, in June.

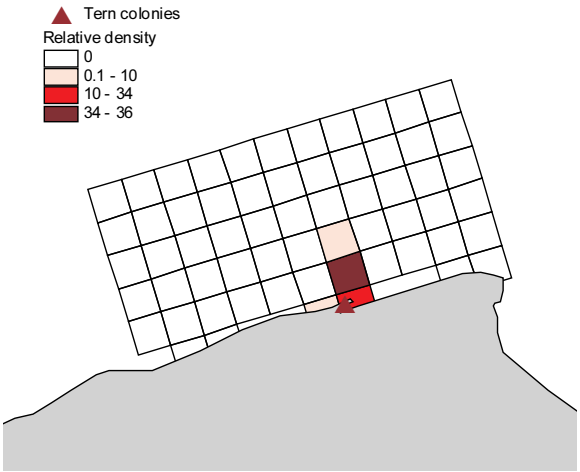

Figure 18. Relative densities of Little Terns in 1km^2 blocks, measured by boat surveys offshore from the Gronant colony, in July.

For the Gronant colony (Figs. 17-18) birds were also found foraging just offshore from the colony itself, especially in the early survey. The few observations of Little Terns further from the colony occur just offshore from a small promontory and sand bar.

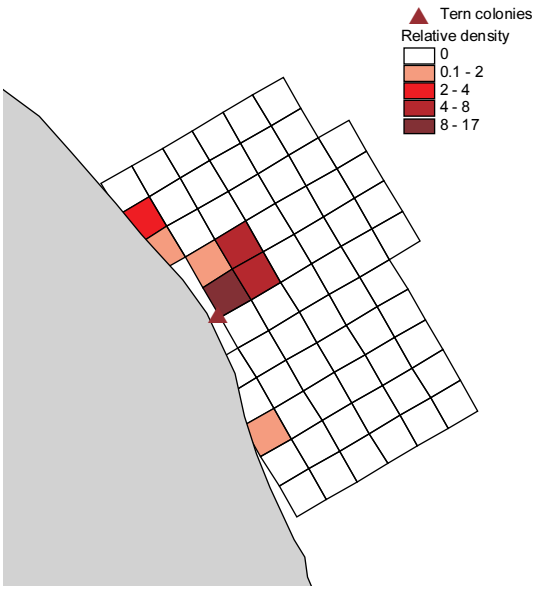

Figure 19. Relative densities of Little Terns in 1km^2 blocks, measured by boat surveys offshore from the Winterton colony, in June.

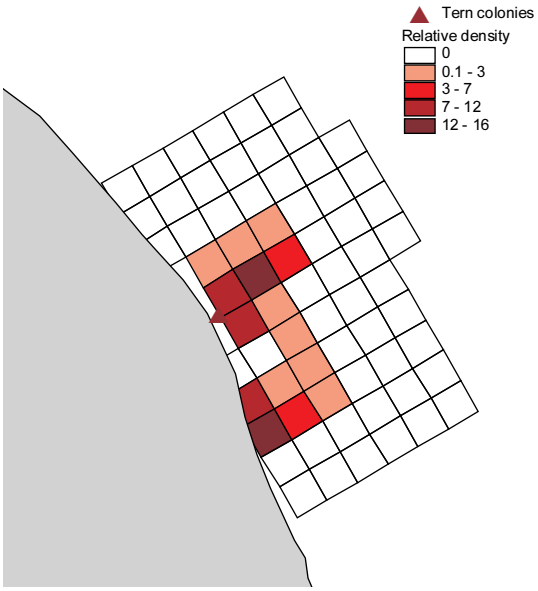

Figure 20. Relative densities of Little Terns in 1km^2 blocks, measured by boat surveys offshore from the Winterton colony, in July.

The foraging distribution of Little Terns around Winterton (Figs. 19-20) also tended to be associated with shallows and sandbars, although birds also foraged over deeper water. The June survey found most observed Little Terns south of the colony, whilst in July more birds were foraging to the north. It is unclear whether this is a seasonal effect or due to variations in prey distribution owing to chance or tides.

3.2.4.2 Distribution of Sandwich Terns off North Norfolk

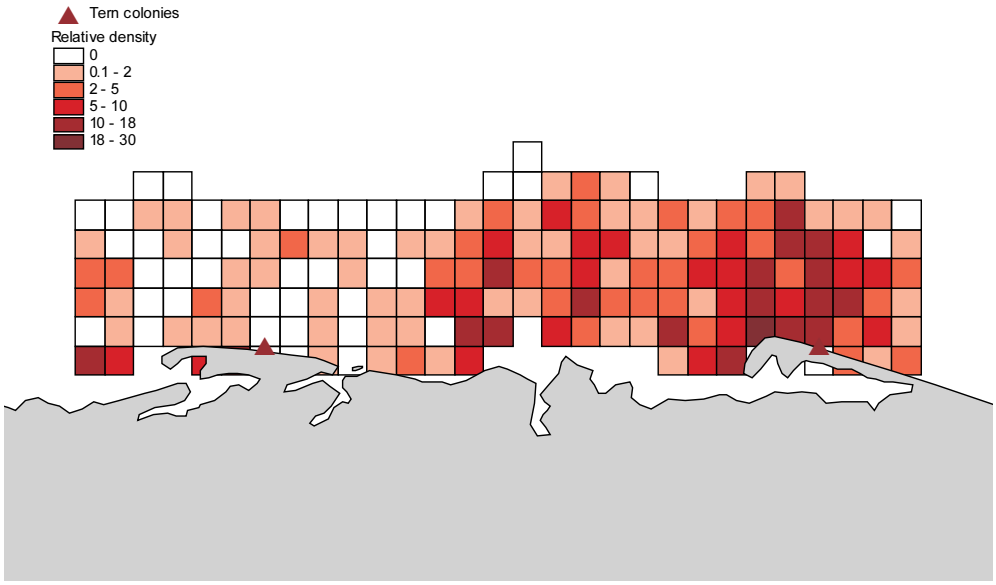

Figure 21. Relative densities of Sandwich Terns in 1km^2 blocks, measured by boat surveys offshore from the North Norfolk colonies, in June.

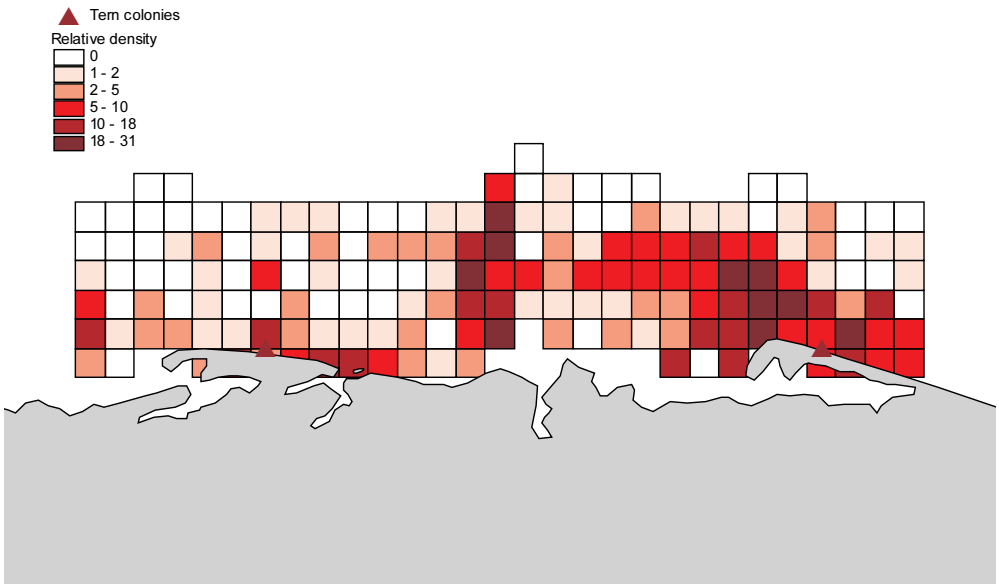

Figure 22. Relative densities of Sandwich Terns in 1km^2 blocks, measured by boat surveys offshore from the North Norfolk colonies, in July.

Aerial surveys clearly demonstrate that Common and Sandwich terns forage beyond the limits of the 5 km boat survey but these data are presented here to complement inshore components of the wider scale aerial surveys of the same region, and to illustrate distribution at different times during the incubation and chick-rearing periods. The distribution of Sandwich terns is clustered around the main colonies of Scolt Head and Blakeney Point (Figs. 21-22). Sandwich Terns occurred most frequently within the distance band 0.5 km from the coast, but were seen further from shore with greater frequency than Little Terns (Fig. 23).

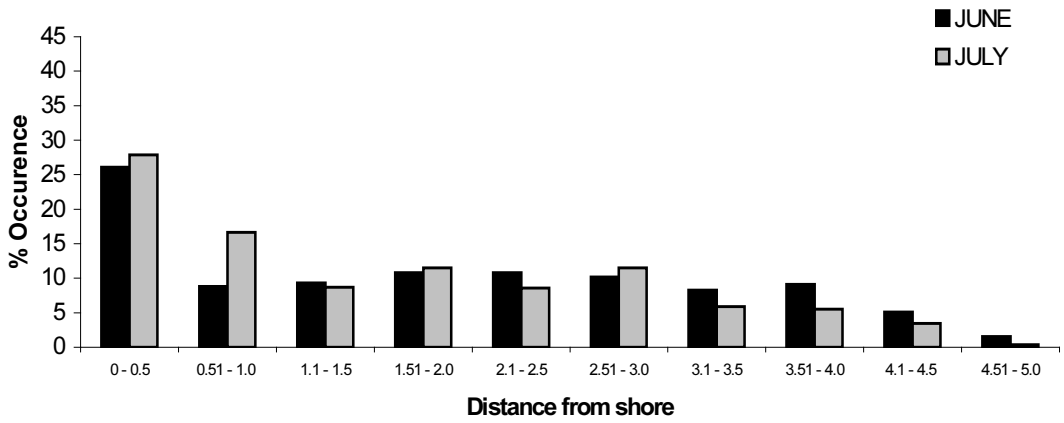

Figure 23. The distance from shore of Sandwich Terns during the north Norfolk boat surveys.

3.2.4.3 Distribution of Common Terns off North Norfolk

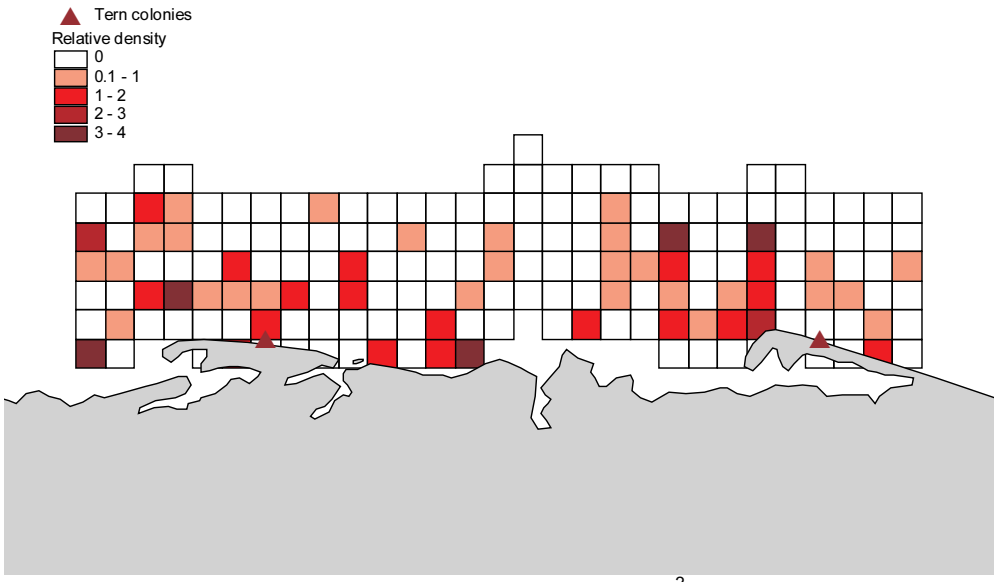

Figure 24. Relative densities of Common Terns in 1km^2 blocks, measured by boat surveys offshore from the North Norfolk colonies, in June.

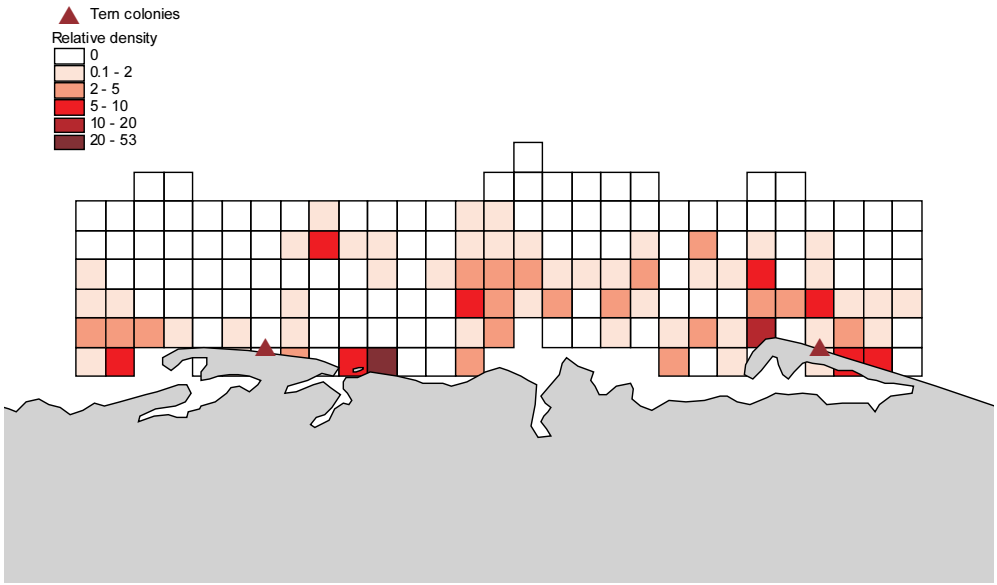

Figure 25. Relative densities of Common Terns in 1km^2 blocks, measured by boat surveys offshore from the North Norfolk colonies, in July.

Common Terns were encountered on boat surveys less frequently than Sandwich Terns, with a patchier distribution of observations (Fig. 24 and 25). Birds were found at greatest density nearest to breeding colonies. During both June and July most observations were within 2 km of the shore, with none seen beyond 4.5 km (Fig. 26). It therefore appears that Common Terns tend to forage closer to shore than Sandwich Terns.

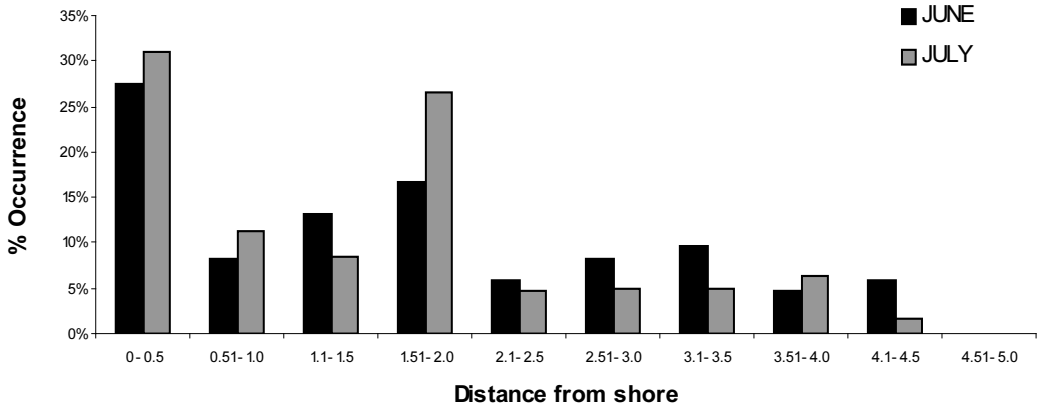

Figure 26. The distance from shore of Common Terns observed during boat surveys off the coast of North Norfolk.

3.2.5 Relative importance of inshore foraging habitats

Inshore foraging habitats were absent at Winterton and only one small intertidal lagoon was available at Gronant, and so all foraging occurred at sea at these sites. In contrast, birds at North Norfolk have access to a large number of estuarine and saltmarsh creeks and lagoons. Of the Little Terns counted during the June and July surveys here, 37% (N = 54) and 45% (N = 68) occurred over inshore habitats respectively. Common Terns in North Norfolk also utilised inshore habitats, but their relative importance varied greatly among surveys. In June 82% (N = 465) of Common Terns were counted over inshore habitats, whereas in July only 6% (N = 257) were inshore. Sandwich Terns were relatively rare inshore, with only 7% (N = 639) and 1% (N = 791) in June and July respectively. It should be noted that these values are derived from the boat surveys only and since some Common and Sandwich Terns foraged beyond the outer boundaries of the survey area the relative importance of inshore habitats will have been overestimated for these species.

4 DISCUSSION

4.1 Efficacy of the aerial survey

This is the first time that aerial surveys of terns at sea have been attempted, and so some appraisal of the efficacy of this technique is necessary. The speed at which the platform travels and the distances between the birds and observer imposed by altitude creates several problems. Birds are difficult to detect and identify and only limited behavioural data could be recorded compared with surveys from ships. The benefit of aerial surveys is that the high travel speed allows relative distribution of terns to be mapped over their whole foraging range within a single day.

Owing to problems with availability of observers or pilots, no surveys were undertaken during the tern incubation period, and those during the chick-rearing season were conducted in July when many chicks will have fledged. Post-fledging dispersal will have some influence on the numbers of birds at sea. In some instances, birds may have moved out of the surveyed area with their fledged young, thus reducing the density of birds compared with that in the breeding season. Other survey areas may act as staging grounds for terns from other colonies (e.g. Dee Estuary) and hence the numbers detected during post-fledging may be higher than those during the breeding season.

Relatively few birds were recorded during the aerial surveys. The counted total underestimated the actual number present for a number of reasons: a strip (148 m wide) between transect bands C of adjacent transects was unsurveyed, as was a strip directly underneath the plane (88 m wide). Decreasing detectability of birds with distance from the plane will have meant birds in the outer transect bands were also missed (as evidenced by totals in band C generally being much smaller than totals for bands A or B despite this being wider than the former). Further analyses of these data are required to provide estimates of the total numbers of birds present and to compare this with expected numbers at sea derived from attendance studies at the colony. These problems only apply to estimating absolute abundance however, and the data ought to provide accurate maps of relative abundance and distribution during the period surveyed.

Some birds were noted at the edge of the 15 km range as well as beyond this on occasion (while the plane was turning at the end of transects). This indicates that birds were foraging beyond the area surveyed, and future surveys should be extended further out to sea in order to describe the outer limits of the foraging range.

4.2 Quality of the boat and inshore surveys

Only two surveys of each colony were conducted, and this is likely to be insufficient to describe variation in tern foraging range and distribution comprehensively. Foraging behaviour of Little Terns, and indeed the behaviour of the two larger tern species, will be affected by the weather conditions, the state of the tide and the time of the day. As the survey vessels could only leave the harbours at Wells and Conwy at high tide owing to their draught, for the boat surveys at North Norfolk and Gronant most of the transects were carried out over the low portion of the tidal cycle. If foraging distribution is dependent on tidal state, the data collected may not be representative of that throughout the tidal cycle.

As boats move more slowly (thus increasing time available to detect and identify birds and use of binoculars) and are closer to terns than aerial platforms fewer birds are missed or unidentified, but problems can still arise. Some birds will have been missed owing to their distance from the boat or due to sea conditions. The surveys off North Norfolk in particular fell on days with rough seas and the combined effects of birds being hidden in wave troughs, white horses on wave crests, poor light and the movement of the boat will have made terns more difficult to detect. This will result in overall densities being underestimated. Furthermore, if conditions change through the course of a survey, the importance of areas counted during poor conditions would be underestimated relative to those counted during favourable conditions. Avoiding survey work during periods of poor sea conditions is desirable but not always possible given the short length of the incubation and chick rearing periods in terns.

The boat-based surveys were designed primarily to survey Little Terns, although other tern species were recorded during them. Such data collected along the North Norfolk coast are presented in order to complement the inshore component of the aerial survey, but since aerial surveys showed that Sandwich and Common terns foraged beyond 5km, the boat-based survey fails to describe their foraging ranges comprehensively. Boats

transects could be extended to survey the entire foraging area of larger tern colonies as an alternative to aerial surveys, but it would take three to four days to achieve a single survey of each colony.

The use of inshore areas is likely to be highly variable owing to tidal state, and the two surveys of each site are probably insufficient to provide a detailed assessment of the use of such habitats relative to offshore habitats. Caution also needs to be exercised when comparing land based and ship based counts owing to differences in the methods used and the data not being wholly comparable.

4.3 Foraging ranges and habitats of terns

Little Terns had the most limited range of the species studied, with 90% of birds foraging within 2.5 km of their colony and a maximum range of around 4 km. They were found inshore over creeks, harbours and coastal lagoons in North Norfolk almost as frequently as they were recorded offshore. Offshore foraging habitats in North Norfolk and Gronant were along the tide-line of the beach or over near-shore sandbanks. Benthic prey such as sandeel, sand goby and shrimp formed a notable proportion of the diet at these sites (unpublished data) and would be more available to Little Terns in shallow water above such habitats.

Little terns also forage up to 2.5 km from the shore, especially directly out from the colonies, with the offshore range being greater in July when feeding chicks at the Norfolk colonies. On the latter occasion at Winterton, by far the most important of the colonies, many birds observed were seen carrying prey from far to the south and certainly beyond the surveyed area. Radio contact with other boats in the area suggested Caister Shoal, a sandbank around 1 km from shore and some 8 km from the Winterton colony was being utilised at this point. Such use of sites a considerable distant from the colony later in the season corresponds to the natural seasonal decline of their principal Clupeid (herring and their relatives) fish prey in the area.

Common and Sandwich Terns had a far wider foraging range relative to their colonies than Little Terns. The boat-based surveys around North Norfolk found that Common Terns occurred widely along the coast although mostly within 3 km of the shoreline, while Sandwich Terns occurred up to, and doubtless beyond, the 5 km limit of the surveys. Aerial surveys of Common Terns and Sandwich Terns along the North Norfolk coast confirmed the concentration of birds around the colonies and along the coast, but showed that terns also ranged far beyond the 5 km limits of the boat based surveys and occurred 15 km out to sea and probably beyond this. Surveys along the North Norfolk coast found that Sandwich Terns rarely used inshore habitats such as estuaries, lagoons and saltmarsh creeks, while Common Tern use of these was seasonally very variable, being high in June and low in July.

Surveys in Liverpool Bay found that terns were widespread through the area and were mostly offshore with no obvious concentrations near the colony. The low numbers of terns near the Ribble colony may have been due to birds foraging within the estuary rather than offshore, as was the case during one survey in North Norfolk. Future surveys of Common Tern foraging distribution need to ensure that both inshore and offshore habitats are counted so that the relative importance of offshore distribution can be appraised fully. Terns around Hodbarrow were concentrated within 5 km of the colony. This shows that patterns of distribution of terns around colonies can depend on the site. The ranges of terns from the colony agree with other studies of terns that suggest most birds forage within 10-20 km of the colony, but that some may range beyond these limits (see Section 1.2).

4.4 Implications of the survey results to the siting of offshore windfarms

The implications of offshore windfarm development in the proposed areas are different for the three species covered here. The developments proposed will be between 8km and 13km from shore and this is almost certainly well beyond the foraging range of any Little Tern colonies. Therefore, any such developments are unlikely to have any direct influence on this species.

The survey work has shown that Common and Sandwich Terns do range beyond 8km from the shore, and may occur beyond 15km from their colonies. As such, windfarm developments occurring within 15km of a colony have the potential to overlap with the foraging range of terns. However, the bulk of terns tended to occur over nearshore areas within 5km of the colony and within 2km of shore, and so only a small proportion of foraging trips may extend into the zone in which windfarm developments might be proposed. The data available at present are not adequate to assess the relative importance of potential windfarm development areas for either tern species owing to the boat surveys not extending sufficiently far from shore and only a single aerial survey of

each site being conducted after the ideal survey period (see sections 4.1 and 4.2). Further survey work will be required to assess the relative importance of potential windfarm development areas for terns in the context of their wider foraging range and habitat use.

4.5 Recommendations for further work

The results of the Little Tern boat based surveys revealed that they consistently foraged within 3 km of the colony across seasons and sites, and this agrees with previous studies of foraging ecology of this species. There is little chance of their foraging habitat overlapping with windfarm developments if these are built more than 8 km offshore, and so further surveys of foraging ranges of Little Terns are probably not necessary in the context of the Round 2 SEA.

The boat and aerial based surveys revealed that the foraging ranges of Common Terns and especially Sandwich Terns have the potential to overlap with zones suitable for windfarm developments. However the data are not adequate to quantify the relative importance of such zones for terns. Further surveys are required during 2004 in order to assess the relative importance of areas of the sea between 8 km and 13km from the shore for Sandwich and Common Terns, and these need to be placed in the context of the importance of foraging areas outside this range. Surveys should also be conducted during late July and early August to examine tern distribution during the post-fledging period, since roosting flocks of national importance occur in Liverpool Bay and North Norfolk during this period.

The data resulting from these surveys will need to be subject to more rigorous analyses than those used in this report in order to assess absolute densities and numbers of terns using areas that have potential to be developed as windfarms, and to place these in the context of their wider foraging ranges. The results will also need to examined by JNCC to assess whether such sites qualify for designation as discrete marine SPAs or marine extensions to existing tern colony SPAs. Final decisions concerning siting of offshore windfarms need to be made after these assessments have been made.

5 REFERENCES

Becker, P.H., Frank, D. & Sudmann, S.R. 1993. Temporal and spatial pattern of common tern (*Sterna hirundo*) foraging in the Wadden Sea. *Oecologia* 93: 389-393.

BirdLife International (2002) Wind Farms and Birds: an analysis of the effects of wind farms on birds, and guidance on environmental assessment criteria and site selection issues. Draft report by BirdLife International on behalf of the Bern Convention, by Langston, RHW & Pullan, JD.

Brenninkmeijer, A. & Stienen, E.W.M. 1994. Pilot study on the influence of feeding conditions at the North Sea on the breeding results of the sandwich tern *Sterna sandvicensis*. Institute for Forestry and Nature Research (IBN-DLO), Wageningen, The Netherlands. IBN Research Report No. 94/10.

Buckland, S. T., Anderson, D., Burnham, K., Laake, J., Borchers, D. and Thomas, L. 2001. *Introduction to distance sampling: estimating abundance of biological populations*. Oxford University Press, Oxford.

Bullock, I.D. & C.H. Gomersall. 1981. The breeding populations of terns in Orkney & Shetland in 1980. *Bird Study* 28: 187-200.

Cabot, D. Performance of the Roseate Tern population breeding in north-west Europe – Ireland, Britain and France, 1960-94. *Proc. Roy. Ir. Acad.: Biology and Environment* 96B: 55-68.

Clausager, I. & Nøhr, H. 1995. Vindmollers indvikning pa fugle: status over viden og perspektiver. Technical Report no. 147 from The National Environment Research Institute, Ministry of the Environment, Denmark, 51pp

Cramp, S. 1985. *The birds of the Western Palearctic*. Vol. 4. Oxford University Press, Oxford.

Davies, S. 1981. Development and behaviour of little tern chicks. *British Birds* 74: 291-298.

Department of Trade and Industry 1999. New & Renewable Energy: Prospects for the 21st Century. DTI, London.

Fasola, M. & Bogliani, G. 1990. Foraging ranges of an assemblage of Mediterranean seabirds. *Colonial Waterbirds* 13: 72-74.

Gochfeld, M., Burger, J. & Nisbet, I.C.T. 1998. Roseate Tern (*Sterna dougallii*). In: *The Birds of North America*, No. 370 (Poole, A. & Gill, F., eds). The Birds of North America, Inc., Philadelphia, PA.

Heinmann, D. 1981. A range finder for pelagic seabird censusing. J. *Wildl. Manage*. 45: 489-493.

ICES. 2002. Effects of marine wind farms on birds. In: *Report of the Working Group on Seabird Ecology*, pp 37-49. ICES, Copenhagen, Denmark.

Kahlert, J., Desholm, M., Clausager, I. & Petersen, I.K. 2000. *Environmental impact assessment of an offshore wind park at Rødsand*. Natural Environment Research Institute, Rønde.

Kirkham, I.R. & Nisbet, I.C.T. 1987. Feeding techniques and field identification of Arctic, Common and Roseate Terns. *British Birds* 80: 41-47.

Komdeur, J., Bertelsen, J. and Gracknell, G. 1992. Manual for aeroplane and ship surveys of waterfowl and seabirds. IWRB Spec. Publ. 19. Slimbridge UK.

Krüger, T. & Garthe, S. 2001. Flight altitudes of coastal birds in relation to wind direction and wind speed. *Atlantic Seabirds* 3: 203-216.

Mitchell, P.I., Ratcliffe, N., Newton, S. & Dunn, T.E. in prep. *Seabird populations of Britain and Ireland*. T&AD Poyser.

Newton, S.F. & Crowe, O. 2000. *Roseate Terns – the Natural Connection*. Maritime (Ireland/Wales) INTERREG Report No. 2. 60pp. Marine Institute, Dublin.

Nisbet, I.C.T. 2002. Common Tern *Sterna hirundo*. In: *The Birds of North America* (eds A. Poole & F. Gills), No. 618. The Birds of North America Inc., Philadelphia, USA.

Pearson, T.H. 1968. The feeding ecology of sea-bird species breeding on the Farne Islands, Northumberland. *Journal of Animal Ecology* 37: 521-552.

Ratcliffe, N., Pickerell, G. & Brindley, E. 2000. Population trends of Little & Sandwich Terns *Sterna albifrons* & *S. sandvicensis* in Britain & Ireland from 1969 to 1998. *Atlantic Seabirds* 2: 211-226.

Robinson, J.A. 1999. The comparative breeding ecology of sympatric Common and Arctic Terns in N.E. England. Unpublished PhD Thesis, University of Durham.

Shealer, D. 1999. Sandwich Tern *Sterna sandvicensis*. In *The Birds of North America* (eds A. Poole, & F. Gills), no. 405. The Birds of North America Inc., Philadelphia, USA.

Stienen, EWM & Brenninkmeijer, A. 2002. Foraging decisions of sandwich terns in the presence of kleptoparasitising gulls. *Auk* 119: 473-486.

Stienen, E.M.W., van Beers, P.W.M., Brenninkmeijer, A., Habraken, J.M.P.M., Raaijmakers, M.H.J.E. & van Tienen. P.G.M. 2000. Reflections of a specialist: patterns in food provisioning & foraging conditions in Sandwich Terns *Sterna sandvicensis*. *Ardea* 88: 33-49.

Stroud, D.A., Chambers, D., Cook, S., Buxton, N., Fraser, B. Clement, P., Lewis, P., McLean, I., Baker, H. and Whitehead, S. 2001. The UK SPA Network: its scope and content. JNCC, Peterborough.

Uttley, J., Monaghan, P. & White, S. 1989. Differential effects of reduced sandeel availability on two sympatrically breeding species of tern. *Ornis Scandinavica* 20: 273-277.

Wanless, S., Harris, M.P. & Greenstreet, S.R. (1998) Summer sandeel consumption by seabirds breeding in the Firth of Forth, southeast Scotland. *ICES J. Marine Science* 55: 1141-1151.

Wright, P.J. & Bailey, M.C. 1993. *Biology of sandeels in the vicinity of seabird colonies at Shetland*. Fisheries Research Report No. 15/93. SOAFD Marine Laboratory, Aberdeen, Scotland.

ACKNOWLEDGEMENTS

This work was funded by the Deparment of Trade and Industry. We thank Ravenair for providing transporation during the aerial transect. Nick Longfield (Ocean Marine) piloted 'Barinthus' during the ship based transects off Gronant and Paul Lines piloted 'Sea Venture' for those off Norfolk. We thank them for their assistance and hospitality during the ship-based survey work. We are indebted to the wardening staff of the tern colonies for collecting data on inshore foraging distribution, attendance and diet. We are also grateful to Roy Balmford, J. Legg and Sabine Schmitt assisted with collection of boat-based survey data, and to Steve Blain for assistance with designing the transects for the boat-based surveys.