Isles of Scilly
Tern Recovery Project
2003-2004

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Contents

1 UK Biodiversity Action Plan for roseate tern.

UK Biodiversity Group Tranche 2 Action Plans.
Volume 1 – vertebrates and vascular plants.
English Nature, 1998.

Roseate tern (*Sterna dougallii*) Action Plan

1. Current status

1.1 The roseate tern has a highly fragmented breeding range in the north-east Atlantic. Its European stronghold is the Azores (Portugal) which supports 1170 pairs, representing around 60% of the north-east Atlantic population. Elsewhere the species breeds only very locally in Britain, Ireland and France. In 1996 there were 677 pairs at the two sites in the Republic of Ireland (including 557 at Rockabill, the main colony in the British Isles since 1986), around 100 pairs in Brittany, France and 64 pairs at five main sites in the UK. It is therefore one of the UK's rarest breeding seabirds. Although the UK population has declined greatly (from 1000 pairs in 1969 to 210 pairs in 1989), many of the birds have moved to the growing colony at Rockabill. Productivity at this colony is good and has been a major factor in the recent increase in the north-west European population as a whole. The key wintering area for birds breeding in the UK is west Africa, particularly Ghana.

1.2 The roseate tern is specially protected under Schedule 1 of the Wildlife and Countryside Act 1981 and Schedule 1 of Wildlife (Northern Ireland) Order 1985, and is listed on Annex I of the EC Birds Directive and Appendix II of the Bern Convention.

2. Current factors causing loss or decline

2.1 Most, if not all, of the decrease in UK breeding numbers is due to a change in distribution, since the colony at Rockabill, in the Irish Republic, has shown a corresponding increase in numbers. The reasons for this re-distribution are not well known. The overall trend for the species in north-west Europe is upward.

2.2 Outside the breeding season, the trapping of terns for sport or food in west Africa has been suggested as a major cause of mortality. Also, long-term changes in sea-surface temperature may be partly responsible for the consistent and continued decline of fish stocks, eg *Sardinella*, in coastal west Africa and the Gulf of Guinea. As the winter progresses, *Sardinella* become less available to terns in this region and the whereabouts of roseate terns and the composition of their diet in the December to May period remain unknown.

2.3 Some competition may occur between early nesting roseate and late nesting common terns, at sites with few crevices or long vegetation. At some sites, there is a possibility of competition between terns and gulls for nesting areas.

2.4 Predation, particularly by foxes and rats, may restrict nesting to offshore islands. Even on remote sites, predation by the larger species of gulls may threaten breeding attempts.

2.5 Flooding of nesting areas has been a problem at some sites.

3. Current action

3.1 The most important roseate tern colonies in the UK are now within nature reserves and a number have been designated as SPAs.

3.2 Management for the benefit of roseate terns has been implemented at all regularly-used sites and destruction of gull eggs has taken place at several roseate tern islands.

3.3 A colour-ringing scheme is established throughout Britain and Ireland, and a roseate tern coordinator has recently begun work in the Republic of Ireland.

3.4 RSPB and BirdLife International have funded an education programme by the Government of Ghana to try to reduce the incidence of winter trapping there.

4. Action plan objectives and targets

4.1 Increase the UK roseate tern population to 200 pairs by 2008.

4.2 Maintain favourable conditions at current and historical breeding sites in the UK to ensure there are a minimum of five colonies with at least ten pairs in each by 2008.

5. Proposed action with lead agencies

The objectives and targets should be achieved by ensuring the management and protection of existing and former roseate tern breeding sites throughout the UK; and by encouraging international cooperation and action to ensure that the north-east Atlantic roseate tern population is conserved.

5.1 Policy and legislation

5.1.1 None proposed.

5.2 Site safeguard and management

5.2.1 Ensure that the protection of breeding colonies is actively considered in development policies and proposals. (ACTION: CCW, EHS, EN, SNH)

5.2.2 Maintain and, where appropriate, enhance species management measures at all regularly used breeding sites and a suite of formerly used sites. (ACTION: CCW, EHS, EN, SNH)

5.3 Species management and protection

5.3.1 Assess levels of predation at breeding sites and, where necessary, carry out programmes of predator control. (ACTION: CCW, EHS, EN, SNH)

5.4 Advisory

5.4.1 None proposed.

5.5 Future research and monitoring

5.5.1 Continue to monitor the UK population through the Seabird Monitoring Programme. (ACTION: JNCC)

5.5.2 Ensure continued international cooperation on research, monitoring and management of the north-east Atlantic roseate tern population. (ACTION: EHS, JNCC)

5.6 Communications and publicity

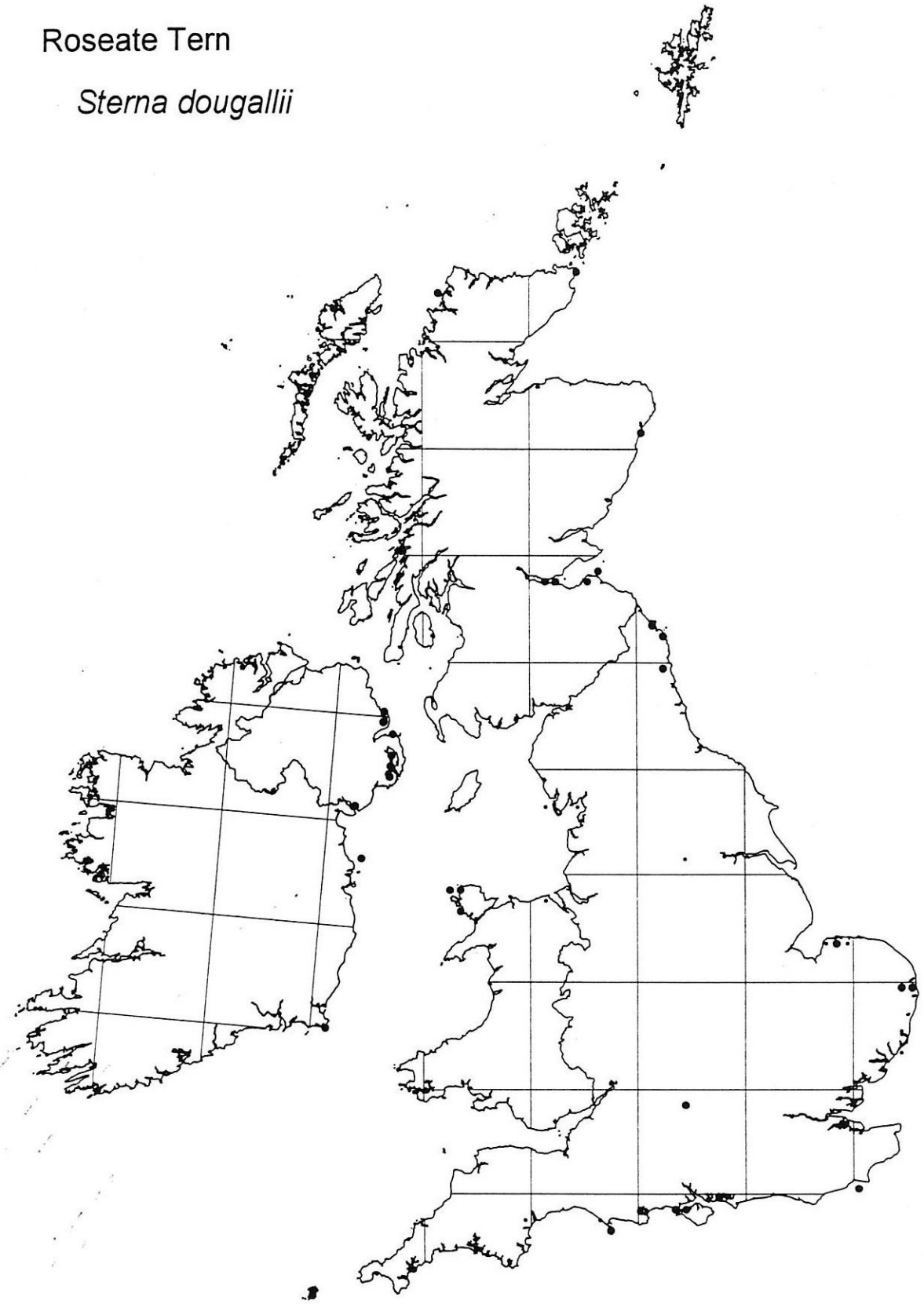
5.6.1 Use the roseate tern as an example of a bird under pressure from factors operating outside the UK in order to reduce persecution in the wintering grounds in west Africa. (ACTION: JNCC)

5.7 Links with other action plans

5.7.1 None proposed.

Roseate Tern

Sterna dougallii



Breeding distribution of Roseate Tern in Britain and Ireland, 1993-1996 (by 10 Km square).
Source: RSPB data, National Tern Monitoring Surveys (1993-1996).

● Record of breeding

• Record with no evidence of breeding

2 A fieldwork manual for research work on roseate terns in Europe.

Norman Ratcliffe and Adrian del Nevo.
RSPB, 1995.

A Fieldwork Manual for Research Work on Roseate Terns in Europe

Norman Ratcliffe and Adrian del Nevo (1995)

Introduction

The roseate tern has declined throughout its north Atlantic range in the last 20 years and the causes of this decline are still poorly understood. A long term demographic study is needed to investigate productivity, recruitment, survival and emigration of roseate terns in all the main European colonies in order to elucidate the factors affecting roseate terns at a population level. The results from such a study would be useful in the formulation of effective conservation policy and action.

The roseate tern database was set up in order to collate information on trends in colony size, productivity and survival from colonies in the north-east Atlantic. The aim of the project was to collect data to allow diagnosis of the causes of the decline in roseate tern numbers by comparing population and breeding trends between areas, and attempting to associate changes with external factors influencing the different populations. The success of the database is totally dependent on a commitment from all contributors to collect the data every year for all colonies in a standardised way to allow valid statistical comparisons to be made. The project is heavily dependent on collaboration between a large number of organisations and volunteers.

The 1995 roseate workshop session held at Glasgow University offered an opportunity for field workers from almost all the colonies in the north Atlantic to discuss a common approach to data collection. This meeting went a long way to resolving problems that had existed to date and deciding on standardised methods. This report presents the plan of research and methodology that was decided on at the meeting.

Disturbance

Disturbance is here defined as a situation where human activity has significant detrimental impacts on breeding performance, site fidelity or adult survival. It is important to minimise such effects while obtaining the best information possible. The behavioral responses to intrusion such as flying round in circles, mobbing and dreads should not considered as disturbance as the costs involved for the birds are so small (probably less than a single foraging trip).

Workers should only visit colonies if they have training in ornithological field work or are accompanied by experienced field workers. Roseate terns are legally protected and you will require written permission from English Nature, Scottish Natural Heritage or Countryside Council for Wales (or related organisation outside the UK) in order to enter a colony. In order to handle and ring chicks you will also require a ringing licence or will need to be supervised by a licenced trainer. Ringing chicks without experience could lead to injury or death and will result in prosecution. If you do not have a licence contact the ringing group in your area and ask for assistance or training.

There are 4 main ways in which human disturbance can affect terns:

a) Direct damage

This results from crushing eggs and chicks underfoot or injuring during handling. Roseate terns chicks hide extremely well, often in low vegetation. Even small clumps of grass can contain young chicks. Nests too are often well hidden. Avoid stepping on vegetation wherever possible. In colonies with dense grass a search on hands and knees should be conducted, ensuring that no chicks are in front of your direction of travel. Breakage of eggs during weighing can be avoided by always processing eggs close to the ground and over a soft substrate. Care should be taken when handling chicks and this requires special training.

b) Thermal stress

The chilling of eggs can cause retardation of embryo development and so increases the incubation period. Only in very extreme cases will embryo death occur (predators regularly kept roseate and common terns off nests all night in the USA but the eggs still hatched). Young chicks are also vulnerable to cold weather. Very hot conditions can have effects too. Visits should not be made to colonies in very hot conditions or in cold wet weather. To minimise disturbance try to make several short visits, separated by a couple of hours, rather than one long one. If eggs feel cold to the touch or young chicks are shivering you should leave the colony. The amount of time that can be spent in the colony will vary accoding to conditions. For most of the season you should not spend more than 40 minutes should be in a colony, although in large colonies it may be possible to work one area without disturbing another.

c) Nest and colony desertion

Terns do not desert nesting attempts readily, and once laying commences it will require serious disturbance to cause abandonment. Checks on nests during the early breeding season within time periods specified above should not cause serious problems, but trapping is not recommended until the last week of incubation. Colony desertion only takes place in extreme circumstances such as people spending an entire day in the colony. Before laying, terns often return to the colony in early morning and late evening to inspect its suitability. Human intrusion at this stage could result in birds moving elsewhere and should be avoided.

d) Increased predation

In tern colonies that are associated with gulls take care that the gulls do not take eggs or chicks while you are in the colony and the adults are distracted. Following handling, chicks (especially older ones) may become stressed and will run away. This should be prevented where possible as the chicks may suffer conspecific aggression or starvation. Chicks placed in cover such as dense vegetation, holes or in nest boxes usually stay put. Older chicks may hop and fly down to the shoreline, but in these cases the parents will usually find them.

Research proposals and standard methods

1. Colony censuses (High Priority)

Method 1: Clutch counts

The best way to assess colony size is a thorough count of all nests 14-20 days after the first egg has been laid. This will be the period when most nests are present. In northern Europe colonies that are visited infrequently, the nest counts should be conducted in the last week of June. In the Azores the optimal timing of counts depends on the island group. Flores should be counted in the 3rd week of May, the central group in the 1st week of June and Santa Maria in the 1st week of July. This method is recommended in all cases where access to the colony is possible.

The search must be thorough in order to locate all the nests as clutches are often well hidden in vegetation or rocks. Care must be taken not to count common tern nests in areas where species nest together. Identifying clutches to species can be difficult. Roseate eggs tend to be longer, paler and more finely speckled that those of common terns. Illustrations can be found in plate 89 of Cramp (1985). These only provide a rough guide and initially it is best to identify the eggs while accompanied by and experienced individual. In some cases, definate identity can only be established by identifying the bird returning to the nest or revisiting the nest at hatching to identify the chick.

Abandoned nests should not be counted (cold, dirty eggs). If possible repeat visits should be made to ensure all nests are counted. Nests should be marked with a numbered tag next to the scrape so that no nest is counted twice. Tags should be secure or the birds may move them. On sand, gravel or soil substrates lollipop sticks work reasonably well. Coloured clothes pegs make very good markers for nests in vegetation. On rock substrates painted stones are probably the best nest markers.

Method 2: Counts of apparently incubating adults

Counts of incubating birds can be used in a situation where clutch counts are not possible and a vanatage point outside the colony exists. Ensure that all areas in the colony can be seen from the viewpoint. Incubating terns can be distinguished from resting birds by differences in posture. Resting birds usually stand with the body is held horizontally, while incubating terns sit with the breast pressed down and the tail pointing upwards at an angle.

If the colony is large or on undulating ground, several vantage points may be needed. If so subdivide the colony using natural landmarks to avoid double counting. Even if these precautions are taken birds may still be missed as roseate terns often nest in dense cover. Counts should be made between the last week of incubation and the first week of hatching, ideally several counts will be made on different days. The peak count should be used for year to year comparisons.

Method 3: Flush counts

In colonies where time is short, or where counts of incubating birds or active nests is difficult, flush counts can be used. Birds are flushed from the colony and counted several times as they circle over the colony area in a tight flock. A mean of the counts is then used to give an estimate of colony size. The flush count should take place between the last week of incubation and the first week of hatching. Two separate counts should be made in a day: one during late morning (10-12am) when few non breeders are present and another in the last hour before dusk when both breeders and non-breeders will be present. Counts should ideally be made by the same person each year.

This method is very crude and correction factors are needed to estimate the number of breeding pairs. For Arctic terns on Shetland, the number of birds flushed during mid-day was equivalent to 1.5 times the number of nests in a colony (Bullock and Gommersall 1980). Thus to estimate the number of pairs divide the total birds counted by 1.5. However, calibrations for each colony (number of active nests counted / number of birds in flush count) would be ideal if estimates of this type are to be made regularly. Flush counts are inaccurate and are most suitable for smaller inaccessible colonies that can't be seen from a vantage point, such as the cliff sites in the Azores.

2. Breeding parameters

The collection of standardised data on the following breeding statistics is an essential part of the monitoring programme. Studies of breeding biology provide an indication of food supply and predation for a colony, provide predictors of future recruitment into the breeding population and can lead to management to improve productivity.

2a: Egg biometrics (Medium Priority)

The data needed from the egg stage are laying date, clutch size and egg volume. Nests should be searched for 14-20 days from the date when the first egg is seen in order to reduce disturbance at the critical post-laying season when desertions may occur. Verify that nests belong to a roseate tern if common terns are in the same colony.

Record the number of eggs in the nest and check around the scrape for displaced eggs or signs of predation if there is only one egg. Single eggs may be an uncompleted clutch so try to recheck any single egg clutches again 2 days later. The nest should be marked so that it can be relocated on subsequent visits (see above). The marker should have a nest number written in permanent ink for cross reference between visits. Mark the larger egg with an 'A' in non toxic permanent marker and the smaller with a 'B'.

Measure the length and breadth (at the widest point) of the egg to the nearest 0.01mm using vernier calipers. The weight of the eggs and the date of measurement must also be recorded. Minature electronic balances will be provided to larger colonies to reduce measurement errors in weighing and to speed up processing. This data will be used to calculate egg volumes and to back-calculate laying date. Laying date can be calculated from egg density because eggs lose weight (due to evaporation) at a constant rate up to the point the egg begins to hatch (Furness and Furness 1981). Once the eggs is starred (punctured or cracked) by the hatching chick, the rate of water loss increases, so note any signs of starring. See Appendix 1 for equations to calculate egg volumes and laying dates. Note that addled eggs lose weight at different rates to developing ones and should not be included in this analysis.

2b: Chick biometrics (Medium Priority)

As the time of hatching approaches, nests should be inspected more frequently so that the chicks can be ringed before they wander away from the nest. This will allow the A and B chicks to be identified and associated with the nest of origin. This approach is far better than ringing older chicks of unknown history, since more thorough analyses of the factors affecting chick growth and survival can be made. Note the hatching date of any newly hatched chicks as this is useful to cross reference the predictions of laying date from egg and chick measurements.

Chicks should be weighed to the nearest 0.1 g using a pesola balance and the length of the wing should be measured to the nearest 0.5mm with a wing rule (using maximum flattened cord method. Remember to subtract the bag weight or zero the balance to account for the bag. Balances should be zeroed and calibrated using a 50 or 100g weight before each visit to ensure that all measurements from different balances are comparable.

Marked chicks should be searched for and measured regularly (every 3-5 days) to estimate growth and survival. The provision of chick shelters will make them easier to find, as well as enhancing productivity. These shelters could be boxes or half buried tyres which are dark inside. Repeat measures of chicks will be especially valuable between 4 and 14 days so that the linear growth rate of individual chicks can be estimated accurately. Birds greater than 21 days should also be measured to estimate the asymptotic mass. See Figure 1 for a diagram of a typical tern chick growth curve and Appendices 2 and 3 for estimating the age of chicks. It is essential that tern chicks are identified to species correctly before ringing. Figures 2 and 3 give details on how to identify tern chicks at different ages.

2c: Productivity (High Priority)

Productivity is the most important breeding parameter to estimate for each colony as it is an important component is the study of population viability and avian demography. Productivity is defined here as the number of chicks fledged per pair. If individual nests are followed, more accurate statistics such as breeding success (number of fledglings per egg) or fledging success (number of fledglings per hatchling) can be calculated and this is useful data.

Productivity is difficult to assess for roseate terns. It is hard to establish if missing chicks have moved, are hiding, have been taken by a predator, have died and disintegtated or have fledged. Productivity can be estimated by a variety of methods. They vary in accuracy, the amount of information generated and the effort required to achieve an estimate. The method employed will depend on the colony being studied, time available and logistical constraints. The various methods do give slightly different estimates of productivity (Nisbet *et al.* 1990).

Method 1: Clutch and brood survival

This is the most accurate method that allows very detailed information to be collected on the stage at which losses occur and the factors that may affect productivity and is recommended if time and access allows. The method involves repeated visits to all or a sample of clutches and broods and so is more intensive than Methods 2 and 3. This method will be most applicable to Rockabill and Coquet where resident wardens will be able to visit the colony regularly.

Marked nests should be checked at 3-5 day intervals for predation and addled eggs. Predation of eggs can be identified by eggs being missing from the scrape prior to the expected hatching date. Addling can be identified by the gloopy liquid noise made by the egg when it is gently shaken. Break open any eggs that are **definately** addled (ie. sound addled and well past expected hatching date) to see if any development has taken place or whether the eggs were sterile. This will monitor the rate of sterility and embryo death for the colony.

The actual losses at the egg stage is likely to be underestimated because clutches may be lost before they are even found. For this reason the calculation of daily survival of clutches is better than calculating hatching success. The Mayfield method (Mayfield 1975) can be used to calculate daily nest survival rates (see Appendix 4). This is best done on a computer as it involves a considerable degree of data processing. The data required are the dates of each visit, the nest numbers and the fate of the clutch (intact, losses). The unit of measurement is the clutch so record a nest as lost even if 1 egg remains from a 2 egg clutch.

Once the chicks are hatching they become mobile and may be missed on visits despite being present. This means different methods are necessary to assess chick survival. Chicks should be ringed at an early age while they can still be associated with their nest and their survival monitored by searching for them on subsequent visits. As a lot of chick mortality occurs in the post-hatching period it is important that chicks are ringed young or underestimates of fledging will occur. Make a note of the nest from which the chicks hatched if possible.

Thorough systematic searches for ringed chicks should then be conducted at 3-5 day intervals to find as many chicks as possible until all chicks have fledged. Roseate tern chicks are extremely good at hiding and all vegetation, cracks and holes should be searched thoroughly. Young chicks sometimes die in the nest and are trampled into the nest material if another egg or chick are being brooded. The effort invested in searching should be similar on each visit. During repeated visits ring any newly hatched chicks and record the ring numbers of those ringed on previous visits. Any dead chicks should be collected and aged from wing length. Chicks should be weighed and measured as part of growth studies (see above) and this data can used in

subsequent productivity estimates.

There are three main ways that productivity can be assessed. The simplest is to calculate the number of chicks that reach 15 days old and divide this by the number of pairs in the colony or sample. This technique is good for colonies where predation is low as chicks that reach 15 days will probably fledge. Nisbet *et al.* (1990) recommended a further analysis that incorporates growth data to predict which chicks fledge (Appendix 5). Where predation is higher, a Jolly-Seber mark recapture model (Seber 1973) within age classes (0-4, 5-15, 15+ days) should be used to calculate survival rates. This calculation is complex and RSPB has a computer program to carry out this analysis. The data required are the date, a list of the ring numbers and the wing lengths for all chicks for each separate visit.

Method 2: Mark-recapture study of older chicks

In a situation where it is not possible to gain access to the colony throughout the season, a simple mark recapture model can be used to estimate the number of large chicks in the colony (Walsh *et al.* 1995). This method will be particularly useful in a situation where you are not a ringer and are dependent on help from a ringing group. Ringers will be most likely to want to ring older chicks at the weekends, and this tecnique fulfils this requirement.

The method involves two visits to the colony within a single day approximately 1 week before the first chicks will fledge. The whole colony area must be searched for chicks, so in larger colonies several ringers may be needed. Any chicks over 15 days old (as estimated from wing length) should be ringed and released. Try to ensure they don't run away by placing them in cover. Smaller chicks should be ignored as they are less likely to survive.

The colony should be searched in a systematic manner so that no parts are missed. Later in the day a repeat visit is made. The second search should be of a similar effort to the first but follow a different pattern (zig-zags N-S for the first visit and E-W the second is a good search technique). The ring numbers of all chicks are noted and the number of unringed chicks over 15 days recorded (these can be ringed too). The number of large chicks is then calculated as:

$$N = R1*N2/R2$$

Where: N = Number of large chicks

R1 = Number ringed on first visit

N2 = Total number of chicks (ringed and unringed) found on second visit

R2 = Number of ringed (R1) chicks captured in second visit.

This should be repeated 3 times at 1 week intervals to cover the spread of hatching. On the second week chicks will fall into 2 categories:
(i) Chicks that were too young to be ringed in the first week that are now old enough to be classed as fledged. These should be included in the analysis.
(ii) Chicks that were included in last weeks analysis that have not yet fledged. These can be ringed but should be excluded from the analysis.

The calculation should be done separately for each weekly visit. The final productivity figure will be the sum of chicks estimated for the three visits divided by the number of pairs in the colony.

Method 3: Counts of fledged chicks

This method uses counts of fledged chicks as they sit around the colony waiting to be fed. For small colonies (<20 pairs) a direct count of chicks seen is often sufficient if access to the colony is difficult. The number of fledglings can be divided by the number of pairs to estimate productivity.

In larger colonies an estimate of the ratio of ringed to unringed chicks should be made. As many chicks as possible are ringed in the colony. Counts of unringed and ringed fledglings are then made as they stand around the colony waiting to be fed by parents. Productivity is estimated from the equation:

$$R1 / (PR \times N).$$

Where: R1 is the number of chicks ringed in that year.
PR is the proportion of ringed chicks seen in the post fledging period
N is the number of nests in the colony.

One problem with this method is that fledglings may interchange between adjacent colonies (Ryan pers comm) although this is unlikely to be a serious bias.

Other methods in use

The method of subtracting totals of dead chicks and addled eggs from the total number of eggs found during clutch counts is flawed as it assumes all losses from the colony are detected. As this assumption is unlikely to be justified, this method will lead to serious over estimates of productivity and should be discontinued.

3. Estimate survival rates and colony fidelity (High Priority)

The estimation of adult survival is a vital part of research on the population dynamics of roseate terns. As with many long lived seabird species, the life history strategy of terns is to have a long lifespan and low breeding output. Declines in survival rate are of more concern than short term fluctuations in productivity and there is evidence that this has occurred for roseate terns in the Atlantic.

Continued collection of data on Rockabill and the extension of these methods to other colonies is considered a very high priority. The use of these methods also allow estimates of inter-colony movements and rate of recruitment, all of which are important variables in any meta-population analysis.

Ring reading so far has been focused on BTO rings, but these are difficult to read. In order to facilitate ring reading roseate special rings have been developed. These rings have 4 digits arranged in the following pattern:

A4	B2	W2
06	34	81

These examples read A406 B234 and W281. As many chicks as possible on all colonies in all years should be ringed with roseate special rings and efforts should be made to trap and ring adults (see Recommendation 4). The ring numbers can be read with a telescope on successive years so that the survival of the birds can be monitored.

It is essential that accuracy is maintained in ring reading, otherwise birds may be mis-classified as present in the colony. Studies suggest that ring reading should only be attempted when the observer is less than 25m from the bird. To get closer to the birds a mobile hide or camoflage netting can be used. Wide coverage of all parts of the colony is needed in order to avoid bias towards certain sub-colonies.

It is recommended that hides or camoflage netting is just draped over you rather than using cumbersome poles so that you can walk round and stop at a suitable place, allow the terns to settle around you and then move on when all the legs have been read. All terns where both legs were seen (ringed or unringed) should be recorded to estimate the effort invested in ring reading at each site between years. Rings that have been incompletely read or seen and not read must also be recorded. In colonies where tall vegetation, make ring reading impossible, wooden platform perches should be built above the vegetation so that rings can be seen.

4. Catch and mark adults and measure adult body condition (Medium Priority)

In order to increase the sample size of ringed adults and to mark BTO ringed birds with roseate specials, nest trapping should be conducted. This will increase the sample size for the survival analyses and ensure a more representative sample of age classes. Biometric data can also be collected so that a bird's size and condition can be estimated.

Nisbet (1981) recommended that roseate terns should be captured between 17 days into incubation and before the eggs are pipped. The best time is when the eggs are starred. Under these conditions, no detrimental effects on hatching were detectable. The terns will leave the nest to bathe for several hours before returning to incubate, and this varies between colonies (Burger *et al.* 1995). The mate will take over incubation duties once the trapped bird has departed if it is present. The effect of trapping on adult behavior and hatching success should be monitored, and trapping should stop if there is evidence that harm is being done.

Walk-in traps on natural sites or drop door traps can be used to catch adults during the late incubation stage. To ensure no damage to eggs occurs, take the eggs out of the nest and place them in a margerine tub or similar container packed with cotton wool or polystyrene chips to keep the eggs warm. Dummy eggs should then be placed in the nest scrape (Quail eggs filled with wax will do). Swap the real eggs back after trapping. There is anecdotal evidence that clap nets and mist netting may cause nest and colony desertion and these techniques should **not** be used.

Adults rearing chicks can be captured if enclosures are used as a part of diet or productivity studies (see section 5). Lids can be fitted and closed by means of a string from a hide when the adult returns to feed the chick.

Only one adult should be caught in a day from any one nest. Trapped birds should be bagged and ringed with BTO and roseate special rings. If the bird is ringed with a standard metal ring already, note the ring number and put a roseate special on it. Linear measurements of head and bill, bill length, bill depth at the gonys and tarsus (see Fig 4) should be measured to the nearest 0.01mm with vernier calipers. Wing length should be noted to the nearest 1mm with a wing rule and weight to the nearest 1g with a Pesola balance. This data will be useful for estimating adult condition during the incubation stage and for sexing using discriminant analysis.

5. Monitor diet and foraging ecology (Medium Priority)

In order to determine variations in food and foraging pattens, studies of time budgets, feeding frequency, food type and food size will be conducted. This will provide useful data to diagnose variations in productivity.

Method 1: Provisioning rates

This involves the detailed monitoring of a number of broods from a hide to identify food types, estimate their size, and quantify the rate at which items are provisioned to chicks (fish per hour).

Monitoring provisioning rates of free ranging broods is very difficult, especially in dense colonies with a lot of cover. The best way to do this is to enclose broods with wire cages. The cages should be 40cm high and approximately 2m in diameter. The mesh should be chicken wire with a 15mm diameter mesh. There should be room for the adult tern to land easily (a landing platform on one post of the cage can help) and a shelter for chicks (a roseate tern nest box is ideal) and the bottom of the cage should be buried to prevent escape. The shape of the cage is usually square or circular.

The cage should be erected late in the incubation stage so that adults get used to going in and out before the chick hatches. Putting cages up after hatching can lead to parents trying to feed chicks through the mesh and the provisioning rate being reduced so this should be avoided. This type of cage design has been used successfully in many tern studies on Shetland, Orkney and Coquet Island and causes no detrimental effects on chick survival. This work can also be used to monitor growth rate and survival for enclosed chicks. Chicks should be released at 15 days old as they are likely to be more active at this stage and need more room.

The number of broods that require monitoring should be not less than 10 to allow statistical comparisons, and preferably 20. Only about 5 broods at a time can be followed during one watch or there will be too much activity to follow, so subsamples of the broods should be watched in a randomised pattern. Watches should be not less than 2 hours in duration, ideally observers should swap after 2 hours to prevent loss of concentration.

Any food bought to chicks should be identified (see Appendix 6) and the time at which it was bought should be noted. The length of the prey in relation to the bill length (to nearset 0.5 bill) should also be recorded. The accuracy of identification and size estimation should be assessed by using a model terns head (a cardbord cut-out will do) or the head of an adult tern found dead on the colony. Record the fate of the fish (eaten by chick, parent, dropped, stolen by another bird). Fish that have been dropped in the colony should be collected and placed in the model's bill by an another worker and shown briefly to the observer at a range similar to that used in observations. The observer should record what he thinks he sees and then compare the results with the actual fish seen. This should be repeated with a wide variety of species and sizes until the observers become proficient at identification and size estimation.

This data can be used to assess percentage composition in the diet represented by different fish species, the rate at which items are provisioned to chicks (items per hour). As fish of different species and sizes have different energetic density, an estimation of energy content of fish is needed to make meaningful comparisions of provisioning rates. Relationships between fish size and energy content for different species are given in Harris and Hislop (1978) and are best calculated on a computer.

For more detailed studies, adults can be marked using dye soaked sponges in the nest cups during incubation. This will mark the breast feathers so that individual members of the pair can be identified. The attendance of adults can then be monitored for each territory by noting the time of arrivals and departures. If time off the territory is assumed to be spent foraging, the catch per unit effort (kj of food per hour foraging) can be calculated. This is a sensitive indicator of food availability.

Method 2: General dietary assessment

If it is impossible to see several broods from a hide, then food type and size watches can be conducted. The type and size of the prey being carried by randomly selected terns flying into the colony should be recorded in a similar way to that described above. This gives an indication of overall diet for the colony but affords far less information than Method 1.

Method 3: Fish dropped on the colony

The size and species of fish dropped on colony can be a useful indicator of diet. Fish should be collected, identified and measured. It is important that this is done in conjuntion with other studies to ensure that the fish dropped are representative of the diet. These fish can be used to calibrate identification and size quantification as described in method 1.

6. Sexing (Low Priority)

The sex of terns can have important effects on their survival rate, with females often living longer than males. A technique for sexing roseate terns has been developed in the USA that uses DNA from feathers. It will be worth doing this on any adults caught but as chicks will probably have a low return rate it is probably not worth doing on them.

A breast feather from an adult can be plucked, placed into a screw-top vial and covered in 40% alcohol. The birds' ring number and the colony of origin must be recorded on a sticky label in permanent ink on the side (don't write straight onto the vial or the mark will rub off). These samples will then be sent to a lab for analysis. RSPB are currently looking for a lab in Britain that can perform the analysis.

Observation of copulations of marked individuals from a hide are also useful for sexing birds. The bird on top will be a male. Courtship feeds during the pre-laying stage are provisioned exclusively by the male to the female, so this is also useful for sexing. Read the ring numbers of any birds that you manage to sex if possible.

Further Reading

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Appendix 1: Equations for the calculation of egg volumes and laying dates.

(1) Egg Volume

$$V = 0.00048 * L * B^2$$

Where V is the clutch volume in ml, L is the egg length in mm, B is the egg width in mm.

(2) Laying date (Zingo *et al.* 1995)

(a) First calculate the fresh egg mass from linear dimensions (notation and units as for egg volume):

$$\text{Fresh mass} = 0.0005166 * L * B^2$$

(b) Calculate the proportion of the fresh mass represented by the weighed value:

$$P = \text{observed mass} / \text{fresh mass}$$

(c) The stage of incubation is estimated from the equation:

$$\text{Day} = 134.088 - 133.005 * P$$

The laying date can be calculated as:

$$\text{Laying date} = \text{Day of measuring} - \text{stage of incubation}$$

This method results in a mean error of 2 days with errors as high as 8 days occurring. It is not applicable to abandoned and addled eggs and is least accurate for starred and pipping eggs.

Appendix 2: Approximate age of roseate tern chicks according to morphology and plumage characteristics. Values with question marks in brackets are interpolations for classes in which few data were available. This is a rough guide only so always record wing length of unknown aged chicks.

Plumage class	Characters	Age
1	Newly hatched, legs short, fat, chin black	0-2
2A	Legs elongate, narrow shank between foot and joint, no pin feathers on outer winf	2-6 (?)
2B	Pin feathers on outer wing present but not erupted. Black chin almost gone.	5-10 (?)
3A	Pin feathers erupted on outer wing	11-13
3B	Tail feathers erupted (shaft visible), but less than 6mm long (white not visible). No black feathers on the nape.	13-16
4A	Tail feathers more than 6mm (white visible), but down still on tips. A few black speckles on the nape when brushed.	15-20
4B	No down on the tips of the tail but down on tail coverts. Black appears on nape. Mantle feathered with some down tips.	18-22
5A	Nape black with speckles. No down on back, but a little down on tail coverts. May fly when frightened.	20-23
5B	Fully feathered and free flying. No down except on forehead.	23 +

Appendix 3: Approximate age of roseate tern chicks in relation to wing length (mm) for reference. NB: This is only a rough guide; record wing length of chicks in all cases, not age as judged from this table.

Age	Wing
0	<16
1	18
2	20
3	22
4	24
5	26
6	30
7	35
8	41
9	47
10	53
11	60
12	66
13	73
14	80
15	86
16	93
17	99
18	104
19	109
20	114
21	117
22	121
23	124
24	127
25	129
26	131
27	133

Appendix 4: Calculation of clutch survival from the Mayfield method. The probability of a clutch surviving from one day to the next is estimated from the equation:

$$P = A / (A+B)$$

Where A = total number of nest days (the sum of all the daily totals of nests during the observation period) and B = total number of nests lost. The day on which a nest is lost is not counted as a nest day. Nests were assumed to be lost half way between the last two checks (therefore, if the check interval is 3 days, lost nests survived for 1.5 days). The unit of measure is the clutch, as the fate of individual eggs in a clutch is not independent.

Example: Wardens on Rockabill monitored the fate of 100 roseate tern nests. They visit the study nests every 3 days. A total of 4 vists are made. The results were as follows.

Visit 1: 100 nests marked
Visit 2: 97 intact nests, 3 nests missing
Visit 3: 93 intact nests, 4 nests missing
Visit 4: 90 intact nests, 3 nests missing

A simple estimation of hatching success would give 90% success.

The Mayfield method gives:

Number of nest days survived = $97 \times 3 + 93 \times 3 + 90 \times 3 = 840$
Number of nest days missing = $3 \times 1.5 + 4 \times 1.5 + 3 \times 1.5 = 15$
Therefore total nest days = 855

$$P = 840 / (840 + 10) = 0.99$$

The probability of the nest surviving for one day is 0.99.

Given an incubation period of 23 days the probability of hatching is:

$$0.99^{23} = 0.79$$

Therefore a better estimate of hatching success is 79%

Appendix 5: Estimating productivity (Nisbet *et al.* 1990)

This method makes use of growth data to predict which chicks are likely to starve. This is the standard method used in the USA and is the recommended method for work in Europe. Measured chicks are assigned to the following categories:

Dead: D1, found dead.
D2, dissappeared after being below normal range of masses for age when last encountered (ie below mean minus 2.5 standard deviations for mass of survivors). These will most often be B chicks that fail to gain mass and disappear 6 days after hatching.
D3, disappeared after being normal mass while sibling encountered regularly.
D4, B chick never found, A chick encountered regularly.

Fledged: F1: Known to have reached the age of 15 days and within the normal range of masses when last encountered.
F2: Known to have reached the age of 5 days and within normal range of masses when last encountered.

Unknown: U1, all chicks in the brood disappeared before age of 5 days and within normal range of masses when last encountered.
U2, chicks at marginal mass (1.5 - 2.5 standard deviations below mean for survivors) when last encountered after surviving 10 days or more. Most chicks in this category will be B chicks.

These categories are used to calculate 2 estimates of productivity. The first uses broods with known outcomes (D1, D2 and F1). N is the number of broods for which all chicks fell into one of those categories plus the number of clutches that failed prior to hatching. Productivity is calculated as F1/N.

For the second estimate of productivity, N is defined as all broods except those classed as U1 and including all hatching failures. Fledging birds are classed as F1, F2 and half of the U2's. Productivity is calculated as (F1 + F2 + (U2 / 2)) / N.

This is good estimate of fledging success in colonies where predation is low or non-existant. In such colonies, chicks that survive to 15 days and are of a normal mass will usually fledge.

3 Tern populations and productivity.

Bird monitoring methods: a manual of techniques for key UK species.
Gillian Gilbert, David Gibbons and Julianne Evans.
RSPB, 1998.

Tern populations

These three methods – taken from the *Seabird Monitoring Handbook* – are appropriate for sandwich, roseate, arctic and little terns (also for common tern *Sterna hirundo*).

Breeding terns can be very mobile in comparison to other seabirds. In some cases, whole colonies may shift location from year to year, or a large proportion of one colony may move to a different colony (not always nearby) in a different year. Pairs which fail at one colony early in the breeding season may even move to a different colony in the same season. This makes it particularly important to try to fill any gaps between currently monitored colonies.

Method 1 should always be used where possible. It can be used at colonies where 80% or more of the occupied area can be viewed from vantage points; it involves no disturbance and produces reasonable estimates. If it is not possible to use Method 1, use *Method 2*, which is a useful method for colonies where it is only possible to see up to 80% of the occupied area from suitable vantage points. If this method cannot be used either, *Method 3* provides a quick estimate of the number of adults present; it is designed for use particularly in colonies where counts of apparently incubating adults or active clutches are difficult.

1. Counts of apparently incubating adults

Information required

- maximum number of Apparently Incubating Adults (AIAs).

Number and timing of visits

One to three visits (one week apart), between mid-May and late June. At least one should be made during the late incubation period, approximately 3½ weeks after the first incubating bird is seen or the first egg is laid (usually early June).

Time of day

Any time.

Weather constraints

Avoid cold, wet and windy days.

Sites/areas to visit

Any colonies not currently being monitored.

Equipment

- nest markers, eg pasta shells.

Safety reminders

If working alone, always ensure someone knows where you have gone and when you intend to return. If cliffs or steep slopes are to be climbed to gain access to beaches, use the correct safety equipment and do not work alone. If working with boats, never work alone. The boat should be operated by an experienced and trained boat handler and life-jackets should be worn at all times. Take the necessary equipment to deal with any emergency. Be aware of the signs of Lyme's disease which can be caught from seabird ticks.

Disturbance

All tern colonies are very sensitive to disturbance so try to keep this to a minimum. Terns should never be flushed from the nest in rain or strong winds. When counting nests, visits should not be made to colonies in poor weather or in very hot conditions. To minimise disturbance it may be best to make several short visits rather than one long one. As a rule, not more than 20 minutes should be spent in a colony. Care should be taken that predators such as gulls and skuas do not take advantage of your presence to rob unguarded nests. If in doubt, leave the colony and return at a later date.

Methods

Apparently Incubating Adults (AIAs) can be counted in colonies where most (not less than 80%) of occupied areas can be viewed from suitable vantage points. When choosing vantage points, it is important to allow for vegetation growth as the season progresses. Large and complex colonies will require more than one vantage point. Ensure that parts of the colony are not double-counted or missed. Use physical features, if possible, to divide the colony into subsections to be counted from each vantage point. Mark these subdivisions and vantage points on a sketch map of the colony. Large colonies which cannot be counted in one day should be covered on consecutive days (equivalent to one visit), in order to avoid double-counting failed breeders making a second attempt in a different part of the colony.

Count the number of birds that appear to be incubating a clutch of eggs, whether or not nest material is visible. Incubating birds can be distinguished from off-duty resting birds by their posture: a bird incubating will be sitting in a hollow or scrape and thus be partly hidden with its tail pointing up at a sharp angle; resting birds which are not incubating are more visible and their tail is held at a shallower angle, although this might not be so where birds are sitting in slightly undulating terrain. Where nests are spaced widely enough it is usually possible to distinguish members of the same pair (one sitting, one standing nearby). Using a sketch map, record all nests or clutches seen.

Attempt to estimate the number of nests in any parts of the colony that cannot be seen from the vantage points (minimum and maximum) from the density of nests in the visible part of the colony. If more than 20% of the colony cannot be observed from vantage points, use Methods 2 or 3 (see below).

Keep a note of the counts made on each date and report the maximum count of AIAs for the whole colony on any one visit. If more than one visit has been made, do not sum the maximum counts for each subsection from different visits, as birds which move after a failed breeding attempt might be counted twice.

2. Counts of apparently occupied nests, with eggs or nest material

Information required

- maximum count of 'active' nests.

Number and timing of visits

One to three visits (one week apart), between mid-May and late June. At least one should be made during the late incubation period,

approximately 3½ weeks after the first incubating bird is seen or the first egg is laid (usually early June).

Time of day, Weather constraints, Sites/areas to visit, Equipment, Safety reminders, Disturbance

As for Method 1.

Methods

Active nest counts should be used for colonies where more than 20% of the occupied area is not visible from suitable vantage points. Colonies should be small enough, or divisible into small enough sections, that a complete 'ground' survey can be made without prolonged disturbance.

Determine the timing of the breeding season by casual observations to record the first incubating birds or eggs laid. Counts should be made late in the incubation period about 3½ weeks after the first egg is seen in the colony. Counts in early June are usually suitable if the timing of the season is not known in detail. Keep a note of obvious empty nest-scrapes. If there are many empty scrapes or single eggs it might be more appropriate to count a week later. Record any signs of predation as this will also produce a high number of empty scrapes.

For large colonies which cannot be subdivided and visited on consecutive days, it will be necessary to use several observers walking in a line through the colony. Count accuracy will be improved by the use of markers (these do not have to be numbered). These should be inconspicuous to avoid attracting predators, but should be robust enough to survive a few weeks (eg small stakes). Observers should be close enough to each other to ensure that few, if any, nests are missed. If possible, a second count should be made a week later and a third count two weeks later. The cumulative number of clutches recorded over three dates will provide an alternative measure of the population.

Correct for count efficiency on each visit, especially if the terrain is complex or if more than one observer is used. To do this, walk through the colony on the same day but in a different direction to that used in the initial count and record the ratio of marked to unmarked nests.

Correct for count efficiency as in the following example:

250 nests initially marked
230 marked nests and 15 unmarked nests found on re-check carried out on the same date
Corrected count = (245/230) × 250 = 266 clutches

A rapid, accurate count of active nests should be the priority, but, if possible, record the clutch size on each visit. Keep a note of any obviously deserted eggs, ie those which are displaced, broken, excessively dirty and/or coated in droppings. If in doubt, check whether the eggs are cold.

Report results as:

- maximum count of active clutches on any one visit (corrected for count efficiency where possible)
- cumulative total of active clutches recorded over all count dates
- counts of active clutches (both corrected and uncorrected, ie raw data) on each date
- additional numbers of empty nests (with material) recorded on each date.

Comparisons between years or colonies are best based on peak counts. Although cumulative totals allow for the spread of breeding, they may also include repeat clutches by failed pairs in new scrapes. This means they are less suitable for comparisons because of double-counting.

3. Flush counts of individual adults

Information required

- maximum mean flush count.

Number and timing of visits

One to three visits (one week apart) during the last two weeks of incubation and first week after hatching (usually early June).

Time of day

Preferably 1000–1200 BST, and not outside the period 0800–1600 BST.

Weather constraints, Sites/areas to visit, Equipment, Safety reminders, Disturbance

As for Method 1.

Methods

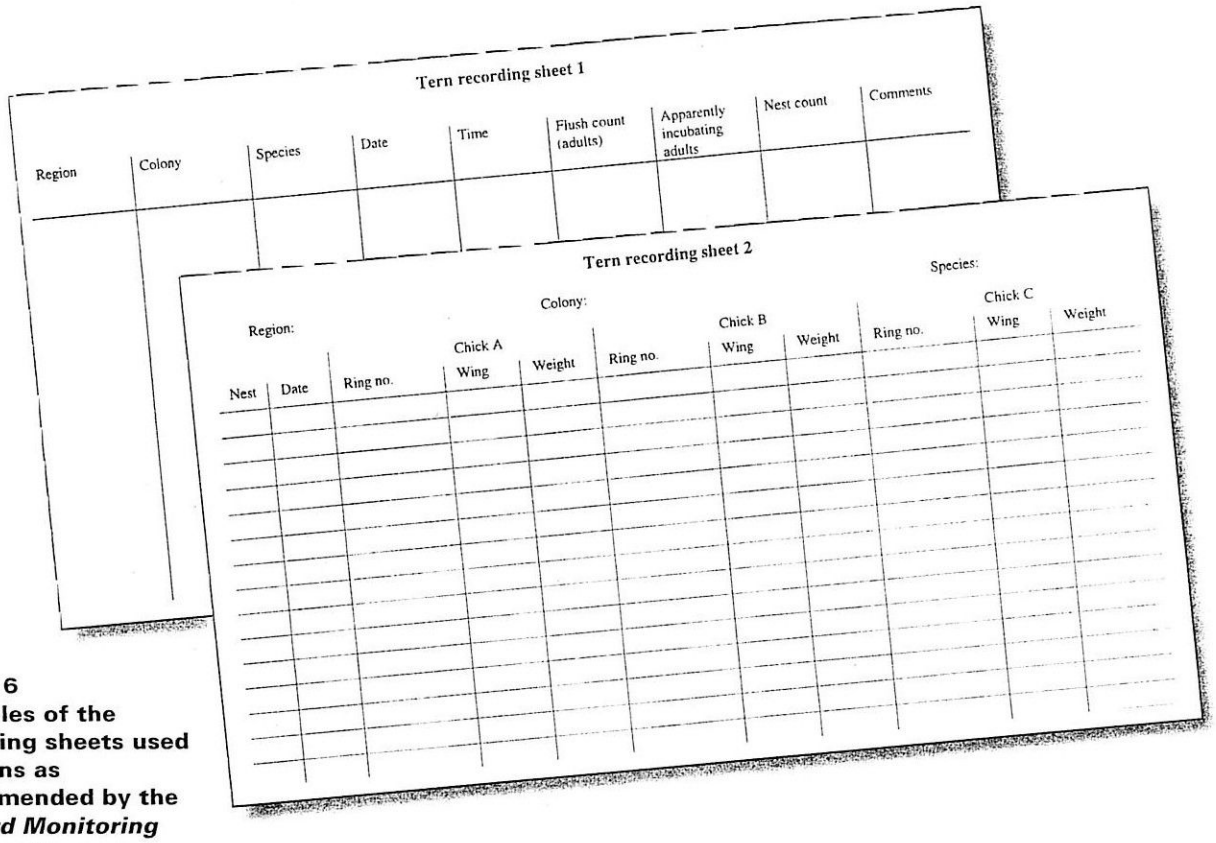
Flush counts are the quickest but least accurate way of counting incubating adults or nests. Flush counts should, if possible, be made on three dates, one week apart, during the last two weeks of incubation and first week after hatching. If the timing of the breeding season is not known and/or only one visit is possible the count should be made in early June. On each date a minimum estimate of the number of birds present should be obtained by counting the number of birds visible on the ground and in the air before flushing. Also count birds resting on the edge of the colony before flushing birds from the nesting area.

Flush the birds from some distance away using a loud noise such as a horn. It might be necessary to get closer for large colonies.

Flush counts provide two different population estimates depending on the time of day, so always record the time. Counts between 1000 and 1200 BST provide a good estimate of the number of breeding adults as most non-breeders are absent at this time. If it is impossible to count at this time then ensure that counts are at least confined to the period 0800–1600 BST, as most non-breeders are present just before dusk.

Count the flushed adults several times as they wheel around in a tight flock over the colony (little terns flock less tightly than other species). At colonies with more than one tern species, flush counts are more difficult, particularly when common and arctic terns are present. Where possible, accurate counts should be made of each species. In mixed colonies flushed flocks may not be single-species, and at large colonies it may be impractical to count each species accurately. Where this is the case, flush count the whole colony and obtain population figures by estimating the proportions of each species from sample counts.

The flush count method is quick, quantitative and repeatable. Without calibration with nest counts it may give inaccurate estimates of breeding numbers, but these estimates will still be useful in assessing changes in numbers from year to year. In Orkney and Shetland it has been shown that the number of flushed birds was equivalent to about 1.5 times the



Tern recording sheet 1

Region	Colony	Species	Date	Time	Flush count (adults)	Apparently incubating adults	Nest count	Comments

Tern recording sheet 2

Region: Colony: Species:

Nest	Date	Chick A Ring no.	Chick A Wing	Chick A Weight	Chick B Ring no.	Chick B Wing	Chick B Weight	Chick C Ring no.	Chick C Wing	Chick C Weight

Figure 6
Examples of the recording sheets used for terns as recommended by the *Seabird Monitoring Handbook*.

number of nests in a colony around midday in the main incubation period (Bullock and Gomersall 1980). However, this correction factor may vary according to species, time of day, state of incubation, weather, food availability or other factors.

Wherever possible make both nest counts and flush counts to allow comparison of calibration factors between different colonies and species.

Calculate the average count on each visit. Report the maximum of these averages. See Figure 6 for an example of the recommended recording sheet for tern population counts.

Reference

Bullock, I D and Gomersall, C H (1980) *The Breeding Population of Terns in Orkney and Shetland in 1980*. RSPB.

Tern productivity

These two methods are taken from the *Seabird Monitoring Handbook*, and are appropriate for sandwich, roseate, common, arctic and little terns.

Several methods exist to monitor tern productivity. Three of these, which involve ringing and chick mark/recapture, are not given here but are documented in the *Seabird Monitoring Handbook*. Two which do not involve ringing are presented here: *Method 1* involves counting nesting/incubating adults, with a single count of large chicks; *Method 2* involves flush counts of adults with single or multiple counts of large chicks.

These two methods, although less accurate than those involving mark and recapture, can be undertaken without having to catch and ring any birds. They are thus more applicable to most fieldworkers and cause much less disturbance to the terns. The estimate based on flush counts is the least accurate of the two methods presented.

1. Nest/incubating adult count, with single count of large chicks

Information required

- maximum count of apparently incubating adults or active nests
- estimated number of large chicks and fledged young.

Number and timing of visits

One visit at first fledging, usually early July (NB a population survey must be carried out earlier in the season; see *Tern populations*, above).

Time of day

Midday.

Weather constraints, Sites/areas to visit, Equipment, Safety reminders, Disturbance

As for the population survey (see *Tern populations*).

Methods

This may be the only possible method for colonies that are visited infrequently. It is most suitable for small colonies or those where pairs breed synchronously.

Count either apparently incubating adults (population survey Method 1) or active nests (population survey Method 2). Around the date of first fledging (±1 week), usually early July, count large chicks (10–14 days old, depending on species; see Tables 2–3), including any nearby fledglings which are associated with the colony. Chicks may be counted from a suitable vantage point at some small colonies, although some may be missed. Keep a separate note of numbers of smaller chicks and unhatched eggs.

Estimate productivity as the number of large chicks plus fledged young divided by the maximum count of apparently incubating adults or active nests. This may substantially underestimate productivity, as some large chicks may be missed and smaller/unhatched chicks not included in the count may survive to fledging. On the other hand, some large chicks may die before fledging.

Table 2
The average incubation and fledging periods for terns (overall ranges in parentheses) and ages at which tern chicks should be recorded as potentially fledged (*BWP*, cited in the *Seabird Monitoring Handbook*).

	Incubation period (days)	Fledging period (days)	'Potentially fledged'
Sandwich tern	(21–)25(–29)	28–30	2 weeks
Roseate tern	(21–)23(–26)	(22–)27–30(–31)	2 weeks
Common tern	21–22	(22–)25–26(–33)	2 weeks
Arctic tern	(20–)22(–24)	21–24	2 weeks
Little tern	(19–)21–22	(15–)19–20	10 days

Table 3
Plumage classes and ageing characters defined by Nisbet and Drury (1972, cited in the *Seabird Monitoring Handbook*). Data for a few retarded chicks (third chicks in common tern broods and second chicks in roseate tern) are given in parentheses. In little tern, pin feathers (primaries) erupt when the chick is between 7–8 and 12 days old (Davies 1981, Norman 1992).

Plumage class	Ageing characters	Age (days)	
		Common tern	Roseate tern
1	Newly hatched. Legs short, fat. Chin black.	0–1 (2)	0–2 (2)
2A	Legs elongated, narrow shank between foot and joint. No pin feathers on outer wing.	2–5 (6)	few data
2B	Pin feathers present on outer wing but not erupted. Black chin almost gone.	6–9 (11–12)	few data (12)
3A	Pin feathers erupted on outer wing.	8–12 (13–19)	11–13 (14)
3B	Tail feathers erupted (shaft visible), but <6 mm long (white not visible). Black feathers not visible on nape.	12–15 (13–20)	13–16
4A	Tail feathers >6 mm (white visible),but down still on tips. A few speckles of black show through down on nape when brushed.	15–18 (22–23)	15–20 (21)
4B	No down on tips of tail, but down on tail coverts. Black appearing on nape. Mantle feathered with some down tips.	17–23 (21–28)	18–22 (23)
5A	Nape black with speckles. No down on back, but a little down on tail coverts. Older birds fly when frightened.	21–25 (21–31)	20–24 (28)
5B	Fully feathered, free flying. No down except on forehead.	24 onwards	23 onwards

Common and arctic tern chicks will need to be counted separately in mixed-species colonies; see Table 4 for identification features.

Table 4
Some plumage features for distinguishing chicks of common and arctic terns (Craik 1985, cited in the *Seabird Monitoring Handbook* which gives further details).

	Common tern	Arctic tern
Underwing pattern in chicks near fledging (with well-developed juvenile plumage)	Black carpal bar.	Grey carpal bar.
Colour of dorsal down (head and body) in younger chicks	Some variation between individuals, but always some shade of brown (cinnamon-brown to 'house mouse' brown); apparently never grey.	Much more variable than common tern, from walnut-brown to silver-grey.
Pattern of spotting on upper body in small downy chicks (0–6 days)	Black spots on back are large and few.	Black spots on back are small, many, and elongated along body axis.
Colour of down on belly in younger chicks	Invariably pure white (unless wet or dirty)	Varies individually, from dark (white with a dark cast which may be intense or slight) to pure white.

2. Flush counts of adults, with single or multiple counts of large chicks

Information required

- number of Apparently Occupied Nests (AONs)
- estimated number of large chicks and fledged young.

Number and timing of visits

One visit at first fledging, usually early July (NB a population survey must be carried out earlier in the season; see *Tern populations*, above).

Time of day

Midday.

Weather constraints, Sites/areas to visit, Equipment, Safety reminders, Disturbance

As for the population survey (see *Monitoring breeding tern populations*).

Method

Estimate breeding numbers of terns from flush counts of adults (population survey Method 3). Apply the correction factor of 1.5.

Count the number of large plus fledged chicks as in productivity Method 1, above. Express results as follows: 50 large chicks and fledged young were recorded in a colony from which 300 adults had earlier been flush counted. Estimate of AONs using correction factor: 300/1.5 = 200; estimate of chicks fledged per AON = 50/200 = 0.25.

When reporting results, make it clear that the estimates are based on flush counts, as the errors are potentially high.

Only use this method to estimate productivity when time or logistical constraints prevent more accurate censusing or when the population has already been censused using a flush count.

References

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