Maritime Ireland / Wales
INTERREG 1994-1999

Roseate Terns - The Natural Connection

A conservation/research project linking Ireland and Wales

April 2000

S.F. Newton and O. Crowe
IWC-BirdWatch Ireland, Monkstown, Co. Dublin.

Maritime Ireland / Wales INTERREG Report NO.2
Measure 1.3: Protection of the Marine and Coastal Environment and Marine Emergency Planning

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Maritime (Ireland / Wales) INTERREG Programme- Building Bridges.

Maritime Ireland / Wales INTERREG
1994 – 1999

April 2000

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Maritime Ireland / Wales INTERREG Report No. 2

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Maritime (Ireland/Wales) INTERREG Programme (1994 – 1999)

The EU Maritime (Ireland / Wales) INTERREG II Programme (1994 - 1999) was established to:

1. promote the creation and development of networks of co-operation across the common maritime border.
2. assist the eligible border region of Wales and Ireland to overcome development problems which arise from its relative isolation within the European Union.

These aims are to be achieved through the upgrading of major transport and other economic linkages in a way that will benefit the constituent populations and in a manner compatible with the protection and sustainability of the environment. The Maritime INTERREG area includes the coastlines of counties Meath, Dublin, Wicklow, Wexford and Waterford on the Irish side and Gwynedd, Ceredigion, Pembrokeshire and Carmarthenshire on the Welsh side and sea area in between.

In order to achieve its strategic objectives the programme is divided into two Areas:

Sub-Programme 1: **Maritime Development:** transport, environment and related infrastructure (59 mEuro)

Sub-Programme 2: **General Economic Development:** Economic growth, tourism, culture, human resource development (24.9 mEuro)

The Marine and Coastal Environment Protection and Marine Emergency Planning Measure (1.3) has a total budget of 5.33 mEuro of which 3.395 mEuro is provided under the European Development Fund. EU aid rates are 75% (Ireland) and 50% (Wales).

The specific aims of Sub-Programme 1.3 are:

- to promote the transfer of information between the designated areas.
- to establish an in-depth profile of marine/coastal areas for conservation of habitat/species.
- to explore, survey, investigate, chart the marine resource to provide a management framework.
- to develop an integrated coastal zone management system.
- to improve marine environmental contacts and co-operation.
- to promote the sustainable development of the region.
- to improve nature conservation.

Joint Working Group

The Joint Working Group, established to oversee the implementation of Measure, consists of 5 Irish and 5 Welsh representatives.

Irish representation: Department of the Marine & Natural Resources, Department of the Environment & Local Government, Department of Transport, Energy & Communications, Local Authority and Marine Institute.

Welsh representation: National Assembly for Wales, Countryside Council for Wales, National Trust, Local Authority (Dyfed), Local Authority (Gwynedd).

This Report series is designed to provide information on the results of projects funded under Measure 1.3 Protection of the Marine & Coastal Environment and Marine Emergency Planning.

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SUMMARY

Prerequisites for successful seabird reproduction are secure nesting sites, reliable food supply and reasonable weather. In late 1996, Maritime Ireland / Wales INTERREG Programme agreed to fund a three year programme focussed on research and conservation action at Roseate Tern Sterna dougallii breeding colonies in the Irish Sea under Measure 1.3: “Protection of the Marine and Coastal Environment and Marine Emergency Planning”. All the colonies in the area were included: Rockabill, Lady’s Island Lake, the Dalkey Islands (all in Ireland) and Ynys Feurig, Skerries, Cemlyn Bay and Inland Sea (all on Anglesey in Wales). This report reviews progress at these colonies and gives more detail on the research carried out at the core breeding population at Rockabill and to a lesser extent at Lady's Island Lake. The north-west European (Republic of Ireland, U.K. and France) breeding population of Roseate Terns has slowly recovered to about 870 pairs following serious declines in the early 1970’s; between 1997 and 1999, about 70% of the population nested on Rockabill Island, off County Dublin, despite intensive conservation action at the other colonies. Between 1997 and 1999, Lady’s Island Lake in south-east Ireland was the only other viable colony, supporting around 10% of total north-west European breeding pairs, although up to four pairs nested on Anglesey (principally Ynys Feurig and occasionally Skerries). Roseate Tern productivity at Irish Sea colonies varied in the past three years between 0.90 (1997) and 1.22 (1999) fledged chicks per pair. The productivity of associated Common Terns ranged from 0.76 (1997) to 1.35 (1999), while that for associated Arctic Terns ranged from 0.64 (1997) to 1.45 (1998). During poor years, wet weather around the time of hatching, particularly in 1997 and 1998, appeared to result in high chick mortality, and in most cases adults were only able to provide food for one chick and younger siblings died. Sandeels (Ammodytes sp.) were the predominant food presented by all tern species to mates (during courtship and incubation) and to chicks. Substantial proportions of clupeids (Sprats Sprattus sprattus and occasional Herring Clupea harengus) were also delivered to tern chicks, particularly at Rockabill, and other prey seen presented included gadoids and, to a lesser extent, cephalopods and crustaceans (the latter two groups were presented to Common and Arctic Tern chicks only). In 1998 and 1999, surveys were conducted at sea over a radius of 15km from Rockabill to map the distribution of terns and identify oceanographic or biological features associated with their feeding areas. During the chick provisioning period, 98% of adult Roseate Terns ranged no further than 9.5km from the colony. In 1998 terns tended to forage in larger groups in association with other seabirds, whereas in 1999 most foraged singly or with one or two others.In both years, most foraged over relatively deep water in contrast to described behaviour in north-east America. Tern feeding observations were also carried out both from and around the Lady's Island Lake colony in both 1998 and 1999, and their movements here appeared to be more easily defined than at Rockabill, largely due to the marked physical differences between the two colonies.

On 11th April 2000, the project partners participated in a final INTERREG Irish Sea Terns Workshop (Holyhead, Wales) at which the project objectives and deliverables were reviewed and guidelines, conservation actions for future research needs were identified (Chapter 5).

PLATE 1 Rockabill Island, Co. Dublin, the largest Roseate Tern colony in northeast Europe. Most terns nest below the outer wall in the vegetated zone and on the lighter coloured rock immediately below. (IWC).

PLATE 2 Wardens and Project Managers observing the tern colony at Cemlyn Nature Reserve, Anglesey, Wales, during an exchange visit, May 1998. (S.Newton).

PLATE 3 Lamb Island, Dalkey, Co. Dublin: Nestboxes and decoy terns within the newly erected goat-proof enclosure, May 1998; note sound system and loudspeaker at foreground left. (S.Newton).

PLATE 4 Ringing and measuring a tern chick on Rockabill Island. (S.Newton).

1. PROJECT OVERVIEW

1.1 PROJECT OBJECTIVES

To strengthen the protection of the five major Roseate Tern nesting sites in the project area:

- Improve and increase wardening services;
- Upgrade warden accommodation to acceptable standards;
- Provide equipment for efficient operations, health and safety.

To extend protection to at least 2 new sites (Inland Sea, Dalkey Islands):

- Establish tenure or agreement with landowners;
- Establish warden service.

To initiate research and increase knowledge of tern conservation requirements:

- Initiate research on offshore foraging behaviour;
- Improve research on nesting and feeding;
- Continue ringing and migration studies;
- Dissemination of information by seminars and publications;
- Provide data to marine and coastal emergency response plans.

To raise public understanding of terns as indicators of a healthy environment:

- Provide information, general press releases and interpretation wherever possible, especially at Cemlyn and Dalkey.

To exchange information and skills on relevant subject areas:

- Organise regular pre- and post-season seminars for wardening staff and mid season exchange visits for site managers;
- Irish Sea Tern Conservation conference in 1998 (deferred to 30 March 2000).

1.2 ROSEATE TERN INTERREG STEERING GROUP

The overall project was overseen by a steering group comprising senior managers from the INTERREG partnership. This comprised:

Oscar Merne (Dúchas, the Heritage Service, National Parks & Wildlife Research Department)
Alastair Moralee (Royal Society for the Protection of Birds, Anglesey)
Oran O'Sullivan (BirdWatch Ireland)
John Ratcliffe (Countryside Council for Wales, Anglesey)
Dr. Norman Ratcliffe (R.S.P.B., Research Department)
Chris Wynne (North Wales Wildlife Trust)

The group met several times per year and was convened and minuted by Dr. Stephen Newton, Irish Sea Roseate Tern Research and Project Co-ordinator, who was based at IWC-BirdWatch Ireland. Minutes of each of the meetings held to date are on file and available. Additionally, regular contact was maintained by e-mail and telephone, particularly during the tern breeding season.

Pre- and post-season workshops and social gatherings have been held and were well attended by both steering group members and seasonal wardening staff. As well as discussions on successes and problems, most meetings have included visits to one or more of the local tern colonies. The team spirit built up at these events has played a large part in retaining short-term contract staff within the Irish/Welsh tern project throughout the period of INTERREG funding and many of the wardens have been employed in two or more years, often at different sites. During the 1999 breeding season we were able to bring Welsh wardens over to Ireland on four occasions and involve them directly in all conservation, research and survey operations on and around Rockabill, Europe's largest Roseate Tern colony.

1.3 SCHEDULE OF SIGNIFICANT EVENTS

17 January 1997:	*Roseate Tern INTERREG Steering Group meeting 1 (BirdWatch Ireland Headquarters).*
14 March 1997:	*Interviews held at BirdWatch Ireland for Irish Project Coordinator.*
10 April 1997:	*Dr. Stephen Newton appointed Irish Sea Roseate Tern Research Project Coordinator; commenced duty.*
12 May 1997:	*INTERREG Committee visit Cemlyn Bay, Anglesey.Roseate Tern INTERREG Steering Group meeting 2 and Project co-ordinator meets Welsh wardens (South Stack, Holyhead); visit Inland Sea.*
24 July 1997:	*Welsh team visit Dalkey and Lady's Island.*
26 August 1997:	*Rockabill wardens visit Lady's Island Lake and assist with conservation work.*
2 October 1997:	*Roseate Tern INTERREG Steering Group meeting 3 (Dun Laoghaire) & end of season wardens'gathering.*
30 April 1998:	*Roseate Tern INTERREG Steering Group meeting 4 (South Stack, Holyhead); visit Skerries.*
11 May 1998:	*Pre-season workshop/field meeting with wardens (Valley, Anglesey); visit Cemlyn Bay and Ynys Feurig.*
10-14 August 1998:	*Welsh wardens visit Rockabill, assist with conservation work and debrief with project co-ordinator at BirdWatch Ireland Headquarters.*
21-25 October 1998:	*2 Steering Group members attend International Roseate Tern Workshop, Miami, Florida.*
21 December 1998:	*Roseate Tern INTERREG Steering Group meeting 5 (CCW offices, Bangor).*
7-8 May 1999:	*Inland Sea warden assists conservation work on Rockabill.*
9-10 June 1999:	*Welsh wardens assist on Rockabill and "Terns at Sea" surveys.*
22-27 July 1999:	*Welsh wardens assist on Rockabill and "Terns at Sea" surveys.*
26 August 1999:	*Four RTISG members (2 Irish, 2 U.K.) participate in U.K Biodiversity Action Plan workshop held at JNCC HQ Peterborough.*
28 September 1999:	*Roseate Tern INTERREG Steering Group meeting 6 (South Stack, Holyhead); visit Inland Sea.*
22 December 1999:	*Joint Final Draft Report submitted to Marine Institute.*
30 March 2000:	*Irish Sea Tern Workshop, Ucheldre Centre, Holyhead, Wales.*
11 April 2000:	*Final Report with Chapter 5 (Overview & Recommendations) submitted to Marine Institute.*

2. MANAGEMENT OF IRISH SEA ROSEATE TERN COLONIES AND BREEDING SUCCESS, 1997 TO 1999

2.1 INTRODUCTION

2.1.1 The Roseate Tern Sterna dougallii

The Roseate Tern *(Sterna dougallii)* has a scattered distribution throughout the subtropical and temperate regions of the Atlantic, Pacific and Indian Oceans (del Hoyo *et al.* 1996, Gochfeld *et al*. 1998). There appears to be two distinct populations of Roseate Terns breeding in Europe; there have been no records of interchange between the population breeding in the Azores with that of north-west Europe. The north-west European colonies are concentrated predominantly around the Irish Sea, with scattered colonies also found in the western North Sea and the north coast of Brittany in France. The Roseate Tern is the rarest breeding seabird in northern Europe (Cabot 1996) and is listed in Annex I of the EU Birds Directive, in Appendix II of the Berne Convention on the Conservation of European Wildlife and Natural Habitats (1979) and in Appendix II of the Bonn Convention on the Conservation of Migratory Species of Wild Animals (1979). In late 1996, the European Union Maritime Ireland/Wales INTERREG Programme agreed to fund a three-year project aimed at research and monitoring of the Irish Sea Roseate Tern colonies on Anglesey (Wales) and Counties Dublin and Wexford (Ireland), with an emphasis on improved conservation management and enhancing our knowledge of Roseate Tern breeding and foraging ecology and metapopulation dynamics.

2.1.2 Roseate Terns in north-west Europe

The Atlantic population of Roseate Terns (from both North America and north-west Europe) was almost eliminated during the late nineteenth century as a result of the millinery trade (Cabot 1996). Since then, numbers in Ireland and Britain increased to over 3800 pairs in 1968. A substantial decline followed, and by 1972 the species had decreased by 59%. At Tern Island in County Wexford, the stronghold of the north-west European population at that time, the Roseate Tern breeding population had declined by 73% to 1467 pairs (Cabot 1996). The population further declined to its lowest level of 561 pairs in 1987. It was suspected that this decline was largely the result of trapping at their West African wintering grounds (Cabot 1996), and not due to the loss of Tern Island to coastal erosion in 1977/8. However, despite efforts to quantify the extent of trapping during the mid 1980's, there is insufficient evidence to judge the impact of this practice on the metapopulation. Subsequently, the Roseate Tern breeding population has been slowly but steadily increasing since 1987.

2.1.3 Irish Sea Roseate Tern breeding colonies

There are currently two extant colonies on the east coast of Ireland: Rockabill and Lady's Island Lake, and three formerly important colonies in Wales, all on Anglesey, which are presently irregularly occupied: Ynys Feurig, Cemlyn Bay and Skerries (Fig. 2.1). Over the past decade these Irish Sea colonies combined have supported up to 80% of the north-west European breeding population of Roseate Terns. Two other Irish Sea Tern colonies were included in this project as potential Roseate Tern restoration sites: the Dalkey Islands, in south Dublin, and the Inland Sea on Anglesey (Fig. 2.1).

Since 1986, **Rockabill Island** has been the stronghold for breeding Roseate Terns in NW Europe. In 1988, Rockabill was designated a Special Protection Area (SPA) under the EU Birds Directive, and a Statutory Refuge for Fauna under the 1976 Wildlife Act. The Roseate Tern breeding population has received full-time wardening and monitoring there since 1989. Rockabill is a small island (0.9ha) situated 7km off the coast of north County Dublin (grid ref. O320627), east-north-east of the coastal town of Skerries. It consists of two small granite islets separated by a narrow channel. The Lighthouse Island (the larger of the two islets) lies to the south, and in the past has contained the majority of breeding Roseate and Common Terns *(S. hirundo)*, while the other islet, the Bill, has held the majority of the Arctic Terns *(S. paradisaea)*. Rockabill also holds a relatively small colony of breeding Kittiwakes *(Rissa tridactyla)*, a regionally important colony of Black Guillemots *(Cepphus grylle)* and historically held breeding Sandwich Terns *(S. sandvicensis)*.

Lady's Island Lake in recent years has also held a substantial proportion of the NWEuropean population of breeding Roseate Terns (generally between 50 and 140 pairs). It is the last intact back-barrier seepage lagoon in Ireland, situated 3km west of Carnsore Point, County Wexford (grid ref. T101067). The lake is separated from the sea by a 200m wide sandy gravel barrier. It contains two islands, Inish and Sgarbheen,

which form a Refuge for Fauna under the Wildlife Act (1976) and a SPA under the EU Birds Directive and the overall lake area is a proposed candidate Special Area of Conservation under the EU Habitats Directive. The lake itself also forms another SPA. Lady's Island Lake (predominantly Inish) also supports over 1000 pairs of Sandwich Terns *(S. sandvicensis)*, 400 to 500 pairs of Common and Arctic Terns and in excess of 500 pairs of Black-headed Gulls *(Larus ridibundus)*.

The **Dalkey Islands** are separated from the mainland by a deep channel just under 500 metres in width. They comprise a large island, Dalkey Island and three small islets, Lamb Island, Muglins Island and Maiden Rock. Lamb Island lies to the north-west of Dalkey Island and the two are connected at low tide; Muglins supports a small automatic lighthouse and is situated some distance to the east of Lamb Island, while Maiden Rock is the northern-most islet. Traditionally, Maiden Rock has held the majority of the breeding Common Terns and Arctic Terns. Two pairs of Roseate Terns attempted to nest at Lamb Island in 1986 (Coombes 1989). However, their nests were washed out, and they have not been recorded as breeding there since. Maiden Rock (grid ref. O272270) is a bare angular granite islet with no vegetation cover. It is less than seven metres high and is occasionally washed over by the sea. Maiden Rock is an important post-breeding roost site for large numbers of terns, including Roseate, and is a proposed Natural Heritage Area and proposed SPA. Lamb Island (grid ref. O276267) is higher and more protected from the sea than Maiden Rock, and comprises a relatively large flat vegetated surface at its summit. This island is deemed a more suitable location for nesting terns, but access from Dalkey Island means it receives more human disturbance and Brown Rats *(Rattus norvegicus)*, Rabbits *(Oryctlagus cuniculus)* and Feral Goats *(Capra hircus)* are regular visitors.

While the three principal Welsh colonies, Ynys Feurig, Cemlyn Bay and Skerries continue to support breeding Common, Arctic and Sandwich Terns, they have supported relatively few breeding pairs of Roseate Tern since the early 1990's. Formerly one or other supported substantial numbers, and it was anticipated at the outset of this project that continued wardening and other conservation action might encourage future breeding there.

Cemlyn Nature Reserve is situated on the north-west coast of Anglesey, approximately 2.5km west of Wylfa nuclear power station, within the parish of Llanfairynghornwy (grid ref. SH330933). In 1958 it was designated a Site of Special Scientific Interest (SSSI) and is currently part of the Heritage Coast and the North Anglesey Tern Colonies SPA, designated 10/6/92 under the EU Birds Directive. Cemlyn Nature Reserve comprises 25.2 ha of mixed habitat and includes a lagoon bordered by scrub and a shingle bar which separates the lagoon from the bay. It holds the only breeding population of Sandwich Terns in Wales, and also supports breeding Common and Arctic Terns and Black-headed Gulls. Small numbers of Roseate Terns also occasionally breed at Cemlyn.

The **Inland Sea** is an enclosed intertidal lagoon lying between Four Mile Bridge at the south end and the Stanley Embankment about 2.5km to the north which, together with the Cymyran Strait, divides Holy Island from Anglesey (central grid ref. SH2779). It includes three rocky islets and a large shingle spit in the north-west corner which at one time supported over 600 breeding pairs of terns (including Roseate Terns). Currently, the Inland Sea supports around 20 to 30 pairs of Common and Arctic Terns, and up to 50 pairs of Black-headed Gulls. The Beddmanarch-Cymyran SSSI, which includes the Inland Sea, was first designated as a SSSI in 1961 and has been wardened since 1997.

Ynys Feurig comprises three inter-connected inshore rocky islets (3.1 ha) off the west coast of Anglesey close to the village of Rhosneigr and south of Valley Airfield (grid ref. SH304735). They are accessible from the mainland at mid to low tide, and have historically been the most important tern colony in north-west Wales, with Roseate, Common and Arctic Terns nesting alongside one another. The site is an SSSI and is part of the North Anglesey Tern Colonies SPA.

The **Skerries** are a group of islands three km off Carmel Head, the north-west corner of Anglesey (grid ref. SH268948) totalling 17 ha. The islands are accessible from one another at low tide and by small bridges and a large, nowadays un-manned, lighthouse is present. They support a large nationally important Arctic Tern colony, a locally important Common Tern colony, substantial Herring *(Larus argentatus)* and Lesser Black-backed *(L. fuscus)* Gull colonies and a locally important Puffin *(Fratercula arctica)* colony. The site is an SSSI and is part of the North Anglesey Tern Colonies SPA.

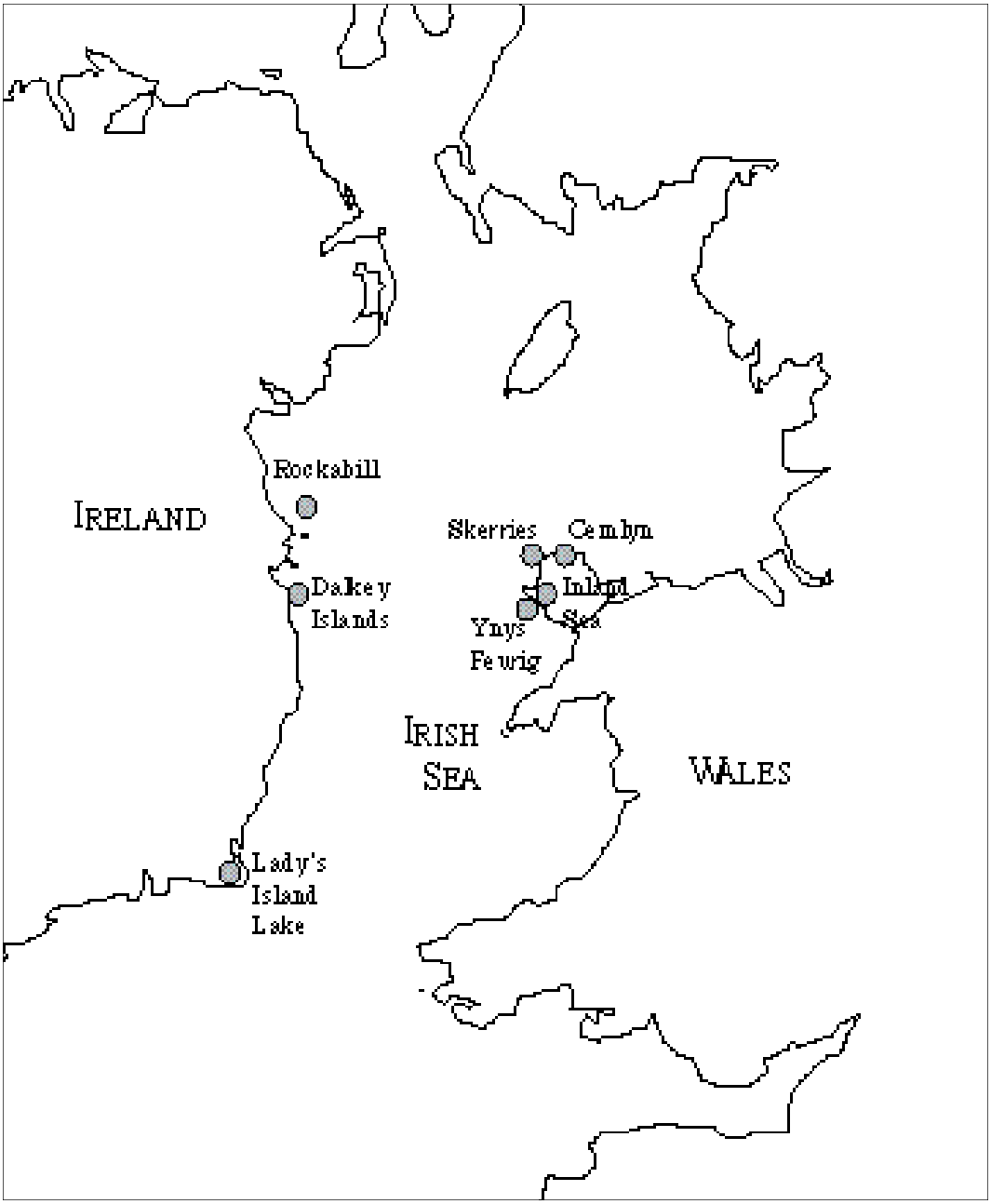


FIGURE 2.1. Tern colonies included in the study and mentioned in the text.

2.1.4 Roseate Tern nest site selection

Adequate habitat and food availability are of fundamental importance to breeding seabirds given the long period of time between courtship and chick fledging relative to most other bird groups. The Roseate Tern is a relatively timid species, and nests in mixed-species colonies, generally among more aggressive species (Gochfeld 1983). In Europe, this species usually breeds alongside other terns (Avery *et al*. 1995), most frequently with Common Terns (Ramos and del Nevo 1995, Casey *et al*. 1995). However, Roseate Terns are broadly exclusive in their selection of nesting habitat, generally preferring sites surrounded by walls and rocks or within vegetation (Burger and Gochfeld 1988, Ramos and del Nevo 1995), and thereby minimise competition for nest sites with the other species. As with most seabirds, Roseate Terns also exhibit site philopatry to varying degrees depending on the particular race and/or colony (Gochfeld *et al*. 1998).

2.2 METHODS

2.2.1 Conservation measures

Habitat management

At the beginning of the season vegetation was managed to create more suitable nesting habitat for Roseate Terns. Scurvy Grass *(Cochlearia officinalis)* and dead Tree Mallow *(Lavatera arborea)* were removed and dense stands of the latter were thinned at Rockabill, Skerries and Ynys Feurig, while some Tree Mallow was transplanted into other less vegetated regions. At Rockabill, flooded hollows were infilled with rubble and soil to prevent flooding. Additionally, several terraces were constructed to stabilise steep-sloping areas.

At Lady's Island Lake, daily water levels were recorded on the Office of Public Works staff gauge. Also at Lady's Island Lake, slates were laid down on top of fast growing vegetation to define a path of "stepping stones" from the waters edge to the main hides on the south end of Inish island. In early spring 1998, a goat-proof fenced enclosure was erected on the upper plateau on Lamb Island, Dalkey to enhance vegetation cover.

At the onset of the 1998 season at Inland Sea, 60 sand-bags were placed around low areas of the North Island to prevent flooding. That season, water levels rose to heights that would have flooded the island had the sand bags not been in place.

Artificial nest sites

Nest boxes (mostly a combination of "three-sided" and "three and a half-sided", with occasional unorthodox structures) were distributed throughout the colonies to create additional nesting sites for Roseate Terns in more open areas and shelters (from weather and predators) for chicks. Tyres were also deployed at Lady's Island Lake and provided useful nest sites for Roseate Terns and chick shelters for Roseate and other tern species.

Tape lures and other decoys

Sound recordings of Roseate Tern calls were played during daylight hours using tape-cassette recorders powered by car batteries at Dalkey (Lamb Island) in 1998 and 1999, and Skerries and Ynys Feurig in 1999 in an attempt to attract Roseate Terns to settle in these colonies. This method has been used successfully in north-eastern USA (Kress 1983). At Dalkey, calls were continuously played on a loop tape early in the season, from arrival through to early chick stages, while at Skerries and Ynys Feurig, calls were set to a timer, and played daily (set to play for 10 minutes every half hour at Skerries and 1.5 minutes every 3 minutes at Ynys Feurig) from late May/ early June through to early August.

Additionally, plastic Roseate Tern decoys (11 in 1998 and 15 in 1999) were placed on Lamb Island within the fenced enclosure and left in place for the duration of the season.

Disturbance

Mammalian and avian predators were monitored at all Irish Sea colonies throughout each season and were discouraged from entering the colony. Nesting attempts by large gulls were also deterred. Pre-season rat baiting was carried out at some colonies where Brown Rats were present in large numbers.

At all sites, helicopter disturbances, whether they be due to landing or low-flying were recorded and adverse effects (such as duration of tern dreads) were noted.

Several colonies, particularly those close to mainland and accessible to the public (eg. Cemlyn and Inland Sea), were extensively monitored for egg-collectors. At such colonies, members of the public were informed of the breeding colonies and were persuaded to keep their dogs on a leash. All boat and sailboard movements around colonies were monitored, especially those close to mainland, which were susceptible to disturbance of this nature (such as Lady's Island Lake and Inland Sea). Signs were placed at entrances to and around most colonies (on piers etc.) to minimise public access when wardens were otherwise occupied. General movement around the colonies by wardens and other personnel were restricted in wet or hot weather, or in strong winds, and any time spent in an individual section of the colony was kept to a minimum.

2.2.2 Survival and mate/site fidelity

Ratios of ringed to unringed Roseate Terns

Tern chicks, predominantly Roseate Terns, have been fitted with British Trust for Ornithology (BTO) rings at several Irish Sea colonies (such as Rockabill, Lady's Island Lake and Skerries) for a large number of years. Between 1985 and 1990, darvic rings were also fitted to Roseate Tern chicks. Since 1992, in addition to the BTO rings, Roseate Terns have been fitted with Roseate special rings which are more easy to read in the field. The ratios of ringed to unringed adult Roseate Terns and of the various ring combinations (BTO, Roseate special and / or darvic rings) were assessed at Rockabill throughout each season between 1997 and 1999 using binoculars and telescopes. Counts were conducted on Roseate Terns loafing in club sites using a minimum sample of 20 individuals during any one count.

Ring origins

Between 1990 and 1999 large numbers of rings on Roseate Terns at Rockabill have been read with a telescope. The success of ring resighting at this colony also lead to similar work being initiated at Lady's Island Lake (1993, 1996-1999) and Coquet Island (1995-1999). This information contributes to an ongoing study on the demography of the species. Ring reading of Roseate Terns at Rockabill, Lady's Island Lake and also at Ynys Feurig between 1997 and 1999 allowed identification of several nest pairs, particularly from the study areas, which ultimately leads to improved information on site and mate fidelity within the species. Later in the season, rings of chicks were read throughout the colony to allow estimation of fledging success, and assess pre-migratory staging of juveniles from other colonies.

Ring reading was mostly carried out from hides overlooking the study areas. Rings were read using telescopes with zoom eye-pieces. At Rockabill, a mobile hide was also used in the colony, but no more than 10 minutes was spent in a particular section if terns did not settle. Also at Rockabill towards the end of the season, when the terns were more habituated to human presence, ring reading was occasionally carried out around the colony without the mobile hide. This permitted ring-reading coverage of areas that were otherwise inaccessible.

At Rockabill, Roseate Tern adults were trapped on their nests during late incubation using a remote control cage trap (70 x 70 x 60 cm) with a sliding door. Only birds on nests clearly visible from hides were trapped, and attempts at trapping nests where adults did not return within 10 minutes of placing the trap over it were abandoned. Unringed Roseate Terns were targeted, predominantly from study areas. All were fitted with BTO and / or Roseate special rings where required, and weight and body-size/plumage measures (biometrics) were taken.

2.2.3 Nest censuses

Generally two to three thorough censuses of tern nests were carried out at all colonies, using standard clutch count methods (see annual colony reports). All nest boxes were thoroughly checked and their contents noted, and open nests were marked in a variety of ways (numbered clothes pegs at Rockabill, numbered stones at Inland Sea). Again, any time spent in a particular section of the colony was kept to a minimum, and only under suitable weather conditions. At Rockabill, Arctic Tern nests on the Bill were marked with numbered concrete pies, placed as close to the nest as possible, while remaining visible with a telescope from the Lighthouse Island. This exercise permitted differentiation between Arctic and Common Tern nests since their eggs are similar. Also at Rockabill, for consistency, only nests found up to and including 34 days after the first eggs were laid were considered as primary nests, and included in final nest tallies (see Crowe *et al*. 1998 for further explanation). At Lady's Island Lake and Cemlyn, parallel rope-lines were used to assist in conducting a systematic count. Sandwich Tern nests at Cemlyn were counted from viewpoints as their nests were densely packed, and it was considered that there was too much of a risk of egg breakage to attempt to carry out parallel rope techniques. At Ynys Feurig and Skerries, clutch counts were carried out, although only a selection of study nests were actually marked. The numbers and mean clutch sizes of Common and Arctic Tern nests presented in the "Results" section of this report were pooled (proportions of Common Tern were presented where defined) given the difficulty in distinguishing the two species in terms of eggs and young chicks.

2.2.4 Nest parameters and productivity

Study area nests

Nests in areas visible from hides were allocated to study areas at all colonies other than Cemlyn Bay and Inland Sea. These study areas were used predominantly for tern chick provision assessment. However, at Rockabill in 1998 and 1999, Roseate Tern nests within the study areas were monitored daily from the beginning of the season; this permitted assessment of nest parameters such as first egg dates, laying and hatching dates and intervals and incubation periods of first (A-) and second (B-) eggs from Roseate Tern nests. Lay-dates were approximated for other Roseate Tern eggs using a combination of wing measurements of known-age enclosure-raised Roseate Tern chicks and mean incubation period of enclosure nests; other Roseate Tern chicks were aged using the standard wing length / age plot derived from known-age chicks and the mean incubation period was subsequently subtracted.

Enclosures and tern productivity

Enclosures were constructed within the study areas at Lady's Island Lake, Rockabill and Cemlyn using bricks, slates, timber, wire-mesh and cement. Enclosure walls were at least 20 centimetres high, and their main purpose was to enclose small chicks once they had hatched and prevent long-distance movements which would confound productivity monitoring. Nests within enclosures were monitored daily as above, and once hatched, chicks were followed until they had fledged. Up to 20% of Roseate Tern nests were contained within enclosures at Rockabill and Lady's Island Lake, and it was assumed that they formed a representative sample of the colony as a whole. Productivity was expressed as the number of chicks fledged per egg-laying pair. At other sites, a selection of study area nests was monitored closely, either through visits or using a telescope, and productivity was estimated accordingly. Productivity at Lady's Island Lake was based largely on a combination of nest census data, chick biometrics and fledgling ring-reading.

Mark-recapture assessment

A mark-recapture assessment for population size was conducted at Rockabill in each year from 1997 to 1999, in two of the enclosures (containing both Common and Roseate Terns) of dense vegetation where chicks proved relatively difficult to follow. This consisted of an initial systematic search of the enclosure when the majority of chicks were still relatively small, where all chicks were ringed. A second search was conducted less than 24 hours later, where all ringed and unringed chicks were recorded. The Peterson estimate, for each species, for each enclosure, was calculated (see Ratcliffe and del Nevo 1995). Only nests which had hatched chicks viable for ringing on the day of the mark-recapture assessment were included in the analyses, and it was assumed that all small chicks ringed and included in the estimates would survive to fledge. The results of this assessment in the two sections are pooled for each species and compared with productivity based on continual monitoring of nests.

2.3 RESULTS

2.3.1 Conservation management

Predation and disturbance

Great and Lesser Black-backed and Herring Gulls persisted around tern colonies throughout the season during all years, and attempted to nest at several colonies. These three species were seen taking tern eggs and chicks on several occasions. It was considered that these large gulls had relatively little negative impact on tern success. However, at Skerries in 1997, 172 juvenile terns were taken by gulls, predominantly Great Black-backed Gulls.

The following raptor species were also sighted at times at Irish Sea tern colonies between 1997 and 1999: Sparrowhawk *(Accipiter nisus)*, Kestrel *(Falco tinnunculus)* and Peregrine *(F. peregrinus)*. These species generally caused prolonged dreads, and on several occasions were also seen taking tern juveniles, and the occasional adult tern. However, at Lady's Island Lake in 1999 a Peregrine persisted around the colony, and at least six adult Roseate Terns were taken. Marsh Harriers *(Circus aeruginosus)*, Buzzards *(Buteo buteo)* and Merlins *(F. columbarius)* were also sighted and although they caused tern dreads, no predation was suspected.

Additionally, Oystercatchers *(Haematopus ostralegus)*, and Turnstones *(Arenaria interpres)* may have taken some tern eggs, although predation by these species was never actually witnessed. Occasionally, Jackdaws *(Corvus monedula)* and Hooded Crows *(C. corone)* also predated tern eggs. Again the relative impact of these species was minimal.

An attempt was made to drain Lady's Island Lake during summer 1998 by Gardaí, as part of a missing person search. The lake level was substantially reduced and a landbridge was formed between the mainland and Sgarbheen. As a result, Red Foxes were responsible for the destruction of all Common and Arctic Tern nests on this island. On the other island, Inish, Brown Rats predated at least 18 juvenile terns (eight Roseate Terns) and two adult terns (one Roseate Tern). Stoats were thought to have predated a number of Black-headed Gull chicks at Cemlyn in 1998.

In general, all of the Irish Sea tern colonies were visited by the public at times. As a result of efficient wardening, there were no major disturbances to the colonies. At colonies close to the mainland, particularly Cemlyn, Dalkey and Lady's Island Lake, promotion of the project raised much interest from the public, with guided walks, telescope viewing and leaflet distribution undertaken.

Disturbance by helicopters was relatively minimal overall. Skerries and Rockabill received the most disturbance of this nature, and it was generally due to the arrival and departure of lighthouse staff. In all cases, the terns appeared to be relatively habituated to helicopters, and dreads were short.

Tape lures

Tape lures appeared to illicit some positive Roseate Tern response at both Skerries and Ynys Feurig. At Skerries, Roseate Terns were seen apparently calling to and flying around the sound system, and one individual was seen displaying with fish to Arctic Terns in close proximity to the speakers. At Ynys Feurig, one pair of Roseate Terns started nesting within 30 metres of the sound system. The effect of the tape recordings at Dalkey was less easy to monitor, given wardens were not resident on the island and the distance from an observation point on the mainland. However, no Roseate Terns were encouraged to nest in the two years the experiment was conducted at Dalkey; however in the first year all the Arctic and Common Terns appeared to settle on Lamb Island, close to the sound system, after a mass nesting failure on Maiden Rock. In most other recent years only a very small number of Arctic Terns have ever bred on this island.

2.3.2 Ring-reading and fidelity

Ring ratios

At Rockabill between 1997 and 1999, the proportion of adult Roseate Terns fitted with both BTO and Roseate special rings increased from 32% to 40%, while there was a consequent decrease in the proportion of unringed Roseate Terns (Table 2.1).

Table 2.1. Percentage of Roseate Terns carrying BTO, Roseate special and darvic rings.

Ring type	1997	1998	1999
BTO only	24.1	24.5	22.1
BTO & Roseate special	31.8	33.5	39.7
BTO & darvic	3.7	2.7	1.4
Roseate special only	2.3	3.2	1.8
No ring	38.0	36.2	34.6
Sample size	**726**	**530**	**712**

Age distribution and natal sites of Roseate Tern adults

In total, 1427 Roseate Tern adults were identified by their rings between 1997 and 1999 at Irish Sea colonies, principally at Rockabill and Lady's Island Lake. The origins of 92 Roseate Terns (6.45%) still remain unknown due to limited ring information. All Roseate Terns identified were originally ringed as chicks in Ireland, the UK or France. While the large majority (89.14%) of Roseate Terns originated at either Rockabill or Lady's Island Lake, there were also sightings of birds that originated at Welsh colonies, principally Ynys Feurig, and also at Coquet Island on the north-east coast of England (Table 2.2), which holds the largest breeding population in the North Sea (35 pairs in 1999, N. Ratcliffe pers. comm.).

Table 2.2. Natal site for Roseate Terns sighted at Rockabill and Lady's Island Lake between 1997 and 1999 and at Irish Sea colonies overall.

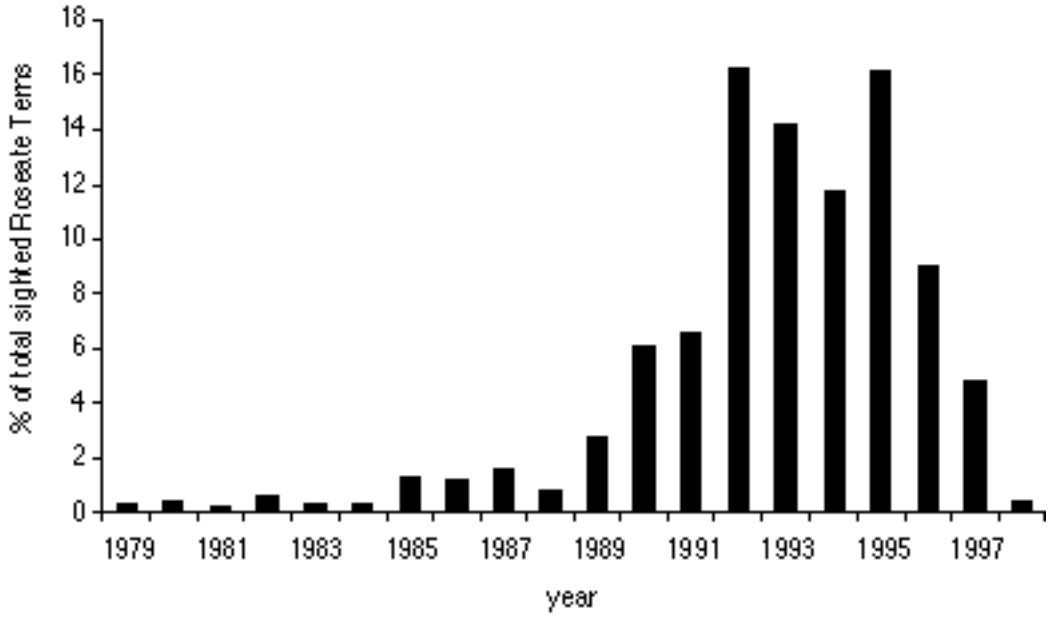
	Rockabill						Lady's Island						Irish Sea	
	1997		1998		1999		1997		1998		1999		1997-1999	
	#	%	#	%	#	%	#	%	#	%	#	%	#	%
Rockabill (I)	540	87.10	749	88.12	705	89.35	15	45.45	14	41.10	25	45.50	1193	83.60
Lady's Island Lake (I)	26	4.19	33	3.88	35	4.44	13	39.39	18	52.90	24	43.60	79	5.54
Swan Island (NI)	2	0.32	2	0.24	1	0.13	-	-	-	-	-	-	3	0.21
Black Rock (NI)	-	-	-	-	1	0.13	-	-	-	-	-	-	1	0.07
Jackdaw Island (NI)	-	-	-	-	1	0.13	-	-	-	-	-	-	1	0.07
Carlingford Lough (NI)	-	-	1	0.12	-	-	-	-	-	-	-	-	1	0.07
Ynys Feurig (W)	15	2.42	16	1.88	16	2.03	4	12.12	1	2.90	1	1.80	32	2.24
Cemlyn (W)	-	-	2	0.24	2	0.25	-	-	-	-	-	-	2	0.14
Skerries (W)	1	0.16	-	-	-	-	-	-	-	-	-	-	1	0.07
Coquet (E)	4	0.65	9	1.06	7	0.89	-	-	-	-	-	-	18	1.26
Long Craig (S)	2	0.32	1	0.12	1	0.13	-	-	-	-	-	-	3	0.21
Isle aux Dames (F)	-	-	1	0.12	1	0.13	-	-	-	-	-	-	1	0.07
Unknown	30	4.84	36	4.24	19	2.41	1	3.03	-	-	5	9.10	92	6.45
Total	**620**		**850**		**789**		**33**		**34**	**-**	**55**	**-**	**1427**	**-**

I = Republic of Ireland, NI = Northern Ireland, W = Wales, E = England, S = Scotland, F = France; # = number.

Additionally, one Roseate Tern that was originally ringed as a chick at Isle aux Dames in France in 1993 has been consistently returning to Rockabill since 1995. This bird was confirmed as breeding in 1998, but was unsuccessful in 1999. In 1999 at Rockabill, there were also sightings of two Roseate Terns that were originally ringed as chicks at Bird Island, Massachusetts, USA and Great Gull Island, New York, USA, both five year old birds. Unfortunately, as each bird was only recorded once and the national rings were not recorded, definite confirmation of these trans-Atlantic movements was not feasible.

The oldest Roseate Terns recorded at Irish Sea colonies between 1997 and 1999 were ringed as chicks in 1979 (Fig. 2.2) in Wales (Ynys Feurig) and Northern Ireland (Swan Island in Larne Lough). Overall, the 1992 and 1995 cohorts were in greatest abundance, and each comprised 16% of total sightings (Fig. 2.2).

FIGURE 2.2. Year of birth for Roseate Tern adults sighted between 1997 and 1999 at Irish Sea colonies (note that more easily field-readable Roseate special rings were first used in 1992- see section 2.2.2 for details).



In all three seasons (1997-1999) at Rockabill, the abundance of both the 1992 and 1993 Roseate Tern cohorts was relatively high. However, in 1998 and 1999, the 1995 cohort was in greatest abundance (20.5 and 17.4% of total sightings respectively) (Table 2.3). The 1995 cohort was also in greatest abundance at Lady's Island Lake in 1997 (Table 2.3). However, in 1998 and 1999, very few members of this cohort were sighted, and both the 1993 and 1996 cohorts dominated at Lady's Island Lake (Table 2.3).

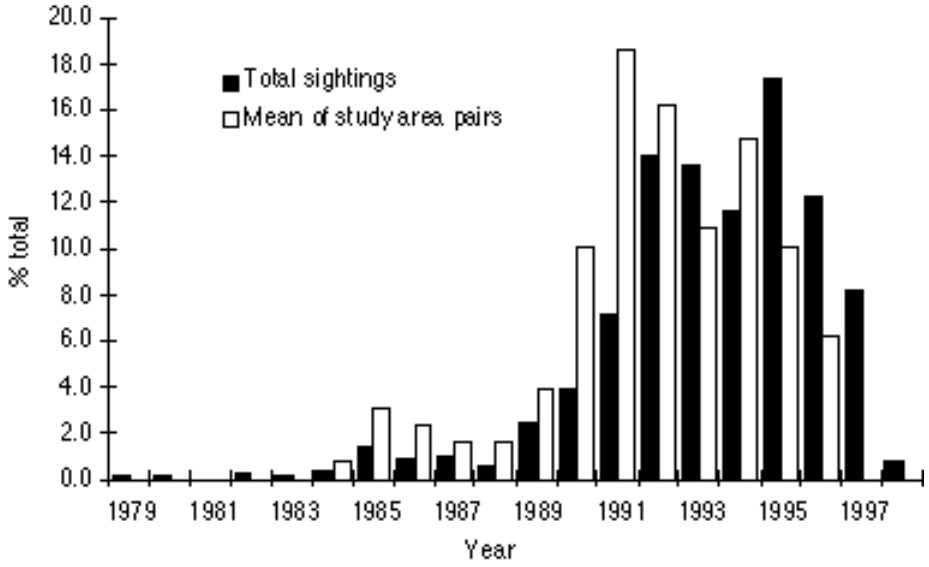
It was assumed that the sample of Roseate Terns resighted in each year was approximately representative of the breeding population. However, most rings were read when birds were loafing in open area club sites not by their nests. A comparison of total resightings with known study area birds at Rockabill in 1999 was conducted. Based on the mean age of 129 study area pairs at Rockabill in 1999 (83 of which had one unringed member), the greatest proportion of breeding Roseate Terns was ringed as chicks in 1991 (Fig. 2.3). Members within pairs were generally of similar age (89% were within two years of one another). In contrast, the 1995 cohort comprised the large majority of resighted birds overall in 1999. This result suggests that some younger, and probably non-breeding, Roseate Terns were identified, and the age distribution of total ring-reads may not be entirely representative of the actual proportions of Roseate Terns breeding. However, observations in the study areas are strongly biased towards pairs nesting in open areas, generally in boxes, which typically comprise older and more experienced breeders.

Table 2.3. Year of hatching of Roseate Terns sighted at Rockabill and Lady's Island Lake between 1997 and 1999.

	Rockabill						Lady's Island					
	1997		1998		1999		1997		1998		1999	
	#	%	#	%	#	%	#	%	#	%	#	%
1979	3	0.48	1	0.12	1	0.13	-	-	-	-	-	-
1980	4	0.64	1	0.12	1	0.13	-	-	-	-	1	1.82
1981	3	0.48	1	0.12	-	-	-	-	-	-	-	-
1982	2	0.32	5	0.58	2	0.25	2	6.67	-	-	-	-
1983	3	0.48	4	0.46	1	0.13	-	-	-	-	-	-
1984	3	0.48	4	0.46	3	0.38	-	-	-	-	-	-
1985	6	0.96	10	1.17	11	1.39	1	3.33	2	5.88	-	-
1986	8	1.29	11	1.28	7	0.89	1	3.33	-	-	-	-
1987	9	1.45	12	1.39	8	1.14	-	-	-	-	-	-
1988	7	1.13	7	0.81	5	0.63	1	3.33	1	2.94	-	-
1989	15	2.41	28	3.25	20	2.53	3	1.00	3	8.82	1	1.82
1990	39	6.28	55	6.39	31	3.93	4	13.33	3	8.82	4	7.27
1991	37	5.95	63	7.39	57	7.22	1	3.33	2	5.88	2	3.64
1992	154	24.76	149	17.29	111	14.68	2	6.67	1	2.94	1	1.82
1993	115	18.49	131	15.20	107	13.56	9	3.00	8	23.53	10	18.18
1994	93	14.95	115	13.34	92	11.66	1	3.33	1	2.94	6	2.00
1995	81	13.23	177	20.53	137	17.36	5	16.67	7	2.59	9	16.36
1996	7	1.13	49	5.68	97	12.29	-	-	6	17.65	15	27.27
1997	-	-	-	-	65	8.24	-	-	-	-	1	1.82
1998	-	-	-	-	6	0.76	-	-	-	-	-	-
Unknown	33	5.35	39	4.52	27	3.42	-	-	-	-	5	10.00
Total	**622**	-	**862**	-	**789**	-	**30**	-	**34**	-	**55**	-

It was assumed that the sample of Roseate Terns resighted in each year was approximately representative of the breeding population. However, most rings were read when birds were loafing in open area club sites not by their nests. A comparison of total resightings with known study area birds at Rockabill in 1999 was conducted. Based on the mean age of 129 study area pairs at Rockabill in 1999 (83 of which had one unringed member), the greatest proportion of breeding Roseate Terns was ringed as chicks in 1991 (Fig. 2.3). Members within pairs were generally of similar age (89% were within two years of one another). In contrast, the 1995 cohort comprised the large majority of resighted birds overall in 1999. This result suggests that some younger, and probably non-breeding, Roseate Terns were identified, and the age distribution of total ring-reads may not be entirely representative of the actual proportions of Roseate Terns breeding. However, observations in the study areas are strongly biased towards pairs nesting in open areas, generally in boxes, which typically comprise older and more experienced breeders.

FIGURE 2.3. Percentage of (a) total ring-reads and (b) study area pairs from different cohorts of Roseate Terns at Rockabill in 1999.



In 1999, it was suspected that a proportion of second-year Roseate Terns was actually breeding at Rockabill, since quite a few birds were seen towards the end of the season with bills at least one quarter red-coloured, and one was seen escorting a young chick. Additionally six first-year Roseate Terns were seen loafing in club sites at Rockabill in 1999, three of which were ringed at Rockabill and three at Lady's Island Lake the previous year.

Roseate Tern survival rates

The analysis of resightings indicated that most young adults arrived at the colony at 1-4 years old, with an average arrival age of around 2 years at Rockabill, Lady's Island Lake and Coquet. Annual survival of adults averaged 78.7% on Rockabill overall, but survival was lower in age classes over 10 years old. This was likely to be the product of senescence or ring corrosion in old birds. Truncating the data at 10 years old produced a survival rate of 80.5%. On Coquet, survival was lower at 76.0% but not significantly so, whereas Lady's Island had significantly higher survival rates than the other two colonies at 85.2%. Juvenile survival rate at Rockabill was estimated at 49.7% and this was far more variable than adult survival (13% compared to 1%). This was probably due to annual variability in survival of different cohorts.

Natal fidelity and dispersal

The ring resightings of adult birds at Rockabill, Lady's Island Lake and Coquet have located birds ringed as chicks from most of the colonies around Britain, Ireland and France, suggesting that the colonies in NW Europe comprise a metapopulation. Coefficients of recruitment were estimated, to determine the likelihood of a bird from a given colony appearing at the focal colony, corrected for the number ringed in the cohort and its age (to allow for losses due to mortality).

Recruitment coefficients were primarily affected by the minimum at-sea distance between colonies. Colonies within the Irish Sea had very high coefficients of recruitment to Rockabill, which suggests that

Rockabill is attracting recruiting birds and breeding adults away from other colonies. This explains the decline of the Northern Ireland and Anglesey colonies. The only colony in the Irish Sea with a low recruitment coefficient to Rockabill was Wexford Harbour, a large colony subject to high ringing effort before it was washed away in the 1970s. Birds from there are less likely to have been seen at Rockabill than expected from the number ringed and constant survival rate, but this is likely to be due to senescence or ring loss as these birds would have been 15-20 years old during the resighting project. Chicks ringed at colonies in the North Sea had low recruitment coefficients to Rockabill and resightings at Coquet Island confirm that movements among the Irish Sea and North Sea are relatively rare.

Recruitment coefficients to Lady's Island Lake from other colonies in the Irish Sea were lower compared to Rockabill, even allowing for its greater distance from them. The recruitment coefficient from Rockabill to Lady's Island Lake was seven times lower than movements in the reverse direction. This suggests the colony at Lady's Island Lake is less attractive to recruiting birds than the large, rapidly growing, colony at Rockabill.

Mate and site fidelity at Rockabill

There appeared to be some degree of both mate and site fidelity among Roseate Terns. At Rockabill, 13 out of 22 Roseate Tern pairs identified in one of the study areas in 1997, returned in 1999. Additionally, three individuals that returned to breeding sites in the 4A study area in 1999 were identified as breeding at these sites in 1997 but were not seen at all in 1998.

Out of 139 pairs of Roseate Terns identified in study areas in 1998, 80 were recorded in 1999 where at least one member was present. Pairs which contained one unringed bird were included in the assessment and thus preclude definite conclusions on the extent of mate fidelity. Of these 80 pairs, 57 pair bonds (71%) apparently remained intact, 25 of which returned to the exact nest site used in 1998 and a further 25 of which returned to within 5 metres of the nest site used in 1998. Three pairs bred in the same general area as 1998, while two pairs moved to different areas of the colony and the breeding sites of two other pairs were not located.

Overall, 23 pairs from 1998 were not together in 1999. Of these 1998 pairs, nine individuals were not seen at all, which included six females, one male and two of unknown sex (one of which was found dead in 1998). Seven individuals were unringed in 1998 and their fate in 1999 is thus unknown. There were two instances where both members of pairs which divorced nested within five metres of their 1998 sites but with different partners. Finally, there were five pairs where both members were identified. In three out of four of these pairs, the male retained the 1998 nest site (or nested in close proximity), and the females moved (one female moved from a nest site in the 4B enclosure in 1998 to one in 6S in 1999). Neither member of the fifth pair was seen near its 1998 nest site in 1999.

Ringing

At most colonies, the numbers of Roseate, Common and Arctic Tern chicks ringed increased between years, and numbers ringed in 1999 were considerably greater than in previous years (Table 2.4).

Table 2.4. Total numbers of tern chicks ringed at Irish Sea colonies between 1997 and 1999.

At Rockabill between 1997 and 1999, 31 adult Roseate Terns were trapped, 20 of which required fitting of both BTO and Roseate special rings, and a further 10 retraps which required Roseate special rings only.

	Roseate Tern			Common Tern			Arctic Tern			Sandwich Tern		
	1997	1998	1999	1997	1998	1999	1997	1998	1999	1997	1998	1999
Rockabill	494	543	895	349	455	1059	18	23	98	0	0	0
Lady's Island Lake	52	101	107	80	95	109	76	28	63	702	708	412
Dalkey	0	0	0	0	5	23	0	3	14	0	0	0
Ynys Feurig	2	1	2	52	129	164	114	182	190	0	0	0
Total	**548**	**645**	**1004**	**481**	**684**	**1355**	**208**	**236**	**365**	**702**	**708**	**412**

2.3.3 Nest census and parameters

Nest census

Although nest boxes were placed at all Irish Sea colonies over the three seasons, they were only used by Roseate Terns as nest sites and therefore only at the four colonies where Roseate Terns nested; Rockabill, Lady's Island Lake, Ynys Feurig and Skerries (Table 2.5). At all sites, tern chicks used these boxes as shelters once they had hatched. A maximum of 260 boxes was used as nest sites (Rockabill 1999), and at Skerries and Ynys Feurig, Roseate Terns only nested in boxes. Tyres were also used as both nest sites by Roseate Terns and chick shelters by all tern species.

Table 2.5. Deployment and usage of nest boxes as nest sites by Roseate Terns throughout the Irish Sea colonies (* indicates that boxes were used by Common or Arctic Terns).

	1997		1998		1999	
	# deployed	% uptake	# deployed	% uptake	# deployed	% uptake
Rockabill	283	75	274	69	327	80
Lady's Island Lake	111	24	80	64	100-120	
Dalkey	30	0	50	2*	37	3*
Ynys Feurig	56	5	54	6	58	5
Cemlyn	30	0	30	0	30	0
Skerries	38	0	67	0	97	1*
Inland Sea	5	0	6	0	0	0

In general, the number of breeding pairs of all tern species (Roseate, Common, Arctic and Sandwich Tern) remained relatively stable or increased at each Irish Sea colony over the three year period between 1997 and 1999 (Table 2.6). Overall, the number of Roseate Tern breeding pairs increased by 11% to 730 pairs in 1999 (Table 2.6), and Rockabill supported the large majority (87.6% overall).

Table 2.6. Summary of Roseate, Common/ Arctic and Sandwich Tern nest censuses at Irish Sea colonies between 1997 and 1999 (percentages of Common Tern nests are presented in brackets).

	Roseate Tern			Common/Arctic Tern			Sandwich Tern		
	1997	1998	1999	1997	1998	1999	1997	1998	1999
Rockabill	602	578	611	545(88)	564(89)	699(87)	0	0	0
Lady's Island Lake	47	80	116	500	459	715	1050	1015	1048
Dalkey	0	0	0	23(61)	34	29(72)	0	0	0
Ynys Feurig	2	3	3	256	362	414(26)	0	0	0
Cemlyn	0	0	0	63(81)	50(96)	36(89)	350	460	604
Skerries	2*	0	0	1086(5)	1066(6)	1188(6)	0	0	0
Inland Sea	0	0	0	26	38	32	0	0	0
Irish Sea total	**653**	**661**	**730**	**2499**	**2573**	**3113**	**1400**	**1475**	**1652**

*One Roseate X Common Tern Pair

There were both site and year differences in the mean clutch size of Roseate, Common and Arctic Tern nests. The mean clutch of Roseate Tern nests ranged from 1.00 at Ynys Feurig in 1999 (based on just three nests) to a maximum of 1.82 at Rockabill in the same year (Table 2.7). At Rockabill in 1999, ten three-egg and four four-egg Roseate Tern clutches were laid. Previous to 1999 on Rockabill, few of these supernormal clutches were recorded (one four-egg clutch and two three-egg clutches were laid in 1997 and five three-egg clutches were laid in 1998). It was only possible to accurately differentiate Common from Arctic Tern nests at Rockabill, Ynys Feurig, Skerries and Cemlyn. The mean clutch size of Common Tern nests at these colonies ranged from 2.23 at Skerries in 1999 to 2.59 at Ynys Feurig in the same year, while the mean clutch for Arctic Tern nests ranged from 1.66 at Rockabill in 1998 to 2.05 at Skerries in 1991(Table 2.7). The mean clutch size of Sandwich Tern nests was relatively consistent at approximately 1.50 (Table 2.7).

Table 2.7. Mean clutch size of Roseate, Common, Arctic and Sandwich Tern nests at Irish Sea colonies between 1997 and 1999.

	Roseate Tern			Common Tern			Arctic Tern			Sandwich Tern		
	1997	1998	1999	1997	1998	1999	1997	1998	1999	1997	1998	1999
Rockabill	1.80	1.67	1.82	2.51	2.43	2.58	1.88	1.66	1.80	-	-	-
Lady's Island Lake	1.70	1.64	1.51	nr	nr	nr	nr	nr	nr	1.50	1.41	1.53
Dalkey	-	-	-	nr	nr	nr	nr	nr	nr	-	-	-
Ynys Feurig	1.50	1.33	1.00	nr	2.45	2.59	1.82	2.02	1.96	-	-	-
Cemlyn	-	-	-	nr	2.54	nr	nr	2.54	nr	nr	1.72	1.42
Skerries	1.50	-	-	nr	2.78	2.23	2.05	1.96	1.86	-	-	-
Inland Sea	-	-	-	nr	nr	nr	nr	nr	nr	-	-	-
Irish Sea overall	1.80	1.66	1.77	2.51	2.47	2.55	2.00	1.96	1.88	1.50	1.51	1.49

nr = no record

The mean clutch size of Roseate Tern box nests (1.84) was greater than that of open nests (1.68) at both Rockabill and Lady's Island Lake (Fig. 2.4). The mean clutch size of Roseate Tern nests at Rockabill was higher than that at Lady's Island Lake for both box (1.88 and 1.70 for Rockabill and Lady's Island Lake respectively) and open nests (1.66 and 1.49 for the two sites respectively). There was also intra-colony variation (eg. at Rockabill in 1999, the mean clutch of Roseate Tern nests ranged from 1.50 in one of the old lighthouse gardens to 1.93 in one north-east section of the island).

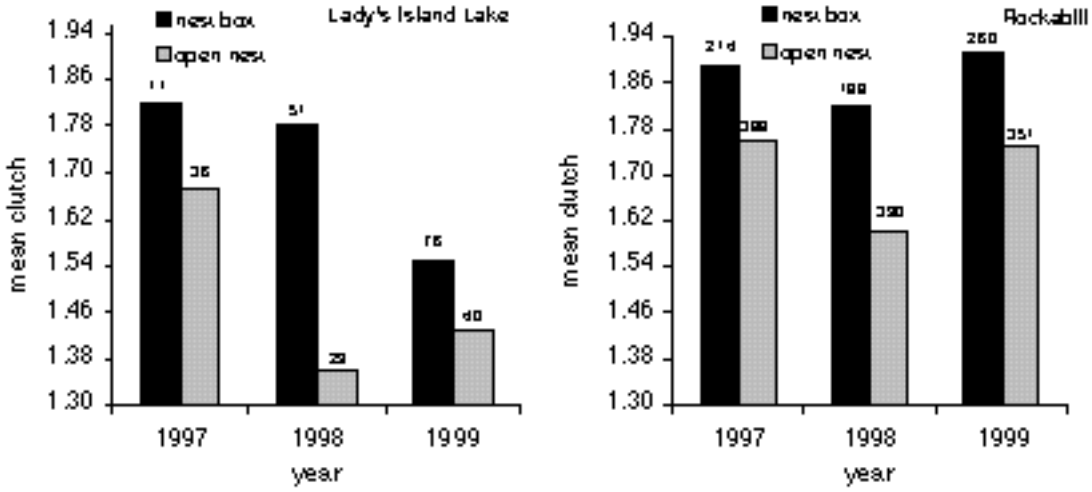


FIGURE 2.4. Mean clutch size of Roseate Tern nests at Lady's Island Lake and Rockabill between 1997 and 1999 (values over bars indicate sample sizes).

2.3.4 Observations of nests in study areas

Nests were generally initiated at Lady's Island Lake three to six days before Rockabill, while nests at the two Anglesey were initiated up to two weeks later (Table 2.8).

Roseate Tern egg-laying appeared synchronous throughout the Rockabill and Lady's Island Lake colonies and the majority of eggs (66 - 76%) were laid over 10- to 11- day periods (Table 2.8). The median lay-date for Rockabill and Lady's Island Lake decreased from 1 June and 30 May respectively in 1997 to 27 and 23 May in 1999 (Table 2.8).

Table 2.8. Egg-laying parameters of Roseate Tern nests at Rockabill, Lady's Island Lake, Ynys Feurig and Skerries. Bracketed figures represent the percentages of eggs laid unless otherwise stated.

Site	year	first eggs	peak lay date	main laying period	median laying period	n(% of total eggs)
Rockabill	1997	25-May	30 May (13.7)	26 May - 5 June (76.0)	01-Jun	408 (37.5)
Rockabill	1998	24-May	28 May (10.2)	25 May - 3 June (71.4)	31-May	527 (54.6)
Rockabill	1999	19-May	26 May (12.3)	23 May - 1 June (74.3)	27-May	806 (72.4)
Lady's Island Lake	1997	17-May	27 May (22.6)	24 May - 2 June (66.0)	30-May	53 (66.3)
Lady's Island Lake	1998	21-May	27 May (23.7)	23 May - 2 June (77.3)	28-May	101 (77.7)
Lady's Island Lake	1999	5-May20	May (12.2)	16 - 25 May (76.4)	23-May	135 (77.1)
Ynys Feurig	1997	30-May	-	-	-	-
Ynys Feurig	1998	03-Jun	-	-	-	-
Ynys Feurig	1999	29-May	-	-	-	-
Skerries	1997	01-Jun	-	-	-	-

The overall incubation of A- and B- eggs at Rockabill in both 1998 and 1999 was relatively consistent at 23 days (Table 2.9). In 1999, lay and hatch intervals were similar. However, in 1998, the lay interval was marginally shorter than hatch interval, while both parameters were longer than those in 1999 (Table 2.9).

Table 2.9. Incubation periods and lay and hatch intervals of Roseate Tern eggs and chicks at Rockabill in 1998 and 1999. Values tabulated are mean ± sd (sample size).

	1998	1999
Incubation (A-eggs)	22.9 ± 1.1 (39)	22.9 ± 0.9 (130)
Incubation (B-eggs)	23.3 ± 1.3 (22)	22.8 ± 0.9 (110)
lay interval	3.6 ± 1.1 (15)	2.8 ± 0.8 (118)
hatch interval	4.1 ± 0.8 (15)	2.7 ± 0.8 (151)

2.3.5 Productivity

The productivity of tern nests generally increased between 1997 and 1999. This increase was not consistent, and while the productivity of Roseate Tern nests peaked in 1999, it was poorer in 1998 than in 1997 (Table 2.10). Storms had a large adverse effect on Common and Arctic Tern productivity at both Cemlyn in 1997 and Dalkey (Lamb Island) in both 1997 and 1998. At this latter site in 1997, Common and Arctic Terns were probably washed out during their first nesting attempt on Maiden Rock. Following a second failure on Lamb Island many subsequently re-nested for the third time, this time on Maiden Rock, and produced a mean clutch size marginally greater than that of the previous attempt. In total, eight chicks are believed to have survived after all nesting attempts and were used in the final productivity calculation (Table 2.10).

There was substantial within-colony variation in productivity. At Lady's Island Lake, the productivity of one of the enclosures in 1999 was 1.70 fledged chicks per pair. The productivity of one of the enclosures at Rockabill was also 1.70 fledged chicks per pair. This latter enclosure in both 1997 and 1998 also comprised Roseate Tern nests of greater productivity relative to that of other enclosures in the colony. In contrast, another enclosure at Rockabill in 1999 had the lowest Roseate Tern productivity recorded, at 1.20 fledged chicks per pair.

Out of 78 study area pairs at Rockabill in 1999, where the age of at least one member was known, it appeared that older pairs laid larger clutches and fledged more chicks. All pairs aged 14-19 years old laid two eggs and fledged two young, 80% of 9-13 year olds laid two eggs and 67% fledged two young, 87% of 4-8 year olds laid two eggs and 62% fledged two young, while 40% of three year old birds laid two eggs and 20% fledged two young.

Table 2.10. Productivity of Roseate, Common, Arctic and Sandwich Tern nests at Irish Sea colonies between 1997 and 1999.

	Roseate Tern			Common Tern			Arctic Tern			Sandwich Tern		
	1997	1998	1999	1997	1998	1999	1997	1998	1999	1997	1998	1999
Rockabill	1.03	0.88	1.43	0.86	0.96	1.81	NR	NR	1.04^	-	-	-
Lady's Island Lake	0.74-1.13	1.04	0.62-0.98	NR	NR	NR	NR	NR	NR	0.67^	0.70^	0.39^
Dalkey	-	-	-	NR	0.24**	1.28	NR	NR	NR	-	-	-
Ynys Feurig	0.67	0.33	0.67	0.60	1.33	1.61	0.64	1.21	1.40	-	-	-
Cemlyn	-	-	-	0.08**	1.25	NR	0.00	0.00	NR	1.57-1.71	1.00	0.91
Skerries	0.5	-	-	1.92*	1.06	1.52-1.97	1.77*	1.35-1.45	1.30	-	-	-
Inland Sea	-	-	-	NR	NR	NR	-	-	-	-	-	-
Irish Sea overall	0.90-1.05	0.93	1.05-1.22	0.76	1.05	1.26-1.35	0.64	1.35-1.45	1.32	-	-	-

NR = no record
* methods of Galvin and Ryan (1992)
** majority of nests were destroyed by storms
^ number of chicks ringed/number of egg-laying pairs

Mark-recapture assessment

Productivity of both Roseate Tern and Common Tern nests based on the mark-recapture assessment were largely consistent with those calculations based on frequent and continual monitoring of nests and chicks (Table 2.11).

Table 2.11. A comparison of two techniques used to calculate the productivity of Roseate and Common Tern nests in two enclosed sections at Rockabill between 1997 and 1999: continual frequent monitoring and a mark-recapture estimate based on the Peterson estimate.

		Roseate Ter n			Common Tern		
		1997	1998	1999	1997	1998	1999
Continual	# nests	36	40	31	73	-	83
Monitoring	population estimate	34	35	40	60	-	142
	productivity	0.94	0.88	1.29	0.82	-	1.71
Mark-recaptur e	# nests	36	33	28	73	69	80
Assessment	population estimate	32	29	35	63	66	138
	productivity	0.89	0.88	1.25	0.86	0.96	1.73

2.4 DISCUSSION

Ring ratios

Given that around 3% of Roseate Terns sighted between 1997 and 1999 had Roseate special rings only (and were originally fitted with both BTO and Roseate special rings) shows that there is some degree of ring loss. It has been shown, at least for Common Terns, that ring removal of terns in their west African wintering grounds is common (Becker and Wendeln 1996). This factor places obvious constraints on estimates of Roseate Tern survival and fidelity. Also, ringing efforts between years have varied substantially, and in recent years much greater emphasis has been placed on ringing. However, prior to this, only a few ringing visits were ever made to Roseate Tern colonies in each season, and on some occasions they were not ringed at all (eg. Lady's Island Lake in 1994). Additionally, aside from one year in the mid-1990s, there has been no ringing of Roseate Tern chicks at Isle aux Dames in France (which generally supports up to around 100 Roseate Tern pairs each year) in over a decade, As a result, the 30 to 40% of unringed Roseate Terns sighted at Rockabill between 1997 and 1999 probably largely comprised missed chicks, but also to some extent adult birds that lost their ring(s) their rings.

Mate and site fidelity

In 1999, similar proportions of the different cohorts of Roseate Terns were identified at Rockabill as in 1998, with the 1995 cohort most prominent. Relatively large proportions of adult Roseate Terns resighted at either Rockabill or Lady's Island Lake originated at the respective colony which shows that there is some degree of fidelity to natal sites, and with continued collection of nest-history information the extent of this could be quantified more precisely.

It appears that there is little exchange between the north-west European Roseate Tern population and other populations, although it is possible that there is some degree of mixing during non-breeding. In addition to the two unconfirmed US sightings at Rockabill reported above, one Roseate Tern which originated in the Azores was sighted at Cemlyn in 1996 (C. Wynne pers. comm.) and one Roseate Tern ringed at Rockabill in 1991 was seen in Massachusetts in 1993 (Nisbet and Cabot 1995).

Although the majority of Roseate Terns resighted in 1998 and 1999 at Rockabill comprised birds ringed as chicks in 1995 (ie three and four year old birds), it is acknowledged that some proportion of these did not breed. There is also probably some degree of observer bias towards younger birds as a result of the use of more easily read Roseate special rings in 1992, which may explain why the majority of breeding birds identified from study area nests at Rockabill in 1999 were from an older cohort (1991). However, the study areas were also not representative of the entire breeding Roseate Tern population, as they probably comprised older individuals breeding in nest boxes in the more open areas visible from the hides. Several young birds were seen trying to prospect available boxes in these study areas but were excluded by more aggressive neighbouring pairs which had already settled. Persistent aggression occasionally resulted in pairs being forced to abandon their nests, sometimes having already laid one egg. Several second-year birds were seen displaying and prospecting nest sites in 1999 in one section at Rockabill, which has not

traditionally supported a large number of Roseate Tern nests. These may have been the excluded younger birds looking elsewhere for nest space, and as such, habitat management, nest box deployment and general wardening in such areas and at other colonies, such as those on Anglesey, should continue.

Nest-site fidelity could be a substantial deciding factor in terms of nest site and colony selection by Roseate Terns. Both pair and site fidelity were apparent at Rockabill in 1999, with 71% of pairs from 1998 remaining together. Almost all of these pairs, and at least one member of pairs which did not stay together in 1999, returned to the same general nest area used in 1998. However, conclusions based on this study are highly limited given the substantial proportion of pairs included that contained at least one unringed member. Additionally, the fate of 16 divorced pairs was not determined in 1999. Nine individuals, mostly female, were not seen. It is feasible, given the possibility that birds do not return every year, that females are the sex less likely to return, given their larger degree of parental investment in a breeding season. The remaining seven pairs each contained an unringed bird whose fate could therefore not be determined in 1999. However, it is equally possible that the partners that failed to return had died. There were only seven pairs where divorce was actually confirmed, five of which contained at least one member under five years of age.

Trapping of unringed Roseate Terns in study areas at Rockabill between 1997 and 1999 helped to improve mate and site fidelity assessments, although trapping involves a risk of desertion. However, the impact of trapping a small proportion of the large breeding population of Roseate Terns on Rockabill is negligible given the life history characterised by high longevity and low productivity. It is also probable that a loss year in terms of breeding success is balanced by a more productive nesting attempt the following year (since the energy expenditure in a loss year is reduced) (Zingo *et al.* 1997).

Roseate Tern survival

The adult survival rate of Roseate Terns at Rockabill is low for a seabird, but is almost identical to that estimated from ring recovery analyses (80.8%) for Britain and Ireland. This study found that adult survival did not change during the 1970s and 1980s and the current study has detected no change through the 1990s, so it seems that changes in adult survival rate do not explain the observed population changes. The survival rates in this study were also comparable with those found from live resighting studies of Roseate Terns in the USA(Spendelow *et al.* 1995).

Productivity appears to have been consistently high compared to other tern species, and there have certainly been no mass breeding failures of the type that would be required to precipitate the rates of decline observed in the 1970s. All evidence points to variations in juvenile survival being responsible for changes in the population's trend. Recovery rates of three to five year old birds ringed during the decline were lower during the period of population decline and the recoveries of juvenile birds higher, suggesting that these cohorts were subject to higher mortality as first-year birds. Simulation models show that juvenile survival would have had to be between 10 and 20% to produce the decline observed during the 1970s. The juvenile survival estimates from the resighting model, when combined with a constant adult survival (80.5%) and productivity (1.2 chicks per pair), predict the periods of stability and increase during the mid 1980s and 1990s reasonably well.

The low adult survival rate and high productivity will make the population trends particularly sensitive to variations in juvenile survival. This parameter is also very plastic compared to other aspects of the life history, so manipulation of the factors that govern it offer the best opportunity to increase the population size. According to ring recovery data, Roseate Terns winter in West Africa, particularly Ghana, where they feed on the dense shoals of Sardines *(Sardinella sp.)* and Anchovies *(Engraulis sp.)*. Here they are trapped by boys for sport, especially in years when high fisheries landings attract terns to coastal villages. This could create a Guassian relationship between juvenile survival and food supply rather than a logistic one, such that survival fails to reach levels that will promote population growth. Further work in Ghana is being planned to examine trapping rates to test this hypothesis.

Although the recruitment coefficients produce a relative measure of movement rates and an understanding of metapopulation structure, they do not account for the actual number of birds recruiting among colonies. Rockabill is a big, productive colony and so even though the likelihood of its fledglings going on to nest at other colonies may be low, the actual numbers involved can comprise a significant proportion of the total recruitment to smaller colonies. For example, half of the ringed birds at Coquet Island originated from Rockabill, and recruitment from Rockabill is likely to be vital to maintaining the population at this

small, relatively unproductive, colony.

The concentration of such a large proportion of birds at Rockabill is of high conservation concern, since a single localised event such as an oil spill could cause catastrophic mortality. This is exacerbated by the fact that other colonies in the metapopulation are 'sinks' that are dependent on Rockabill as a source of recruitment.

Nest census and parameters

There was an overall increase in the numbers of breeding pairs of all tern species at Irish Sea colonies between 1997 and 1999. The continued slow increase of the Roseate Tern population and stability in Sandwich Terns, with Lady's Island and Cemlyn holding 10-15% of the combined U.K. and Republic of Ireland population, are very important in a north-west European context. The marked increase in Common Tern nests relative to Roseate Terns at Rockabill must be highlighted, given that the 1999 season represented the first time the two species have been recorded breeding in similar proportions. With several pairs of both species nesting in sub-optimal sites in 1999, such as on top of walls (13 Common and 2 Roseate Tern nests), if there are limitations due to site fidelity and nest territories (outlined above), then potential competition for nesting space between the two species is imminent.

At Rockabill and Lady's Island Lake in 1999, the first Roseate and Common Tern clutches were initiated around five days earlier than in previous years. The initiation of egg laying is possibly timed to coincide with the earliest date at which prey becomes available (Safina and Burger 1988). The first Roseate Tern eggs seen at Rockabill were laid by two pairs, both of which nested in the same nest site as in 1998. One of these pairs laid the first clutch seen in 1998. This other pair consisted of one adult ringed as a chick on Rockabill in 1986 and an unringed adult, assumed to be the same unringed bird as in 1998. This unringed adult was successfully trapped and ringed in 1999 and conclusions on the fidelity of this pair should be possible in 2000. The other pair consisted of two nine-year old adults which also laid relatively early in 1998.

There was an apparent lag between first eggs and the main laying session at Rockabill in 1999. Thus while the first lay-day for Roseate Tern eggs was five days earlier than in 1998, the peak lay day and the main period in egg-laying were each around three days earlier than in 1998.

The mean incubation periods of A- and B- eggs were similar, and the overall mean of 23 days is in agreement with that published by Cramp (1985) and Gochfeld *et al*. (1998). Therefore, it is highly probable that parents incubated A- and B- eggs equally, and as soon as they were laid. Lay and hatch intervals between Roseate Tern A- and B- eggs and chicks were similar in 1999, but were each around one day less than 1998 and are within the two to three day range reported to reflect good food availability (Nisbet and Cohen 1975). Laying and hatching intervals did not appear to be affected by the time of season in which the clutch was laid, which implies that food availability was relatively constant throughout the seasons. However, a poor season in terms of food availability was evident in 1998, given that laying and hatching intervals were each on average around three to four days. This resulted in B- chick mortality, since the A- chicks were much more advanced by the time B-chicks had hatched and intercepted any food directed towards the latter.

Roseate Tern breeding parameters

Productivity estimates of tern nests derived from enclosures were generally a good reflection of the true productivity of the colony. The variation in productivity both within and between colonies highlights the need to monitor several enclosures at each colony. Although continual frequent monitoring of enclosures is relatively time-consuming and causes some temporary disturbance, overall productivity remained very high. However, the good agreement between the mark-recapture assessment and continual monitoring in assessing the productivity of both Roseate and Common Tern nests supports the use of the former technique over large parts of the colony, given it requires just two or three visits and is thus more time-efficient and causes much less disturbance.

Good food availability was reflected in breeding success of all tern species in 1999, particularly at Rockabill, with almost 50% of Roseate and 60% of Common Tern pairs successfully fledging two chicks. It is thought that dry weather, in particular when chicks were beginning to hatch, may have been largely responsible (in 1998 strong winds and rain persisted throughout this period). This weather probably had a positive effect on chick success because chicks did not get wet and chill (which was frequently the case in 1998). Also tern fishing success is improved in dry conditions and light-moderate winds (Dunn 1975). Roseate Tern productivity appeared to be positively correlated with parental age. Productivity was particularly low for three year old pairs which were probably breeding for the first time. First time breeders typically lay smaller clutches (Gochfeld *et al*. 1998).

Supernormal clutches

It seems likely that the supernormal clutches at Rockabill in 1999 resulted from multi-female associations, possibly as a result of a female-biased sex ratio. Nisbet and Hatch (1999) suggested that multi-female associations may involve low quality females, which cannot obtain males; they may have higher productivity if they pair with each other and raise some young than if they do not breed at all. The fact that hatching and fledging success appear to have been substantially lower than normal for supernormal clutches would support the low quality female hypothesis. Low hatching success may have resulted from the physical difficulty of properly incubating more than two eggs at once. Recorded incubation periods for supernormal clutches were longer than the overall mean and outside the usual range for Roseate Terns, suggesting that embryonic development may be retarded by poor incubation of supernormal clutches. As a result of poor incubation, eggs from many supernormal clutches may have failed as a result of embryo death. Alternatively, the eggs may never have been fertilised, possibly because low quality females nesting together failed to secure sufficient extra-pair copulations to fertilise their developing eggs.

Conservation management

Despite occasional significant losses of eggs and / or chicks, the overall impact of predators was minimal at Irish Sea tern colonies between 1997 and 1999. However, this was only because of intensive monitoring at all colonies throughout tern breeding seasons by highly motivated and hard working wardens. Without them it is likely that predators would have had a far more significant adverse impact on tern breeding and productivity. Such monitoring and control of predators, both avian and mammalian, is imperative to tern breeding success.

There was a clear preference shown by Roseate Terns for nest boxes. They were taken up as nest sites before open sites, and it is probable that they largely comprised older and more experienced breeders, given the considerable differences in mean clutch sizes of open and box nests and that young inexperienced breeders are known to lay more single egg clutches than older terns (Spendelow *et al*. 1997). The productivity of nests in these areas was also consistently high (e.g. productivity of Lady's Island Lake enclosure in 1999 was substantially greater than that of the colony as a whole). It was inferred that there may be some degree of competition among Roseate Terns for nest sites, and that younger terns appear to be pushed out of the traditional nesting areas into suboptimal breeding habitat. Continued nest box placement in such areas, and other colonies, could potentially encourage nesting there should the present stronghold sites and colonies approach saturation.

Finally, the Roseate Tern tape-lures appeared to attract Roseate Terns only at Skerries and Ynys Feurig, both sites where Roseate Terns have recently nested in small numbers. The apparent failure of the experiment at Dalkey may have been attributable at least partially to the lack of on site observations.

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3. FEEDING ECOLOGY: MATE AND CHICK PROVISIONING AT THE COLONY

3.1 INTRODUCTION

Studies on seabird provisioning at their breeding colonies help to elucidate temporal changes in prey and variability in diet (Shealer 1998) and may help to determine annual differences in prey stocks around breeding colonies (Monaghan *et al.* 1992). Presence and accessibility of prey are of key importance to reproductive success and declines in food supplies may result in parents being unable to increase foraging effort without incurring extra costs, which ultimately leads to a decrease in reproductive success (Monaghan *et al*. 1992).

There is potentially direct competition between seabirds and man in the exploitation of fish stocks, and as such, it is important to assess the cost-effectiveness of seabirds feeding on different prey types. In this chapter, rates of delivery and proportions of the different prey types presented by terns, particularly Roseate Terns, to their mates and chicks throughout the breeding season are compared.

3.2 METHODS

Provisioning studies were carried out between 1997 and 1999 on Roseate Terns at Rockabill, Roseate, Common and Arctic Terns at Lady's Island Lake and on Arctic Terns at both Skerries and Ynys Feurig.

3.2.1 Mate provisioning

Mate provisioning typically entails a male offering a fish to a female in a ritualised manner. This establishes the male's ability to support his partner through food provisioning, owing to her greater energy expenditure as a result of costs involved in producing eggs. This process may also serve to re-affirm the pair bond of an established pair, or may be the first approach of an unmated, young male. All observed occurrences of mate provisioning during the courtship and incubation periods were noted. Prey type and size (relative to bill length) were noted. Records where food was presented but not seen being eaten were not included.

3.2.2 Chick provisioning

Once chicks had hatched, the composition of prey presented to Roseate, Common and Arctic Tern chicks at Rockabill, Lady's Island Lake, Ynys Feurig and Skerries was assessed. Several two hourly and all day (05:00-22:00) chick provisioning watches were conducted on a selection of nests at Rockabill. A maximum of 24 nests was observed at any one time during these watches, which were split into the following three hour sessions: early morning (05:01-08:00), mid-morning (08:01-11:00), mid-morning/early-afternoon (11:01-14:00), mid-afternoon (14:01-17:00) and early-evening (17:01-20:00) and one two hour session in late-evening (20:01-22:00). Hourly rates of prey presentation to each nest for each time period were calculated and compared between years, while overall provision rates between three chick stages (early chick period when the majority of chicks were between 0 and 5 days old, mid chick period when most were 7-12 days old and late chick period when the large majority were 14 to 19 days old) were compared in 1999. In addition, extensive observations were made in 1997 on the roles of the sexes in chick provisioning.

3.2.3 Terminology

In the following account, the following definitions apply:

Sandeel: In the Irish Sea three species may occur: two very similar species; *Ammodytes marinus and A. tobianus*, and one slightly larger species, Greater Sandeel *(Hyperoplus lanceolatus)* (Muus and Dahlstrøm 1974).

Clupeids: Group name for unidentified members of the Herring family; in the Irish Sea the Sprat Sprattus sprattus is presently far more abundant that the Herring *Clupea harengus* (Ratcliffe and Armstrong 1997).

Gadoids: Group name for small whitefish; mostly Pollack *Pollachius pollachius* and Saithe *P. virens* though also includes unidentified members of the rockling family (Muus and Dahlstrøm 1974).

Bill lengths: An estimate of fish size expressed as multiples of the tern's bill length (tip to feathering); can be converted to mm using actual measurements from adults trapped for ringing.

3.3 RESULTS

3.3.1 Prey composition of tern provisions during tern courtship and incubation

Courtship feeding period varied between nests and ranged from one to seven days. Generally, courtship feeding commenced three to six days before the first egg was laid and lasted up to the laying of the final egg. At Rockabill, there was a substantial difference between Roseate and Common Terns in the composition of prey presented to mates. Sandeels were the predominant prey presented by Roseate Terns in all three years and by Common Terns in 1998 (Figs. 3.1a-b). However, in 1999, almost equal proportions of sandeels, clupeids and gadoids were presented by Common Terns, with clupeids being marginally more abundant than the other groups (Fig. 3.1b). In 1997, a substantial proportion of gadoids, which consisted entirely of rockling, was presented by Roseate Terns to mates during courtship (Fig. 3.1a). The extent of Common Tern mate provisioning appeared to be equal during both courtship and incubation, and prey was virtually always presented during the latter stage when relieving a partner at the nest. In contrast, Roseate Terns rarely presented prey during incubation (O. Crowe pers. obs.).

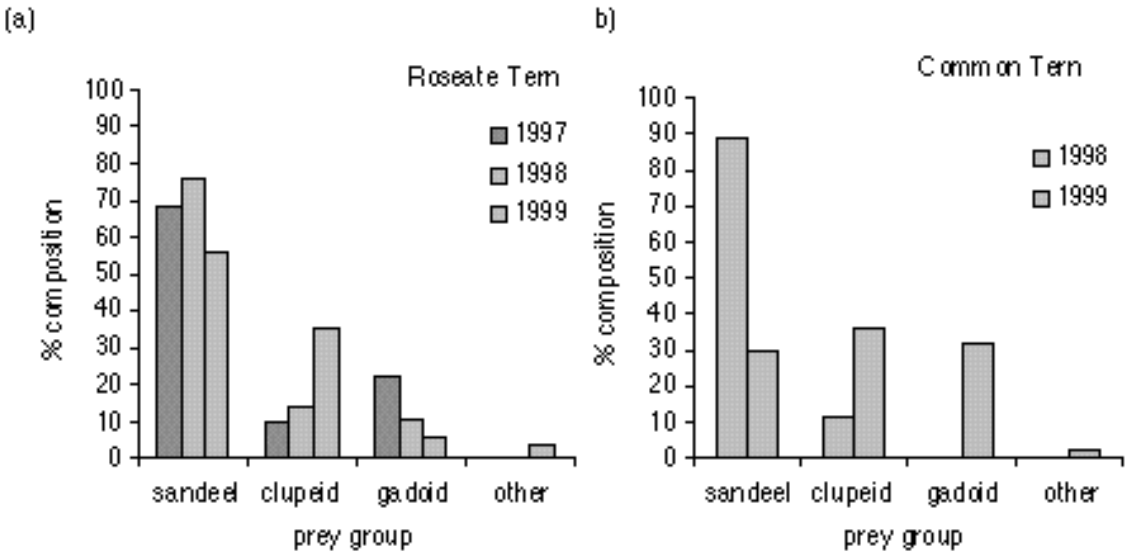

FIGURE 3.1. Percentage composition of sandeels, clupeids and gadoids presented by (a) Roseate and (b) Common Tern mates during the courtship and incubation stages at Rockabill in 1997, 1998 and 1999 (for both species, n = 261, 47 and 86 prey items in each year respectively). The 1997 data for Roseate Terns are specifically from the courtship period, while no data were available for Common Terns in that year.

Sandeels were also the predominant prey presented to Arctic Tern chicks at Ynys Feurig and particularly at Skerries in all three years (1997 to 1999), while clupeids composed the majority of the remainder of prey items (Fig. 3.2). As at Rockabill, clupeids were more prominent in 1999 than in other years among Arctic Tern mate provisions at Skerries (Fig. 3.2a). However, the reverse trend was seen at Ynys Feurig (90% sandeels and 10% clupeids were presented to mates). 'Other prey' comprised largely cephalopods (mostly squid) and crustaceans. At Lady's Island Lake, although sandeels predominated in Sandwich Tern incubation provisions in 1998, clupeids were the more abundant prey type presented during this period in 1997 (Fig. 3.2c).

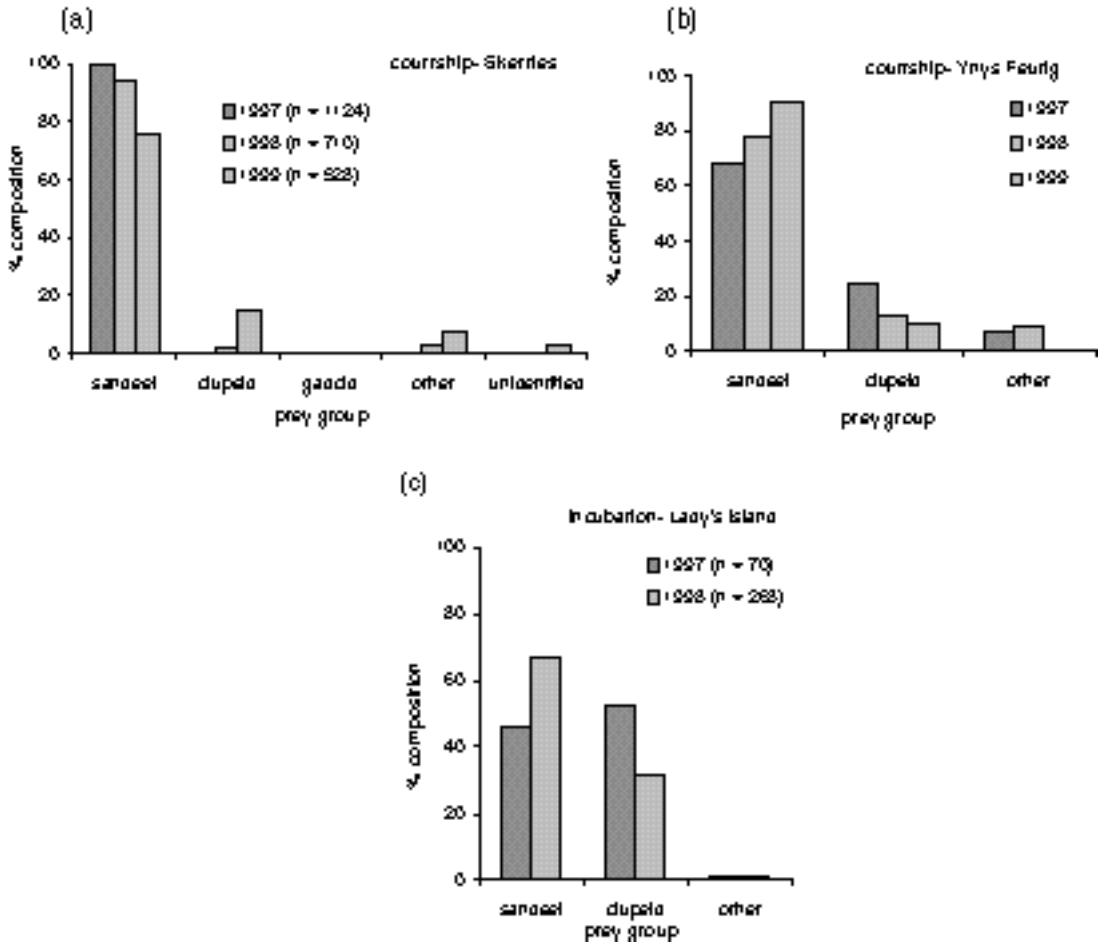

FIGURE 3.2. Percentage composition of sandeels, clupeids and gadoids and other prey presented by Arctic Terns at (a) Skerries and (b) Ynys Feurig to mates during courtship between 1997 and 1999 and (c) by Sandwich Terns at Lady's Island Lake during incubation in 1997 and 1998. Note that sample sizes were not available for Ynys Feurig.

3.3.2 Prey composition of tern chick provisions

In contrast to mate provisions, clupeids were the predominant prey presented to Roseate Tern chicks at Rockabill in all three years (Fig. 3.3); clupeids comprised 37.6%, sandeels 28.6% and gadoids 7.2% of overall prey items, while 20.9% of prey were not identified. However, sandeels continued to be the most frequently presented prey group to all tern chick species at Lady's Island Lake, Skerries and Ynys Feurig (Fig. 3.4).

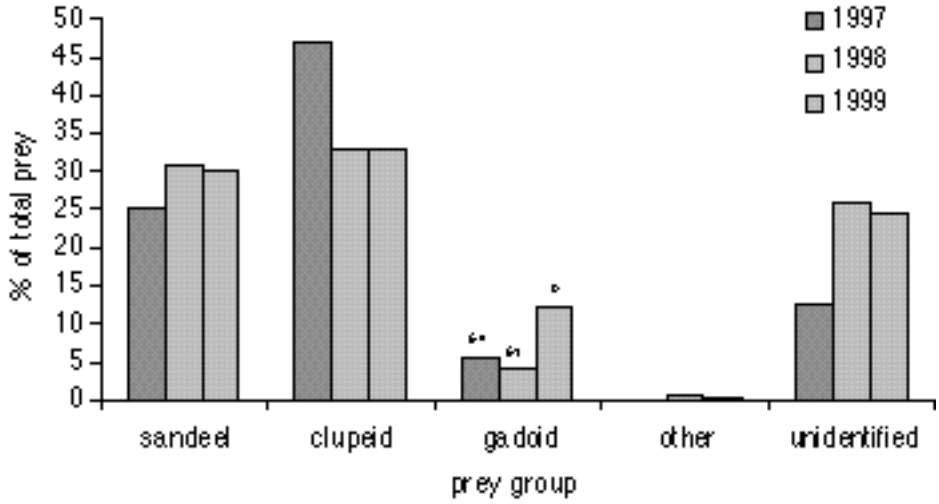

FIGURE 3.3. Prey composition of Roseate Tern chick provisions at Rockabill in 1997, 1998 and 1999 (n = 1373, 1218 and 1750 prey items for the three years respectively). Numbers presented over gadoid bars represent the percentage comprising rockling.

Relative to Rockabill, gadoids were infrequent among chick provisions (Figs. 3.4a-d). Fewer clupeids were presented to Roseate Terns at Lady's Island Lake, particularly in 1997 (Fig. 3.4a), and it appeared that greater proportions of clupeids were presented to Common and Arctic Terns than Roseate Tern at Lady's Island Lake in both 1997 and 1998 (Fig. 3.4d). However, in 1998, the proportion of clupeids presented by Roseate Tern increased during the season, and from mid-July onwards they comprised nearly all of the prey presented to chicks. Sandeels were also the predominant prey group presented to Sandwich Tern chicks at both Lady's Island Lake and Cemlyn, and substantial proportions of clupeids were presented at Lady's Island Lake (Figs. 3.4e-f).

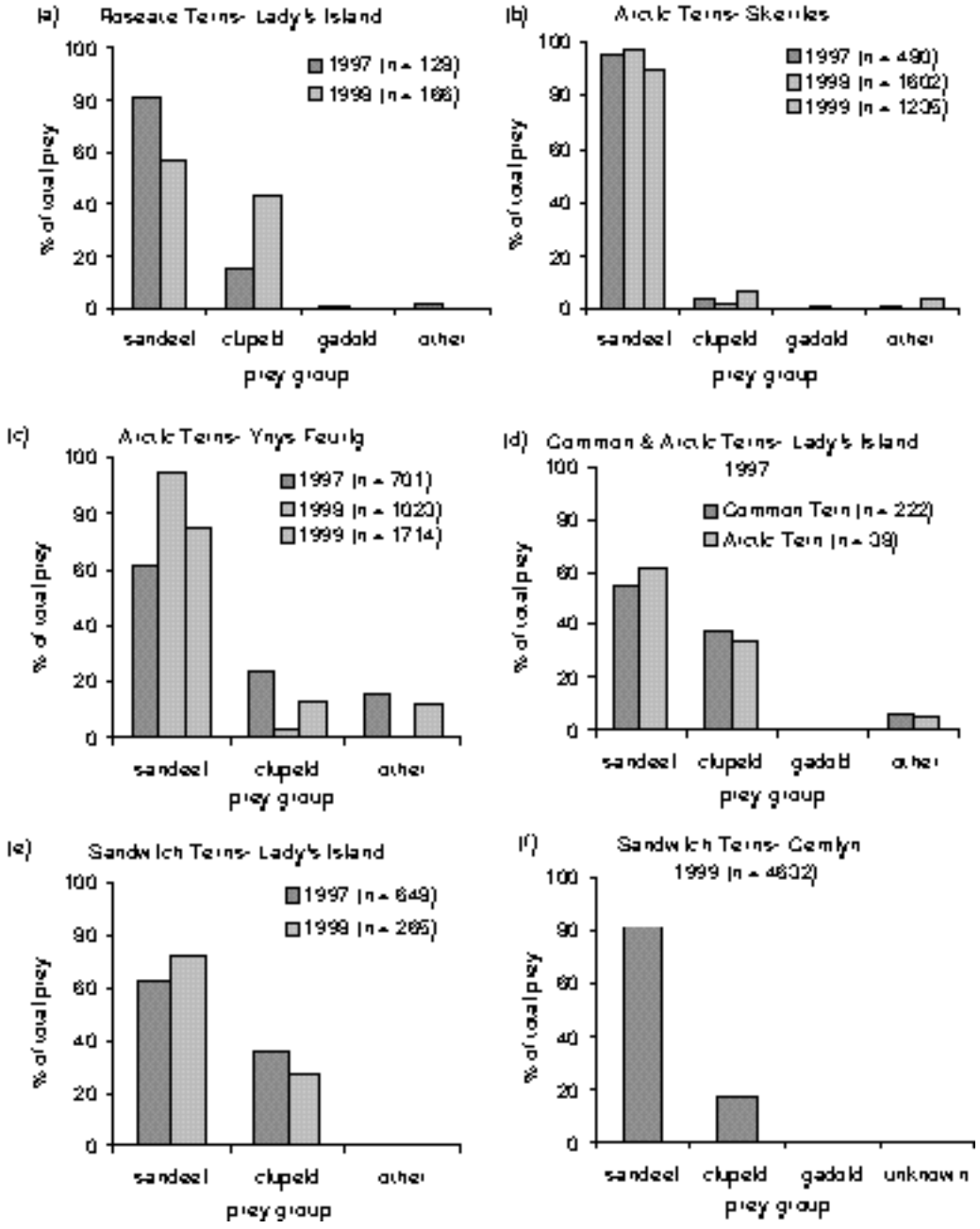

FIGURE 3.4. Prey composition of chick provisions of (a) Roseate Terns at Lady's Island Lake, (b) Arctic Terns at Skerries, (c) Arctic Terns at Ynys Feurig, (d) Common and Arctic Terns at Lady's Island Lake, (e) Sandwich Terns at Lady's Island Lake and (f) Sandwich Terns at Cemlyn.

3.3.3 Rates of prey delivery to Roseate Tern chicks at Rockabill

The overall rates of Roseate Tern chick provisioning at Rockabill in 1997, 1998 and 1999 were 1.00, 1.19 and 2.20 feeds/nest.hour respectively. There were no consistent diurnal trends in prey presentation between years. In both 1997 and 1998, the lowest number of feeds were presented in the early morning session, while in 1999 the lowest number of feeds were presented in mid-afternoon (Fig. 3.5). The maximum number of feeds were presented in mid-afternoon in 1997 (2.04/nest.hr), late afternoon in 1998 (1.59 /nest.hour) and mid-morning in 1999 (2.71/nest.hr) (Fig. 3.5).

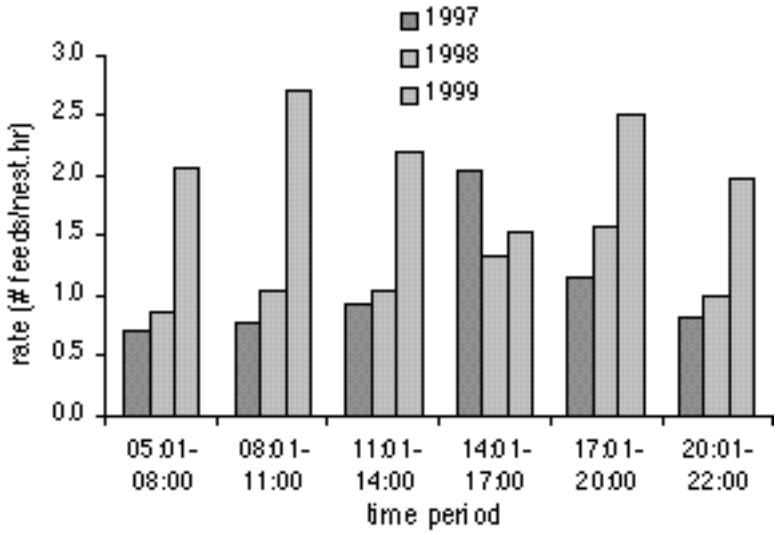

FIGURE 3.5. Diurnal trends in overall chick provisioning rates at Rockabill between 1997 and 1999.

In 1999, diurnal trends were consistent throughout the various stages of chick growth from early chick period through mid chicks to late chicks (Fig. 3.6). Overall, the rate at which prey was delivered to chicks aged 7-12 days (3.09 feeds/nest.hour) was almost twice those at which prey was delivered to young chicks and chicks close to fledging (1.67 and 1.91 feeds/nest.hour respectively; Fig. 3.6). However, it must be noted that in terms of the energetic value of these feeds (given that the calorific content of one 80 millimetre long clupeid is almost two times greater than that of an equivalent sized gadoid and four times that of an equivalent sized sandeel), this relationship was not so apparent, and overall energy provision rates were similar between years (26, 33 and 29 KJ/nest.hour for early, mid and late chicks respectively).

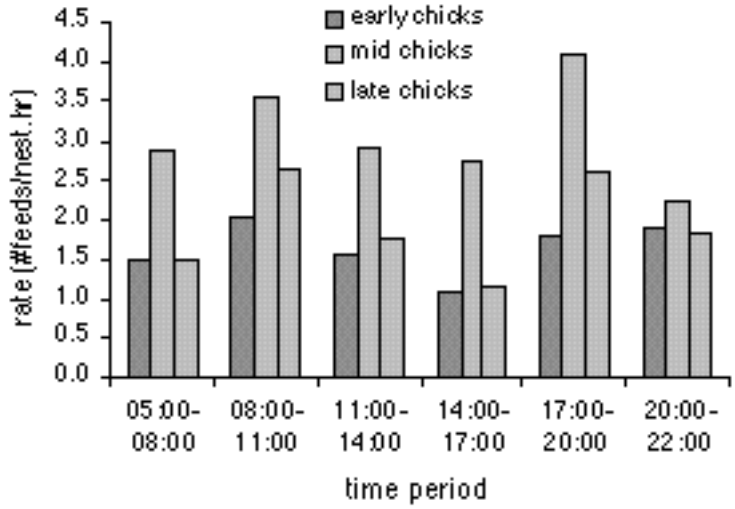

FIGURE 3.6. Diurnal changes in prey provisioning rates to Roseate Tern chicks at three different stages of growth (from early to mid to late chicks; see text for details) at Rockabill in 1999.

3.3.4 Roles of the sexes in Roseate Tern chick provisioning at Rockabill in 1997

It appears that for the first week after hatching, the male does most of the chick provisioning, after which time the contribution by each sex is equal (Fig. 3.7). Further, there is some indication that females increase their provisioning effort relative to males as the chicks approach fledging (Fig. 3.7). However, this latter result may be an artefact of small sample size.

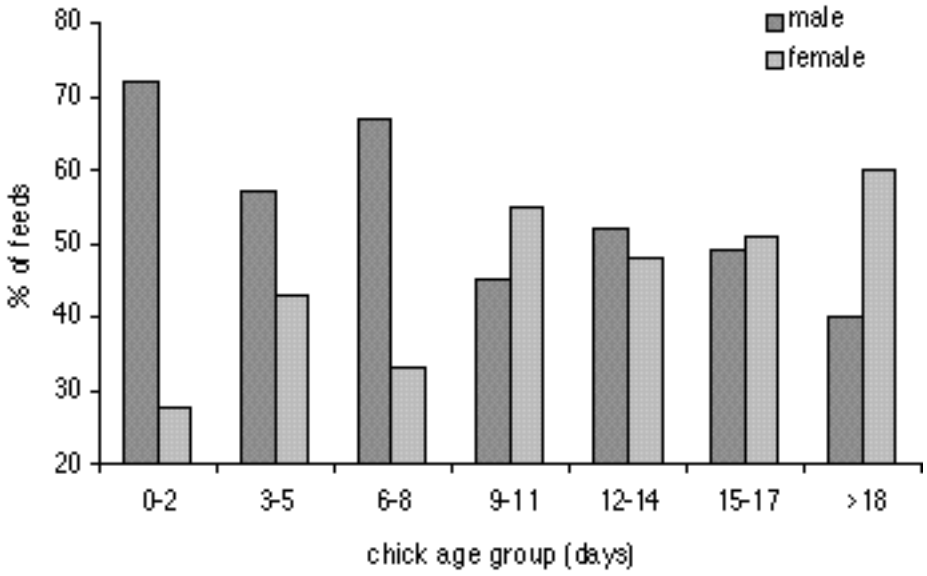

FIGURE 3.7. Percentage of feeds presented by male or female parents relative to chick age at Rockabill in 1997.

3.4 DISCUSSION

Overall, Common and Arctic Terns presented greater proportions of gadoids and 'other prey'to mates and chicks than both Roseate and Sandwich Terns. This may simply reflect differences in feeding ecology. In the US, Roseate Terns have been shown to have a less diverse and more restricted diet than the more opportunistic Common Tern (Erwin 1978). The diet of Sandwich Terns is generally similar to that of Roseate Terns, although the two species have been shown to segregate foraging habitat, with Sandwich Terns tending to feed less frequently over predatory fish and more in inshore areas than Roseate Terns (Shealer 1998). At Lady's Island Lake, the only north-west European colony where the two species currently nest together, Sandwich Terns commence the breeding cycle approximately one month before the other tern species. Additionally, Sandwich Terns at Lady's Island Lake have rarely been described as using the same feeding areas as Roseate, Common and Arctic Terns (Chapter 4). This may explain why clupeids were so abundant among Sandwich Tern mate provisions during incubation, especially in 1997, when other tern species were in the early courtship stage.

Roseate, Common and Arctic Terns generally presented greater proportions of sandeels during mate provisioning than chick provisioning at Irish colonies, after which time sandeels decreased, coincident with an increase in sprats and gadoids in chick diet. This trend may reflect differences in prey availability; the vast majority of mate provisioning observations were from late May and early June, whereas chick provisioning watches were conducted around one month later. This finding is consistent with previous years (Casey *et al*. 1995). Whether or not terns are responding to a decrease in sandeels, or switching to feeding on increasing proportions of clupeids, remains to be tested. However, the abundance of clupeids among chick provisions at the two Welsh colonies, Ynys Feurig and Skerries did not increase, and may reflect geographical differences in prey availability, especially given that sandeels were consistently presented throughout the season. In contrast to incubation, sandeels were the most frequently presented prey item to Sandwich Tern chicks at both Lady's Island Lake and Cemlyn. These findings are broadly consistent with mate provisions recorded during Roseate, Common and Arctic Tern incubation.

The marked rate change in prey delivery by Roseate Terns, yet relatively constant energy provision rate between chick growth stages, seen at Rockabill in 1999 was due to the terns presenting greater proportions of sandeels and gadoids and lower proportions of clupeids during the latter stages; clupeids are much higher quality prey than either of the other two groups (Hislop *et al*. 1991). It should be noted that while the energetic value within the fish families appears relatively consistent (Hislop *et al*. 1991), substantial differences in energy content exist between similar sized Sprats and Herrings (Hislop *et al.* 1991), the two Irish Sea clupeid species. Herrings are naturally much larger than Sprats, and consequently any Herrings captured by terns (up to 160mm long) would be juveniles of considerably less energetic value than similar sized adult Sprats. It had been assumed in recent years that all clupeids presented at Rockabill were Sprats,

since Herrings had not been recorded at their spawning grounds at Carlingford Lough in recent years (Ratcliffe & Armstrong 1997). However, two immature Herrings were found in 1999 (dropped prey), and although this was a relatively small sample, it proves that they were present near Rockabill.

Similar dietary shifts at similar stages of the breeding season among Roseate Terns have been reported elsewhere (Shealer 1998). Predatory fish are thought to rapidly deplete tern prey (Safina & Burger 1988), and it is possible that clupeid stocks, by the mid-chick stage, were to some extent depleted which resulted in the terns having to use 'lower quality' gadoids and sandeels later on. However, this hypothesis is largely untested, and it may have been the case that the Roseate Terns were not so selective and in 1999 were opportunistically preying on more accessible gadoids during the latter part of the breeding season.

The overall Roseate Tern chick provision rate at Rockabill was variable between years, and the peak in 1999 coincided with the majority of pairs rearing, and subsequently fledging, two chicks each in that year (while productivity was around 1.00 fledged chicks/nest in 1998). On several occasions during provision watches, parents were observed moving one of their two chicks into neighbouring vacant nest boxes, possibly to facilitate the allocation of provisions.

The inconsistencies between years in diurnal feeding activity of Roseate Terns at Rockabill could be the result of a wide range of environmental factors alone, such as differences in prey availability, distribution and/or behaviour, which is beyond the scope of this project.

Female Roseate Terns probably expend more energy during the breeding season, given they have to produce the eggs, and the two sexes participate more or less equally in incubation (Gochfeld *et al*. 1998). This behaviour is contrary to that in Common Terns where the male spends significantly more time at sea than the female, and to some extent feeds her while she is on the nest (Cramp 1985). Consequently, female Roseate Terns probably require time to recover, which may explain their lack of participation in feeding young chicks at Rockabill in 1997.

3.5 REFERENCES

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4. FEEDING ECOLOGY: FORAGING AREAS AND THE DISTRIBUTION OF TERNS AT SEA AROUND COLONIES

4.1 INTRODUCTION

Several factors play important roles in determining seabird breeding success. For terns, a safe nesting site, usually an island, is crucial. Additionally, conservation action through professional wardening is necessary to reduce the impact of stochastic events such as weather and predator presence (Chapter 2). In Chapter 3 we have shown the between year and colony variability in type and delivery rate of prey fish delivered to chicks. This is presumably intricately linked to fish availability and accessibility in the seas around colonies.

It has been implied that the depletion of fish stocks has been responsible for the reproductive failure of entire seabird colonies (Monaghan *et al*. 1992). Feeding conditions have also been shown to affect adult tern body mass (Frank and Becker 1992, Monaghan *et al*. 1992) and determine a wide variety of tern breeding parameters such as timing of breeding season (Safina and Burger 1988) and lay and hatch intervals (Nisbet and Cohen 1975).

In north-east America, foraging areas and associations of Roseate Terns have been well documented (see Gochfeld *et al.* 1998 for review). In these parts of the north-west Atlantic, Roseate Terns appear to use one of two strategies: either foraging over tide rips, sand shoals and sandbars, in some cases up to 20-30km from the colony, or more pelagically in deeper water over schools of predatory fish which flush prey fish species to the surface.

However, very little is known about the location of Roseate Tern foraging areas in north-west Europe, or what factors influence the availability of prey fish in the upper part of the water column where plunge diving terns can access them. It has generally been assumed that most foraging is done relatively close to the colony, but there are no quantitative observations to back this up and it could well be an artefact of land-based observers with a view out from the colony limited to about 2km when searching for terns. Kleptoparasitic behaviour has been shown by Roseate Terns in the North Sea (Dunn 1973), whereby they steal fish from other tern species in the proximity of the colony. To date we have rarely observed this behaviour at Irish Sea colonies. More recently, O'Toole (1993) reviewed industrial fisheries statistics for the western Irish Sea and demonstrated that Rockabill was centrally placed in the most productive area for Sprats and that concentrations of sandeels in May/June on the Bennet and Kish Banks were within the foraging range of Rockabill Roseate Terns. However, the distribution of foraging terns around an Irish Sea colony and the mechanisms which bring shoals of small fish to the sea surface have not been studied.

In this chapter we investigate the spatial distribution of foraging terns around colonies, and for Rockabill, the most important Roseate Tern colony, we attempt to determine which physical, oceanographic and biological factors are associated with good feeding areas. Determining where threatened seabird species are at different times of the breeding season could be vitally important knowledge in the event of a serious oil spill, and in assessing the impact of other activities in the offshore sector such as windfarm development and aggregate extraction from shallow sand/ gravel banks.

4.2 METHODS

4.2.1 Observations at Lady's Island Lake

In 1998 and 1999, observations were carried out between late May and late July from sites around Lady's Island Lake. The principal sites (Fig. 4.1) covered were Lady's Island Lake barrier (2km south of the colony on Inish), St. Margarets (3km east of the colony) and Carnsore Point Trig Point (3km south-east of the colony). Watches were each 30 minutes long, and data recorded included tern numbers and species, flight directions, destination, proportion of terns carrying fish, weather and tidal state. Observation watches were spaced out through the day so that 30 minute sessions were undertaken in each of the following time periods: 06:01-09:00, 09:01-12:00, 12:01-15:00, 15:01-18:00, 18:01-21:00. Data were later subdivided into four sessions corresponding with different stages in the nesting cycle of the terns.

4.2.2 Observations from the Rockabill colony

Tern feeding observations were conducted from the lighthouse roof at Rockabill in 1998 and 1999. From this vantage point there were relatively clear views spanning 360°. Observers slowly scanned the sea using a combination of binoculars and telescopes. Any feeding groups were described and their location recorded by compass bearing. Distances of feeding groups from Rockabill were estimated (near < 1 km, mid 1-2 km, far > 2 km) and visibility was gauged by landmarks of known distance from the island; wind speed and sea conditions were also recorded. The numbers and species of any other seabirds seen with tern feeding groups were also recorded. Individuals seen flying out to and returning from assumed feeding grounds were also recorded, but only when they were at least 100m from the island. The activity and direction that the bird was travelling was recorded. Watches were not conducted during rain, when winds were greater than force 5 or when visibility was poor.

In 1998, observations were carried out in two periods; between 26 May and 7 June (incubation) and between 18 July and 9 August (late chicks/early fledging). Watches during the first phase were each carried out for 1.5 hours in the 18:00-20:30 time period. As a result of strong winds, these watches were largely biased towards the south side of the island. The second phase watches were each 30 minutes long and were conducted ad lib.

In 1999, watches were also carried out in two periods. Between 29 May and 11 July, watches approximately 30 minutes long were conducted ad lib and only foraging birds were recorded. Later, between 27 July and 6 August, more thorough 30 minute watches were conducted at 08:00, 11:00, 14:00, 17:00 or 20:00 *ad lib* on different days, when both flying and foraging birds were recorded.

4.2.3 Rockabill sea survey transects

Three series of boat surveys of tern movements around Rockabill were conducted; on 14 and 15 July 1998 during the late chick rearing stage, 9 and 10 June 1999 during late incubation and 16, 22 and 23 July 1999 during the late chick / early fledgling stage. During the 1998 survey, it was assumed that the terns fed largely within 10km of Rockabill and in shallower waters between the island and the mainland. On this basis, east-west transects, each 2km apart up to 10km north and 15km south of the island were conducted. Transects were each 16 to 18km long (5km on the east side of the island) on the north side of the island unless bound by land and 10km long on the south side (Fig. 4.1).

The assumption that terns fed within 10km of the colony was tested in 1999, and an array of radial transects were followed. Radials were 15km long and approximately 5km apart at the distal end (Fig. 4.1). Each radial followed one of 16 compass points: N, NNE, NE, ENE, E, ESE, SE, SSE, S, SSW, SW, WSW, W, WNW, NW, and NNW.

The MV Fulmar, a former pilot cutter based in Loughshinny (1998) and Malahide (1999), was used for surveys of terns at sea. Observations were made from the wheelhouse roof where the observers'eyes were approximately 6m above water level. Distance estimation of birds on or over the sea was made using a pre-calibrated pair of dial callipers held at arms length. A minimum team size of four was required for these surveys: helmsman, navigator, bird observer and bird recorder.

The species, number, direction of flight and foraging activity of all terns observed within 500m in a 180º arc ahead of the boat were recorded. Presence of auks (Guillemots *(Uria aalge)*, Razorbills *(Alca torda)*, Puffins *(Fratercula arctica)* and Manx Shearwaters *(Puffinus puffinus)* were also recorded, as were all species partaking in foraging activity with terns. Thus, transect width for flying birds was 1km. Flying birds or sitting birds put to flight by the boat were monitored by the recorder so that they were not double-counted by the observer. Bird sightings were assigned to 1km long sections (blocks). The boat cruised at an average speed of 15km/hour along transects and waypoints were recorded every kilometre using a hand-held Geographical Positioning System (model: Garmin 12 XL). Water depth was recorded in the centre of each 1km block from the boat's sonar. Weather, visibility and sea conditions were noted regularly.

Tern numbers recorded during sea surveys were transformed into densities (per m^2). Tern records from the radial surveys in 1999 were also divided into eight distance bands beginning 500 metres from Rockabill, with the first band being just 1km in width to help account for non-feeding terns flying around the colony and all remaining bands each 2km in width (total survey out to 15.5km from Rockabill). A series of maps of survey routes and tern distributions, illustrating absolute tern densities around Rockabill, were drawn

using the Dmap software package created by Dr A. Morton. It should be emphasised that these maps both illustrate the distributions and densities of terns based on, at most, surveys of up to 15.5km from Rockabill (1999 surveys), and that the distributions reflect tern presence along transects only, and are not absolute distributions.

4.2.4 Kish Bank survey in 1999

The Kish Bank is a shallow sandbank composed of sand and gravel deposits situated 10km east of Dalkey and Dun Laoghaire in County Dublin. A lighthouse is situated at the north end of the bank, which runs south/ south-east from the entrance of Dublin Bay for approximately 10-12km. The Kish Bank is in close proximity to several important seabird colonies, principally Rockabill (30km), Lambay (20km) and Irelands Eye (15km). Recent evidence (MacLoughlainn 1996) suggested that terns were using the Kish Bank as a post-breeding staging area. As such, similar boat transects to the 1998 Rockabill sea survey were conducted around the Kish Bank on 25 August and 3 September in 1999 to assess its use as a post-breeding staging area for terns. East-west transects were approximately 10km long, centred over the bank, and 2km apart (Fig. 4.2).

4.2.5 Anglesey feeding observations

Feeding terns and their movements were also described at Inland Sea and Cemlyn on Anglesey in 1998 and 1999.

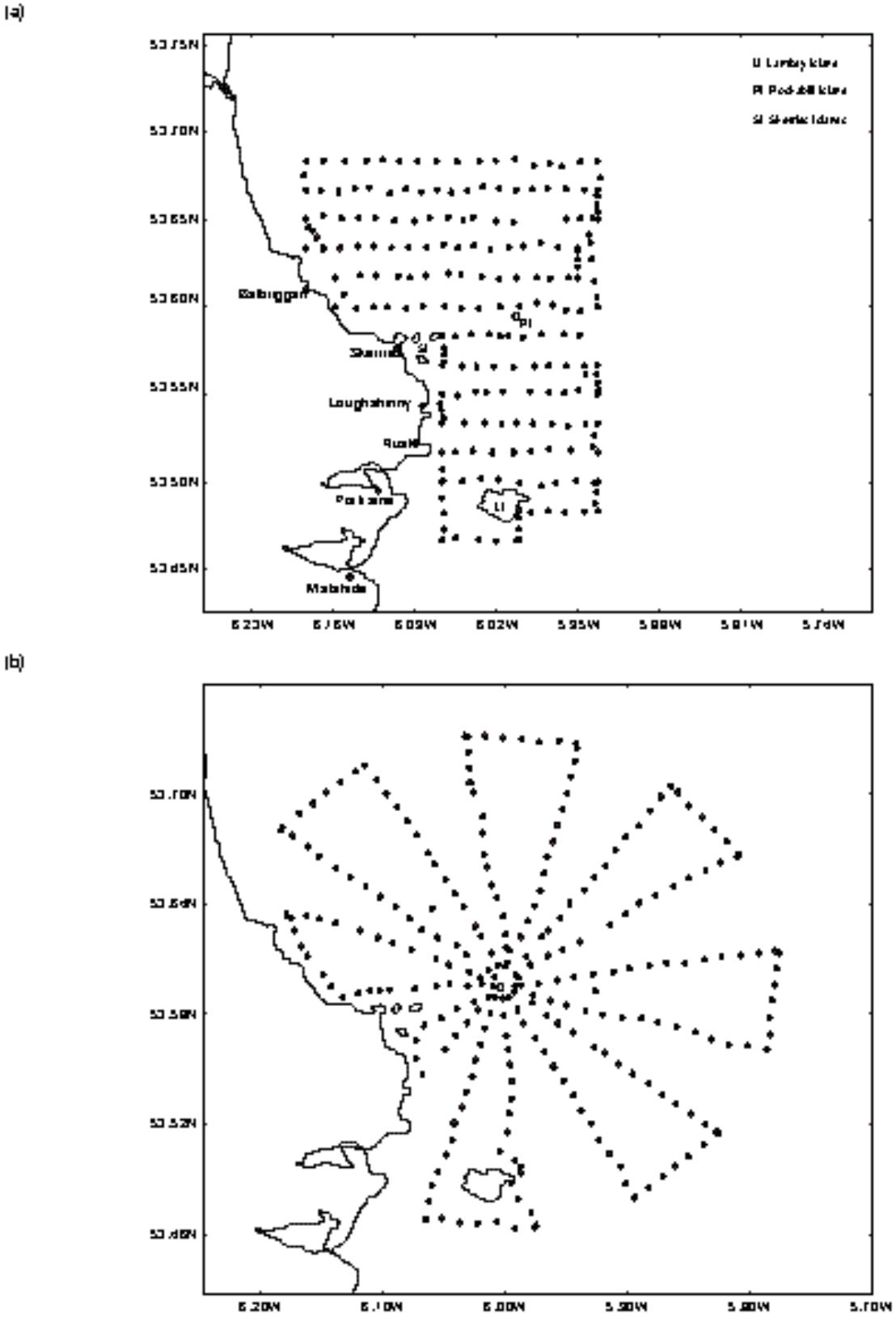

FIGURE 4.1. Transects conducted around Rockabill during sea surveys (a) on 14 & 15 July, 1998 and (b) on 9 & 10 June and 16, 22 & 23 July.

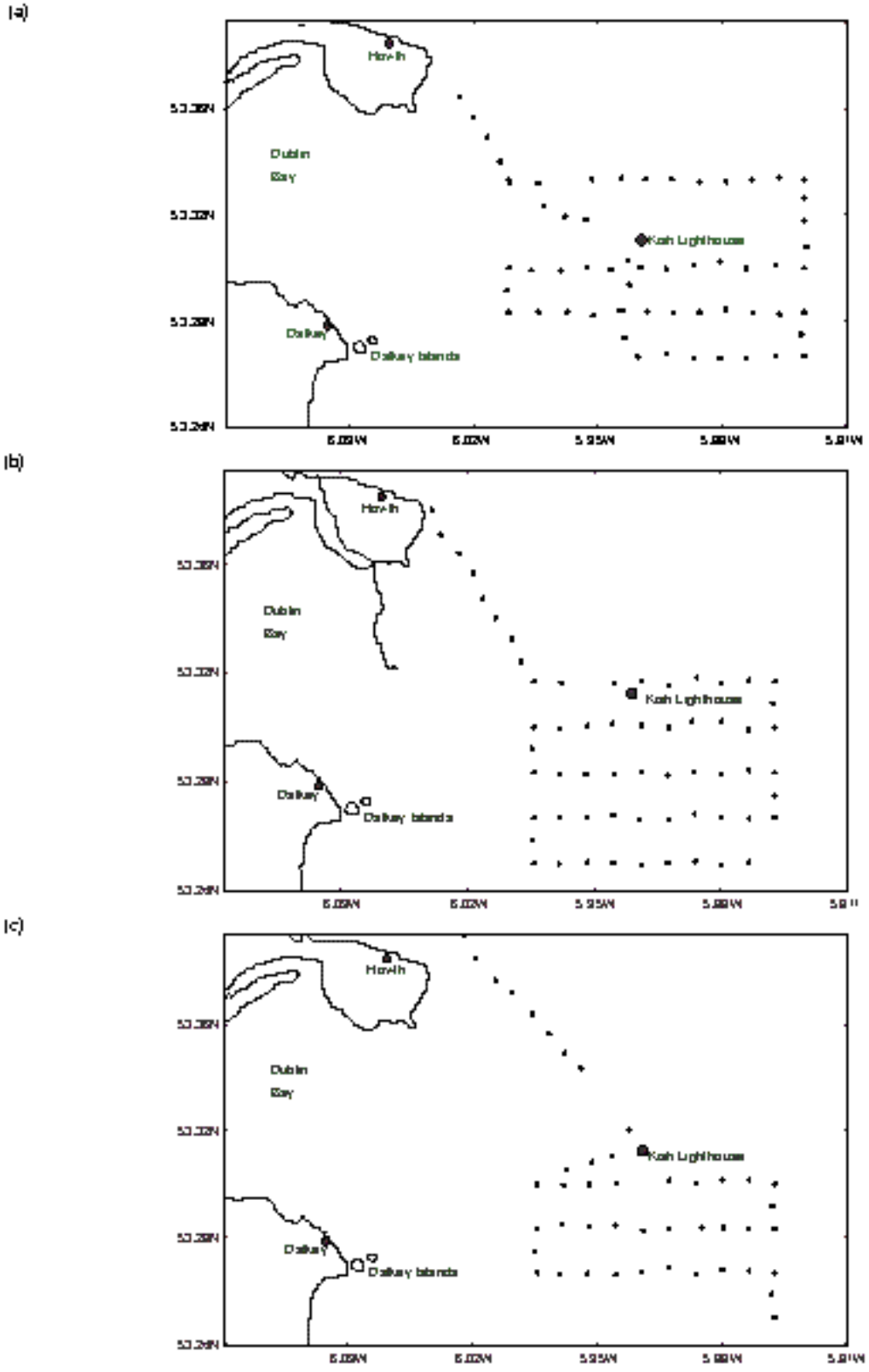

FIGURE 4.2. Outline of surveys conducted around the Kish bank in 1999 (a) at high tide on 25 August, (b) at low tide on 3 September and (c) on a rising tide also on 3 September.

4.3 RESULTS

4.3.1 Lady's Island Lake observations

More extensive observations were conducted at Lady's Island Lake in 1998 relative to 1999, and thus the results between the two years (particularly in terms of tern densities) are not directly comparable. Nevertheless, trends in tern feeding activity appear to be similar between the two years.

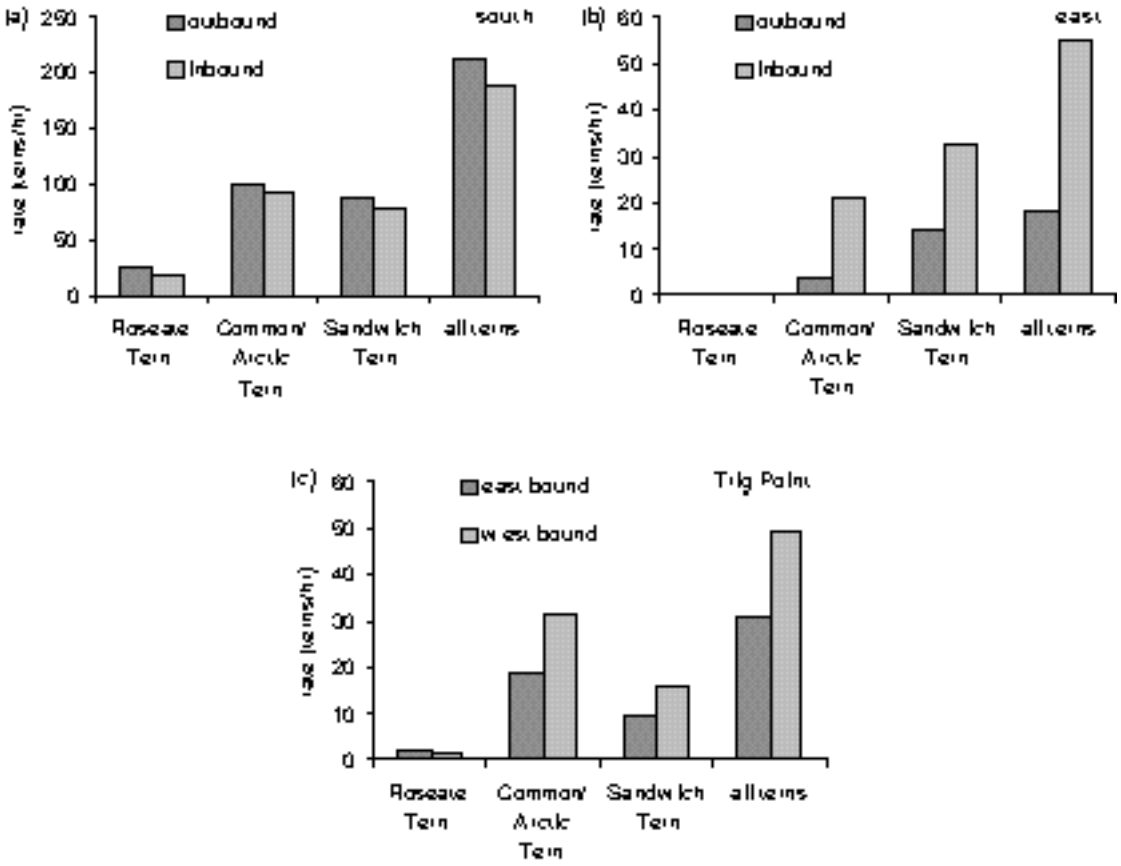

FIGURE 4.4. Rates of tern passage to and from the tern colony at Lady's Island Lake in 1998 (a) across the Lady's Island Lake barrier, (b) across land to the east of the colony and (c) east and west bound past Carnsore Trig Point (see Fig. 1 for details). (Note differences in the scale of the graphs in comparing north/south bound rates with east/west).

In both years, terns appeared to predominantly use north/ south flightlines across the Lady's Island Lake barrier throughout the season (Fig 4.4a and 4.5a). While the majority headed southwards, away from the colony, there was substantial passage of inbound terns (heading north) in 1998, with over 70% of these carrying fish (it must be noted that observations of these flightlines in 1999 were carried out only in July and may not have reflected tern feeding movements overall). These observations linked the colony with an area of considerable Roseate Tern feeding activity detected around Black and Barrels Rocks, and slightly further west towards the Saltee Islands (Fig. 4.3). Terns were also seen to use east/ west flightlines between the colony and the east coast of Wexford, with greater proportions heading west (Fig. 4.4b & 4.5b), presumably returning to the colony (50% in 1998 and 13% in 1999 of terns were recorded heading towards the colony, west bound, with fish). While there were substantially greater proportions of terns heading west in 1998 (Fig 4.4c), there were conversely greater proportions heading east in 1999 (Fig 4.5c). Nonetheless, 50 to 60% of west bound terns in both years were carrying fish and presumably returning from feeding grounds on the east side of Carnsore Point probably on The Bailies (a shallow sand bank which occurs approximately 5km offshore between Carnsore Trig Point and Greenore Point: see Fig 4.4). Additionally, terns were described in both years feeding over an area of turbulence and tide rips to the south-east of Carnsore Point.

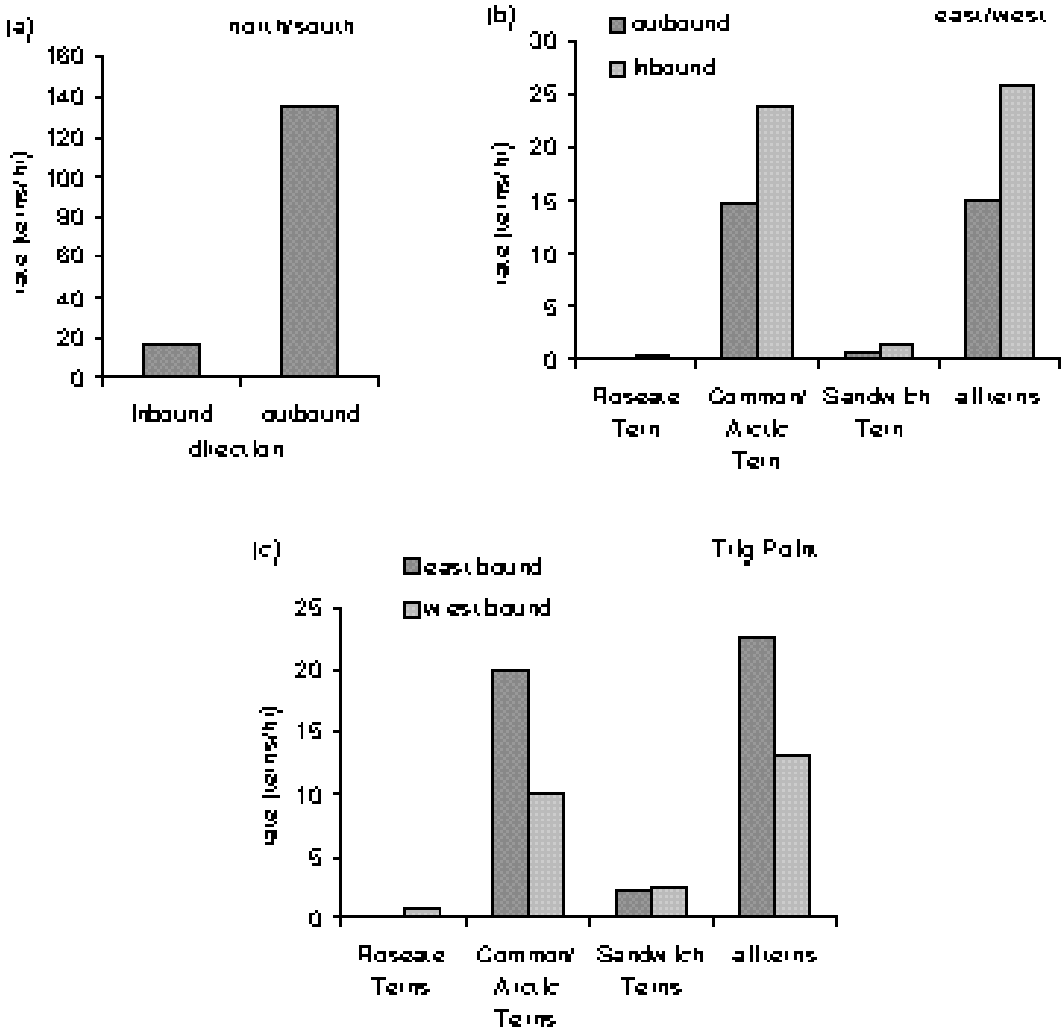

FIGURE 4.5. Rates of tern passage to and from the tern colony at Lady's Island Lake in 1999 (a) across the Lady's Island Lake barrier, (b) across land to the east of the colony and (c) east and west bound past Carnsore Trig Point (see Fig. 1 for details). (Note differences in the scale of the graphs in comparing north/south bound rates with east/west).

Roseate, Common and Arctic Tern movements were consistent with tern movements overall. However, Sandwich Terns appeared to cross land more readily than the other species, and as such, were recorded heading to and returning from assumed feeding grounds across land at St. Margarets (Fig. 4.3) and further north. The northern limit to which this species feeds remains to be ascertained However, Sandwich Terns have been recorded as far north as Rosslare Point during the breeding season, which is approximately 13km due north of Lady's Island (O. Merne pers. comm.).

4.3.2 Observations from the Rockabill colony

In both 1998 and 1999, foraging flocks that contained terns were recorded from all eight sectors, but were most prevalent in the north and south-east sectors (Fig. 4.6). In 1998, few groups were described from the north-east sector. Conversely, this sector was widely used by foraging terns in 1999 (Fig. 4.6). Contrary to expectations, most tern foraging activity took place in the deeper waters on the east side of the island (see Figure 4.7 for depth profile around Rockabill).

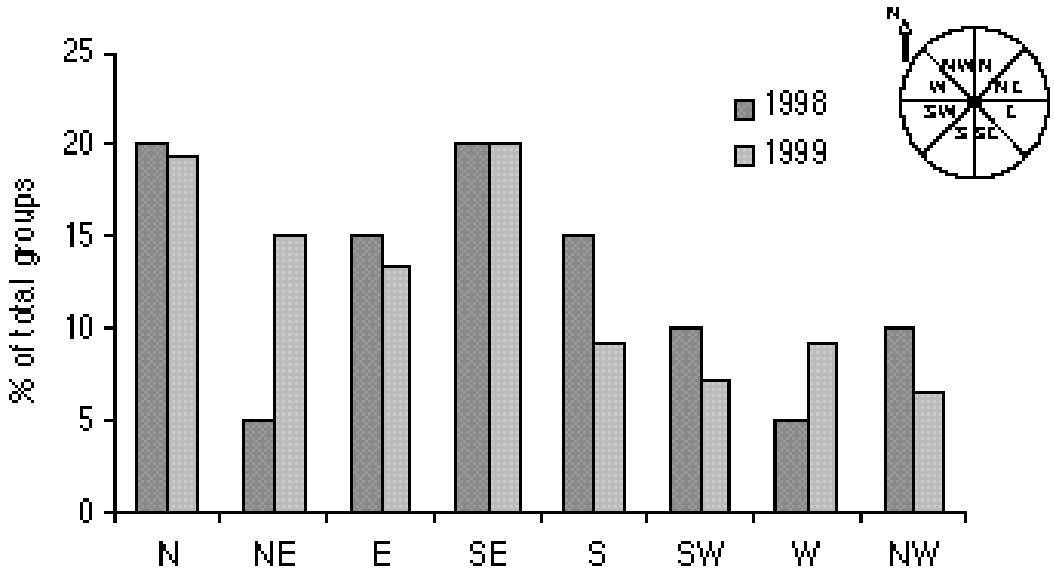

FIGURE 4.6. Distribution of tern feeding flocks around Rockabill in 1998 and 1999 (n = 20 and 165 flocks respectively).

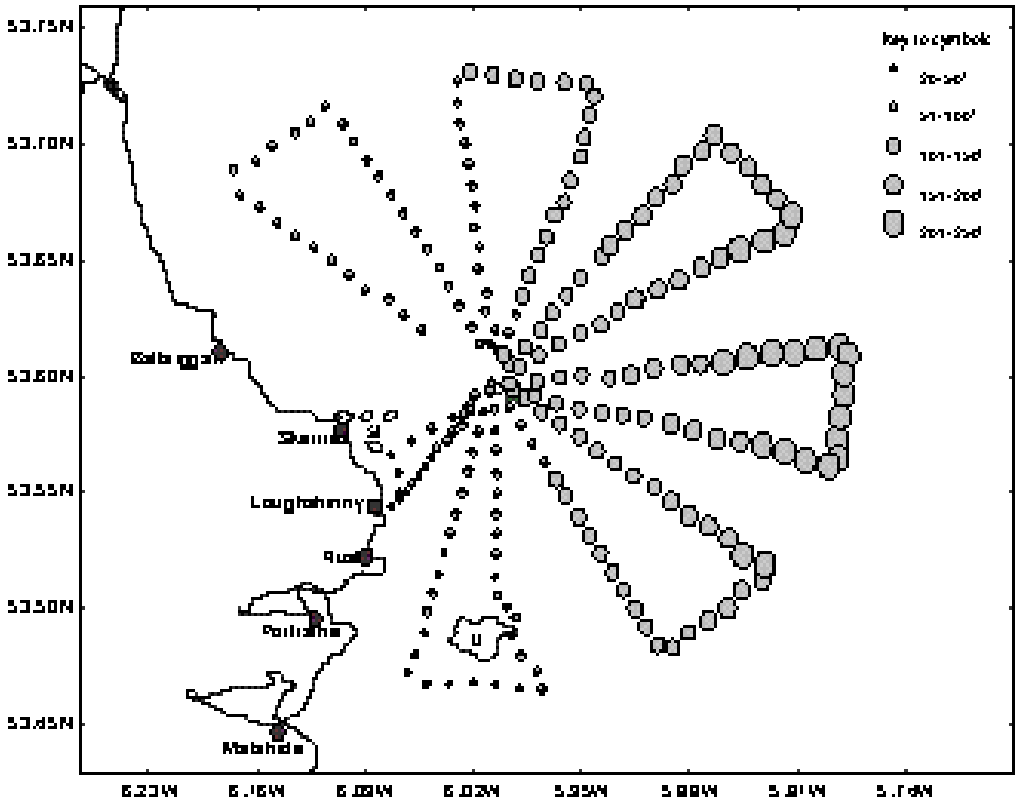

FIGURE 4.7. Water depth profile around Rockabill

Terns in feeding flocks in 1998 were not identified to species level. However, in 1999, flocks containing Roseate Terns were predominantly located between south and west sectors around Rockabill, with few seen feeding in flocks to the east and north (Fig. 4.8). In contrast, feeding flocks containing Common and Arctic Terns were relatively uniform around the island (Fig. 4.8).

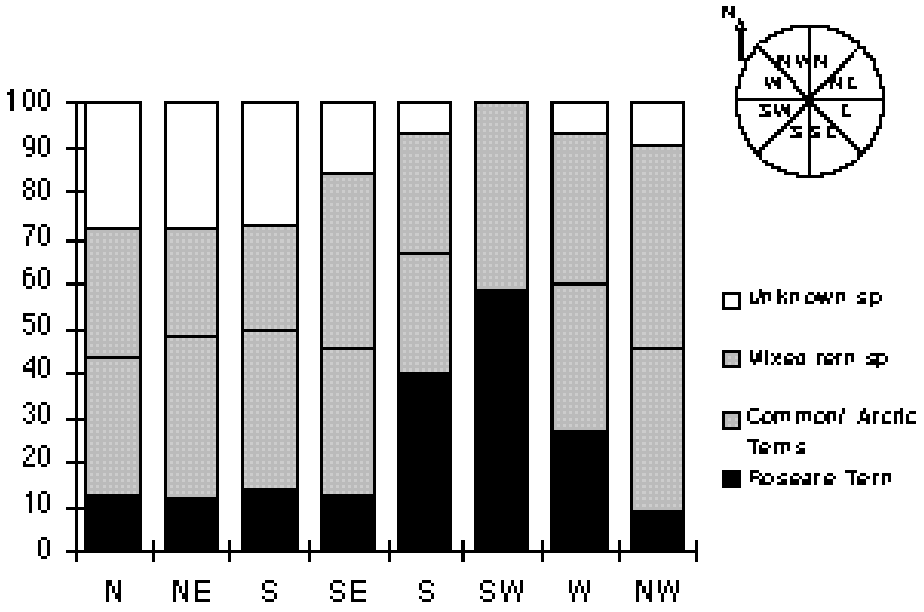

FIGURE 4.8. Percentage composition of Roseate and Common/ Arctic Terns within mixed feeding flocks (n = 165 flocks) between 27 July and 6 August 1999.

There were no obvious trends in individual tern movements, which were broadly uniform around the island in both years (Fig. 4.9). Large numbers of terns were seen heading to and returning from the north-east in 1998, while few were recorded in 1999. This result is contrary to that shown for feeding flocks above. Additionally, no terns were seen heading or returning due east of Rockabill in 1998, although there were considerable proportions of terns foraging in that direction in the same year (Fig. 4.9).

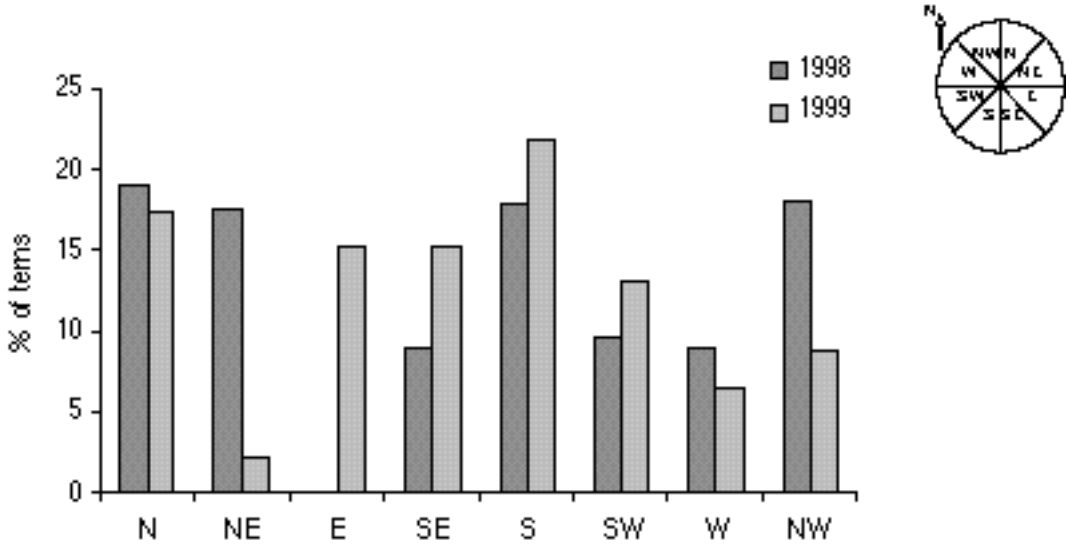

FIGURE 4.9. Percentages of individual terns heading to and returning from assumed feeding grounds in 1998 and 1999 (n = 140 and 46 terns respectively).

There was also very little consistency between the two seasons (1998 and 1999) in the movements of either Roseate or Common / Arctic Terns (Fig. 4.10).

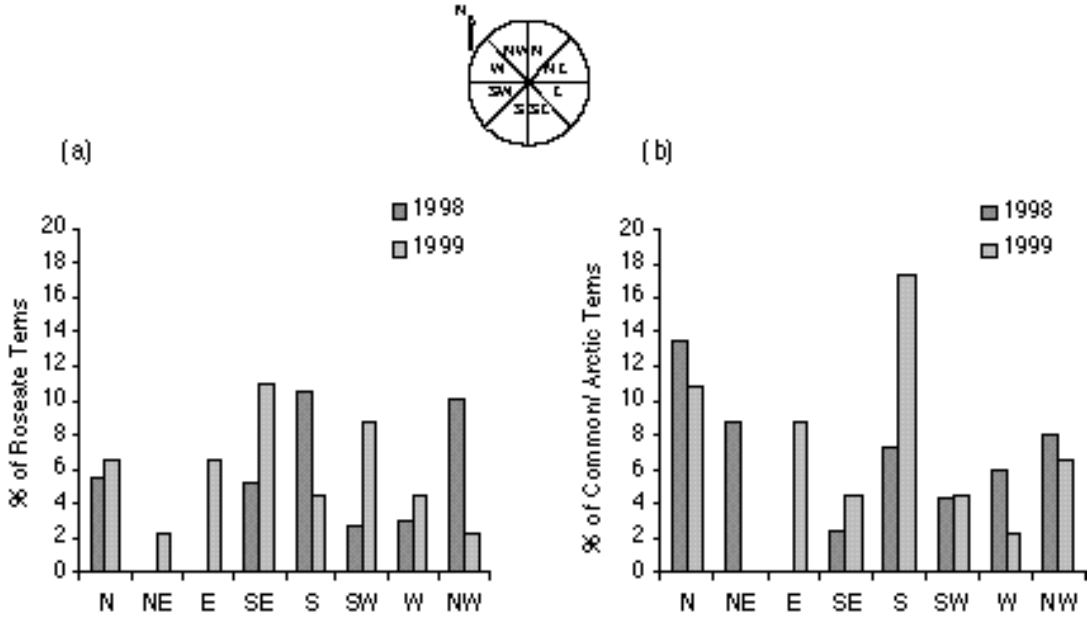

FIGURE 4.10. Percentages of individual (a) Roseate and (b) Common/ Arctic Terns heading to and returning from feeding grounds in 1998 and 1999.

In 1998, terns appeared to associate frequently with auks while feeding (Fig. 4.11). However, this finding was based on a small sample (just 20 feeding groups in 5.5 hours of observations). Nevertheless, auks were present in 50% of tern feeding groups, and overall, 75% of tern feeding groups contained other seabird species; gulls were present in 30% and Manx Shearwaters and Gannets *(Morus bassana)* were each present in 20% of tern feeding groups (Fig. 4.11). In contrast, over 70% of tern feeding groups in 1999 were tern only groups, with auks featuring in just 20%, and the other groups to a lesser extent (Fig. 4.11). This result was based on over 160 flocks.

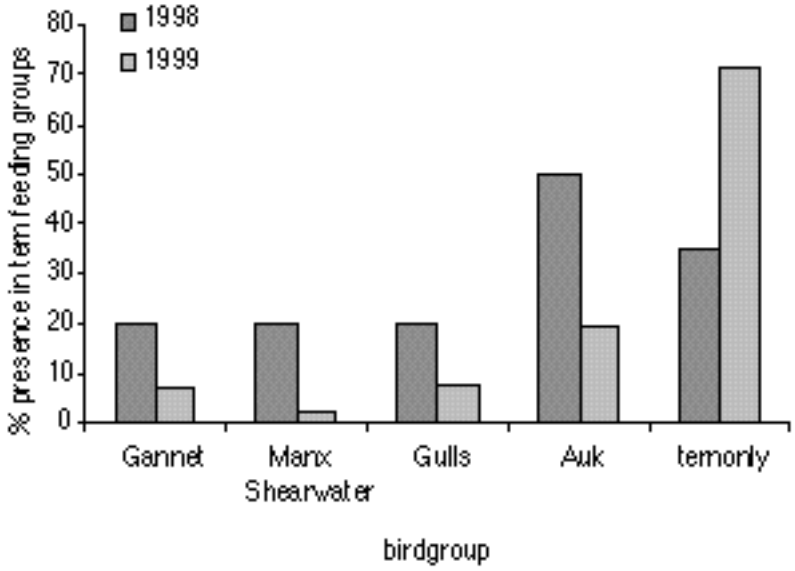

FIGURE 4.11. Proportion of tern feeding flocks containing other bird groups in 1998 and 1999.

On several occasions, Common and Arctic Terns in particular were also seen apparently tracking seals and foraging over large jellyfish in the waters around Rockabill.

4.3.3 Rockabill sea surveys

Greater proportions of terns were recorded feeding on their own during the 1999 surveys than in 1998 survey (45% in 1998, 70% in 1999), or in small tern-only groups of up to five individuals (Figs. 4.12 & 4.13). Consequently, in 1998 there were greater proportions of tern feeding groups containing six or more individuals (31% and 8% in 1998 and 1999 respectively).

In 1999, tern foraging flocks appeared to be much more dispersed around the island than in 1998 (Fig. 4.13). Terns appeared to forage more to the east and south-west, while most foraging activity in 1998 was apparent to the north and south-east (Fig. 4.13).

During all sea surveys, tern distribution was more concentrated around Rockabill, particularly for Roseate Terns (Figs. 4.15, 4.17 & 4.19). During radial surveys in 1999, 67% and 74% of terns were located within 3.5 km of Rockabill in June and July respectively, while 95% and 98% were within 9.5km (Fig. 4.14). No Roseate Terns were recorded more than 9.5 km away, and 47% and 26% of Roseate Terns were located in bands 1 and 2 respectively. Common and Arctic Terns were more dispersed during all surveys (Figs. 4.16, 4.18 & 4.20), and were recorded as far out as the 15.5km limit of radial surveys in 1999. However, as for Roseate Terns, Common and Arctic Terns were also more concentrated around Rockabill, and 36% and 29% were located within bands 1 and 2 respectively.

During the 1999 sea surveys, Roseate Terns were scattered all around Rockabill, particularly during the July survey (Fig. 4.19), and appeared to be less frequent in the north and north-west sectors (Figs. 4.17 & 4.19). Roseate Tern distributions during parallel July surveys in both years (during late incubation) were relatively disparate; in 1998, Roseate Terns had north-west/ south-east distribution (Fig. 4.15), while in 1999 their densities appeared higher and they were more scattered, and relatively high numbers were seen on the south side of the island, particularly in the south-east and south-west (Fig. 4.19). Roseate Tern densities were also higher, and their distribution was more scattered in July, relative to June 1999 (Fig. 4.15). In contrast, there were no obvious patterns in Common and Arctic Tern distribution around Rockabill (Figs. 4.16, 4.18 & 4.20).

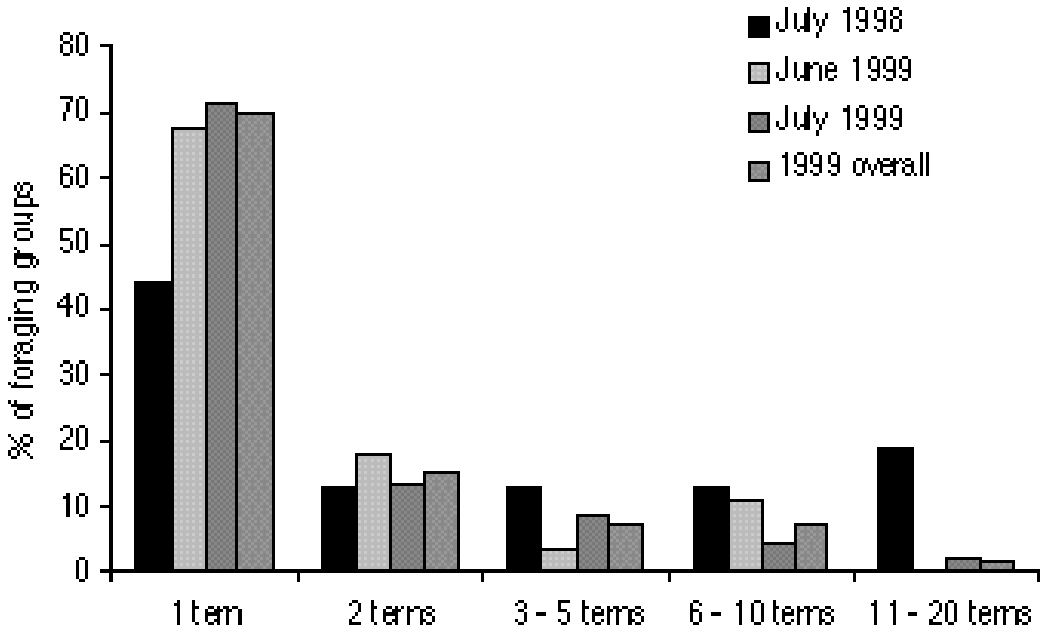

FIGURE 4.12. Size of tern foraging flocks around Rockabill during sea surveys on 14 & 15 July 1998 (n = 16 flocks), 9 & 10 June 1999 (n = 28 flocks) and 16, 22 & 23 July 1999 (n = 45 flocks).

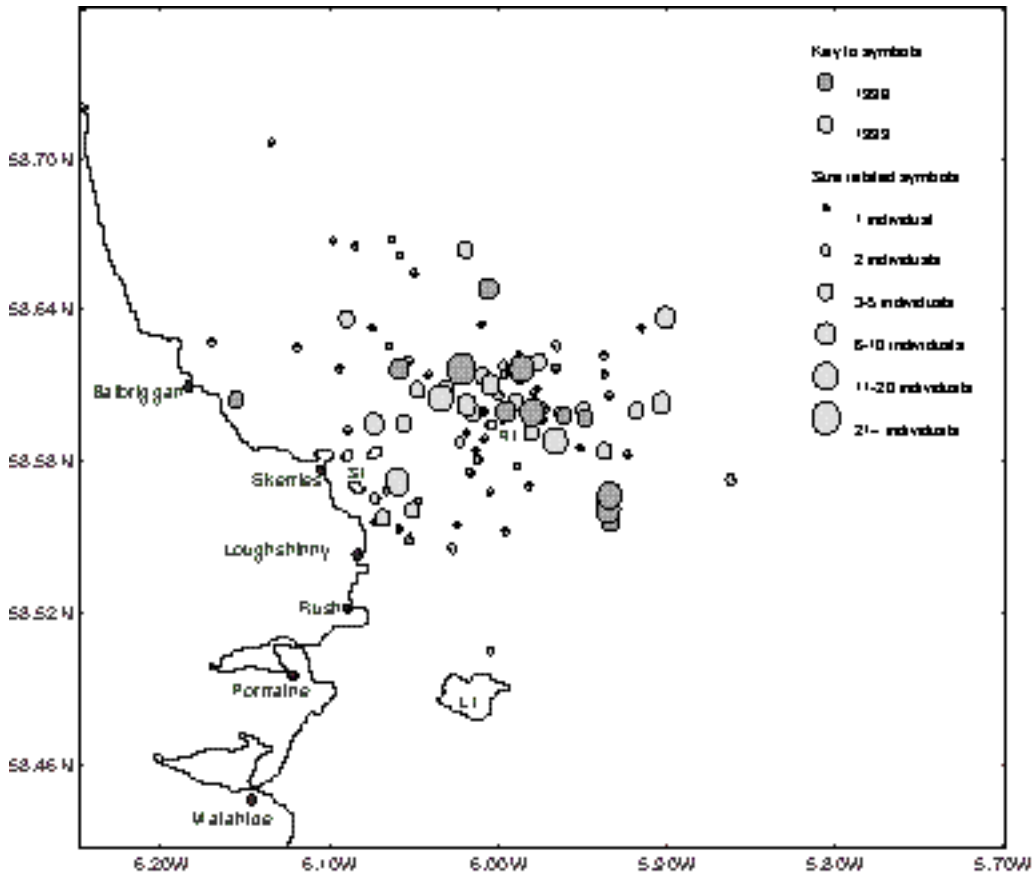

FIGURE 4.13. Location and size of tern foraging flocks around Rockabill on all sea surveys 1998 and 1999.

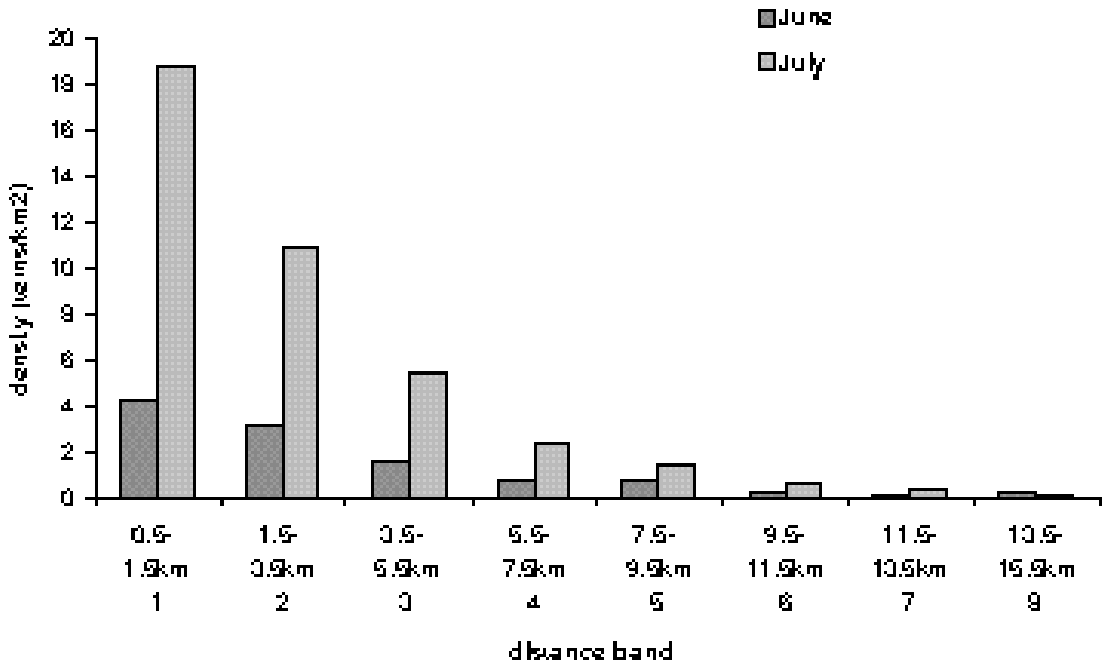

FIGURE 4.14. Change in tern density with distance from the Rockabill colony on 9 & 10 June and 16, 22 & 23 July, 1999.

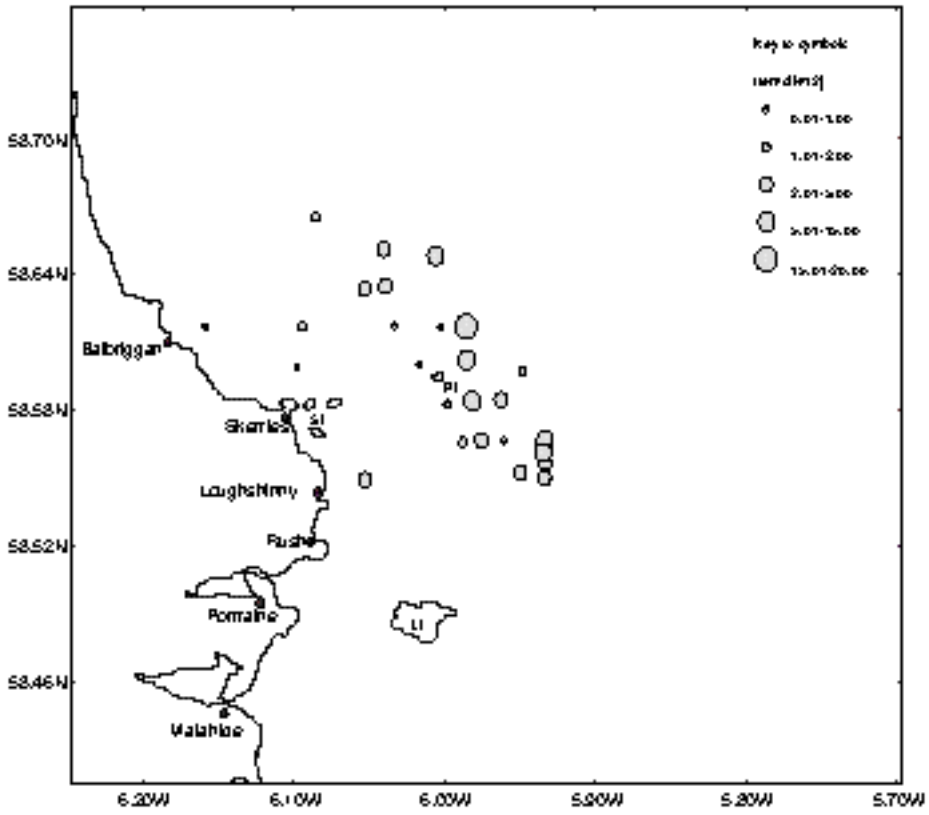

FIGURE 4.15. Roseate Tern density around Rockabill on 14 & 15 July 1998.

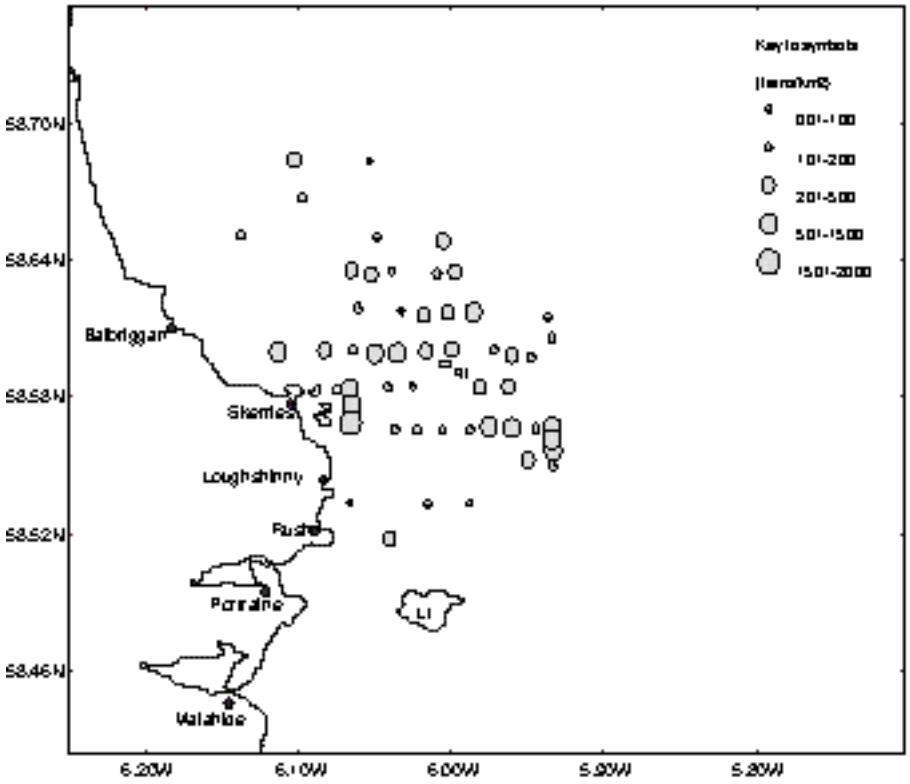

FIGURE 4.16. Common/ Arctic Tern density around Rockabill on 14 & 15 July, 1998.

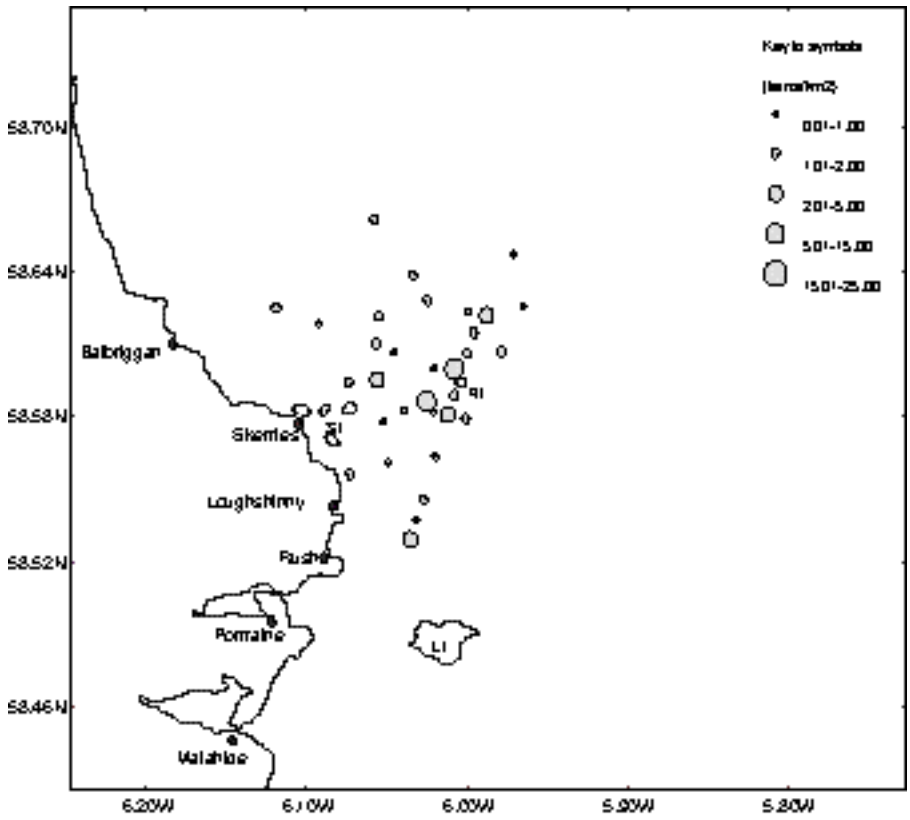

FIGURE 4.17. Roseate Tern density around Rockabill on 9 & 10 June, 1999.

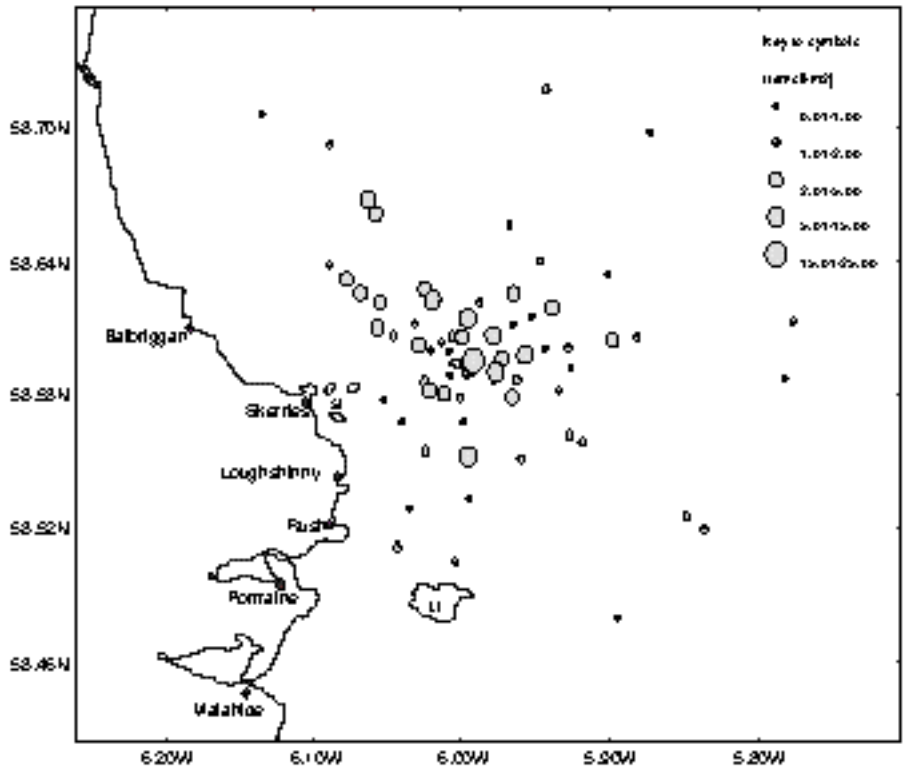

FIGURE 4.18. Common/ Arctic Tern density around Rockabill on 9 & 10 June 1999.

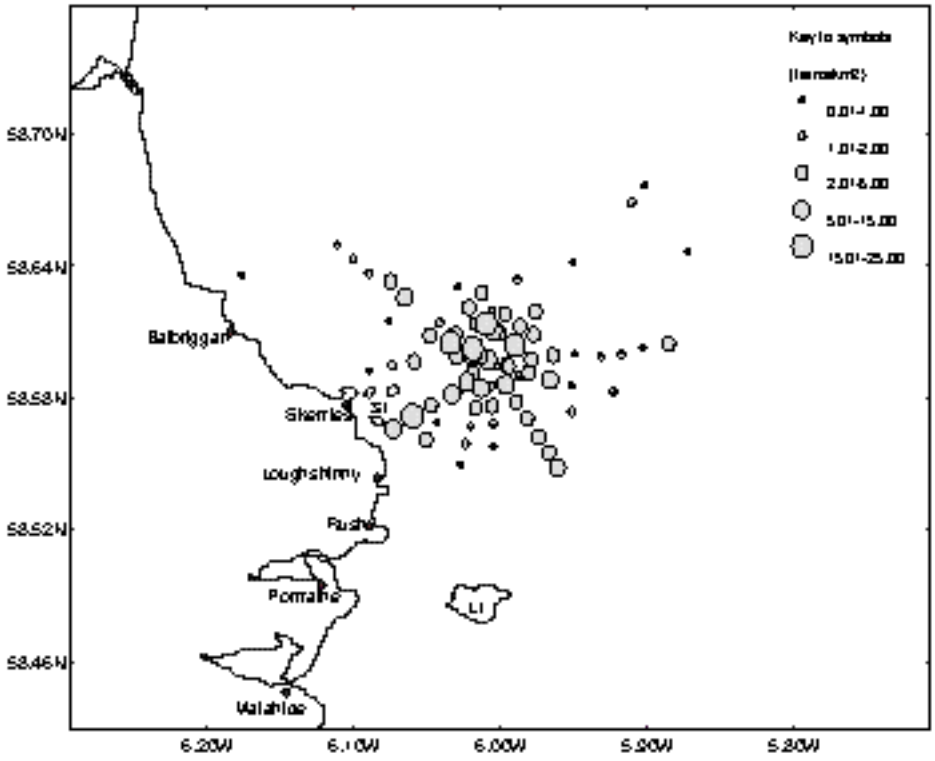

FIGURE 4.19. Roseate Tern density around Rockabill on 16, 22 & 23 July 1999.

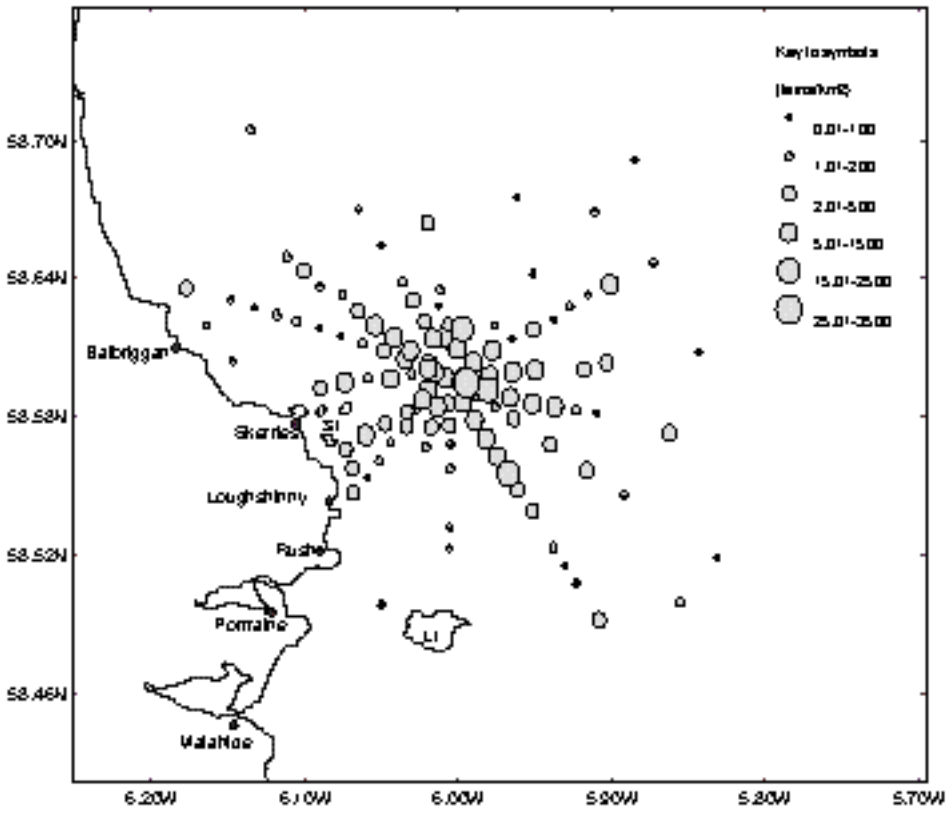

FIGURE 4.20. Common/ Arctic Tern density around Rockabill on 16, 22 & 23 July,1999.

4.3.4 Kish Bank sea surveys

Considerable numbers of terns were located around the Kish Bank in late August and early September, although densities and distributions varied between surveys (Fig. 4.21). Greater proportions of terns were distributed on the east side of the bank during the high tide in August, more concentrated around the bank at low tide in early September, and relatively sparse during the rising tide in early September (Fig. 4.21a-c). Roseate Tern distribution appeared to be relatively centralised around the lighthouse during all surveys (Fig. 4.22).

However, large numbers of Roseate, Common and Arctic Terns were recorded roosting on the Kish lighthouse, particularly in September. On 25 August at high tide there were 10 Roseate and 12 Common/ Arctic Terns, while during the rising tide on 3 September, 500 Roseate and 100 Common/ Arctic Terns were recorded. Around 1000 terns were estimated (during a tern dread) to be on the lighthouse at low tide in September. However, at that point, the terns were too far away to identify and quantify precisely.

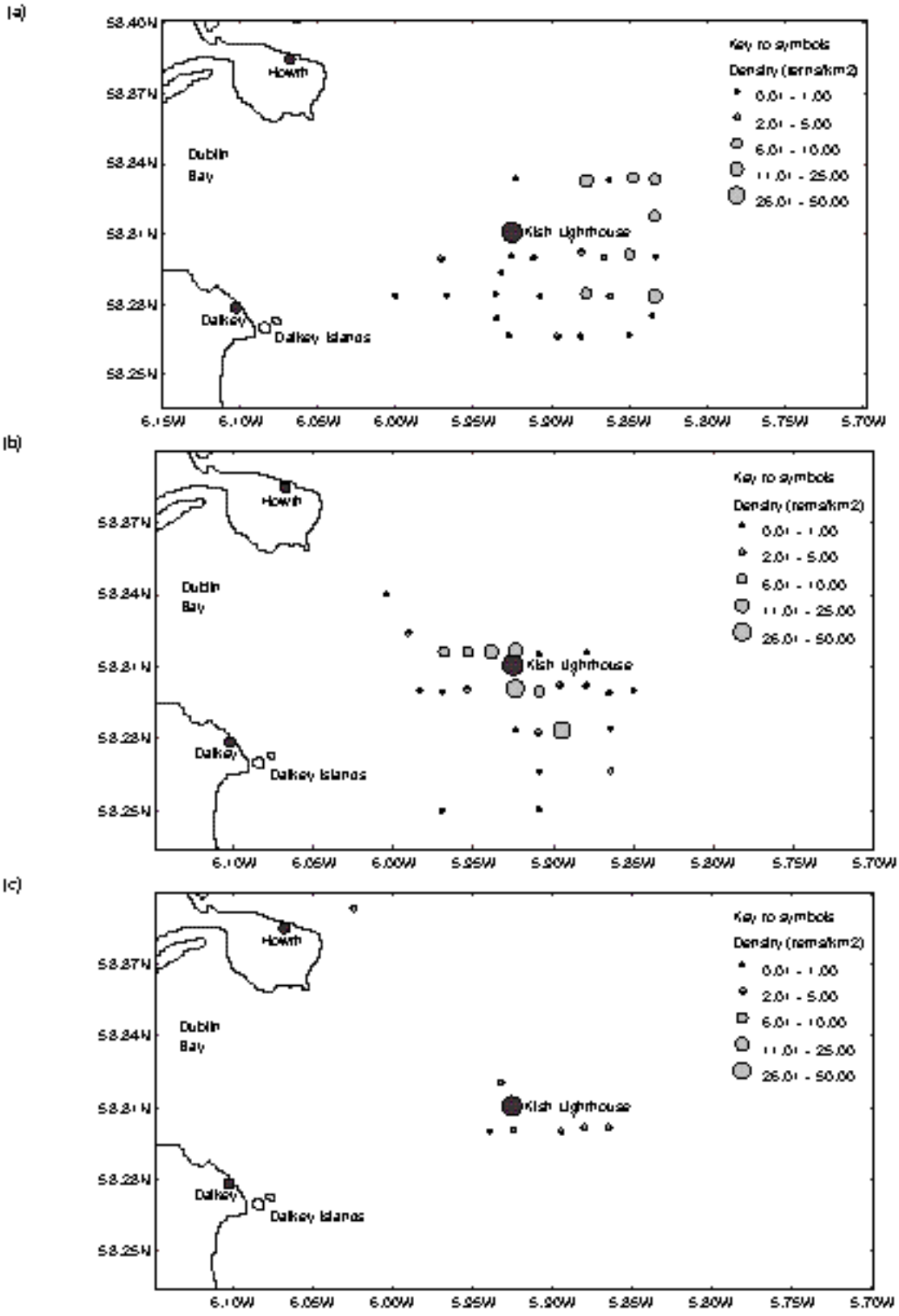

FIGURE 4.21. Tern distribution around the Kish bank in 1999 (a) at high tide on 25 August, (b) at low tide on 3 September and (c) on a rising tide also on 3 September.

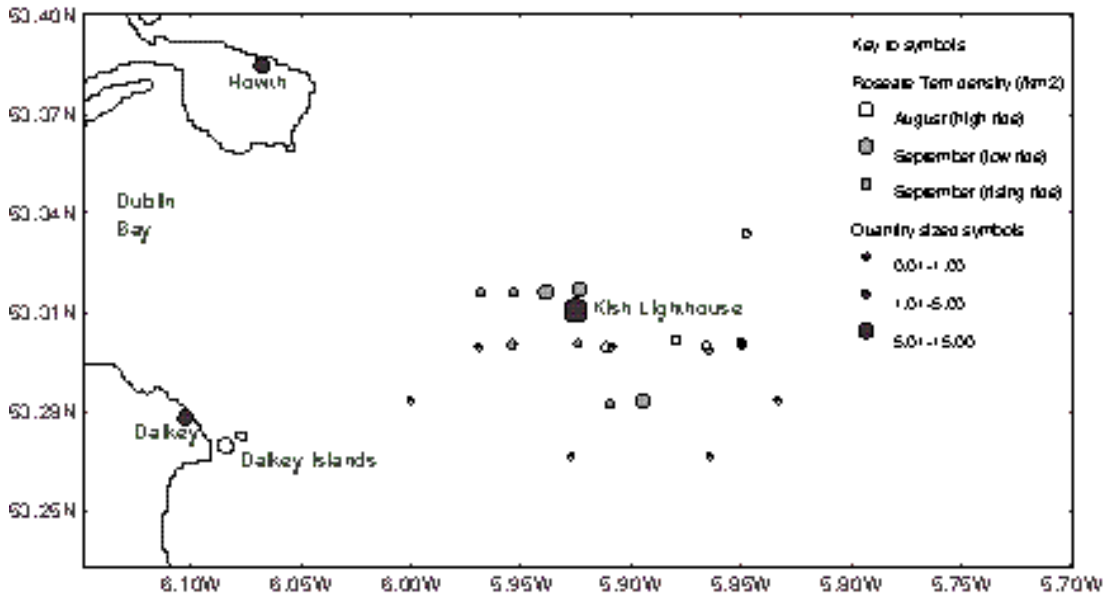

FIGURE 4.22. Roseate Tern densities around the Kish bank in August and September 1999.

4.3.5 Tern feeding behaviour at Cemlyn and Inland Sea

In 1998 and 1999, terns were observed feeding in the lagoon, inshore and out to sea throughout the breeding season at Cemlyn Bay. Mixed tern species flocks were usually associated with lagoon feeding, while both individuals and tern groups were described feeding in the bay, occasionally in association with Red-breasted Mergansers *(Mergus serrator)*. Individual terns were recorded feeding along the coast, particularly at low tide, while large groups of up to 200 Sandwich Terns and much smaller groups of Common and Arctic Terns were recorded feeding up to 2 - 3km out to sea.

At the Inland Sea in 1998, Common and Arctic Terns were predominantly seen feeding on either side of the Stanley Embankment, usually on the opposite side from which the water was flowing (ie on the south side on a rising tide and vice versa). Maximum feeding on the south side of the embankment was observed when the water was in maximum flow, three hours after low tide. Common and Arctic Terns were also observed foraging over shallow water around the shore of the Inland Sea. However, despite equally extensive observations in 1999, relatively few feeding terns were seen.

4.4 DISCUSSION

Our surveys in 1998 were intended to map the distribution of terns within 10km of the colony but principally biased towards inshore and shallower waters as a result of findings in the US (Safina 1990). Somewhat contrary to our expectations, most terns were located over relatively deep water (20-30m), moderately close to the colony, and very few were present in shallow waters close to the mainland or around neighbouring islands. Many terns appeared to forage in association with other seabird species, primarily auks which are able to dive to much greater depths than terns, and in the process they probably drove tern prey such as Sprats and small gadoids to the surface. The simultaneous presence of predatory fish could not be ruled out but given that Irish Sea Cod *(Gadus morrhua)* stocks are known to be very low and local fishermen considered 1998 to be a poor year for Mackerel *(Scomber scombrus)*, then deep-diving birds appear to be the most plausible cue that terns use to identify productive foraging areas. Some of the larger foraging aggregations detected during the boat surveys were also seen by observers on both Rockabill and Lambay. However, our surveys were only a snapshot of foraging activity relatively late in the breeding season and temporal and spatial dynamics over a longer period could not be assessed. Limitations of this method include the possibility that some factor, e.g. tide, weather or diurnal cycle of the birds, co-varied with bird behaviour as survey transects moved away from Rockabill. In addition, given that it took more than one day to complete each survey, the possibility that terns recorded on transects during day one were subsequently using the transects covered during day two cannot be dismissed.

In 1999, our sea surveys covered two periods in the nesting cycle, incubation and chick rearing, and by using a radial pattern of transects we were able to sample both near-colony and more distant areas in a

short space of time thereby minimising confounding effects regarding diurnal cycles and tides. We also hoped to discover a maximum foraging range. During both surveys, June and July, terns appeared much more widespread and less clumped than they had been in July 1998. The majority seemed to forage on their own, or with one or two others, and there was greater use of shallower waters. The lack of association with other seabirds implied that small fish were widely available near the surface, and the mechanism producing this could be either predatory fish, given Mackerel were much more numerous in 1999, or something intrinsic to the prey fish shoals themselves. In July we were confident that most terns were foraging within 9km of the colony, but during incubation in June, a fair proportion of off-duty birds may have been foraging much further afield than 15km, perhaps exploiting sandeels on the Kish and Bennet Banks which are south of Rockabill.

The Kish Bank is certainly used later in the summer when young have fledged, and the local population is probably joined by others from elsewhere in the Irish Sea and beyond (Newton and Crowe 1999). Surveys of such areas 20-30km from the colony need to be conducted in May and June, before the majority of terns have started to nest, and should be a future research priority. The recent interest expressed in near-shore banks in the western Irish Sea by power-generation consortia, as suitable sites for large scale windfarms, should ensure that this survey work is undertaken as part of the EIA process. Clearly, the Rockabill terns are able to use a variety of foraging strategies depending on fish behaviour and abundance. Our land-based observations in the vicinity of Lady's Island Lake in 1998 (Newton *et al*. 1998) indicated that foraging Roseate Terns were most frequently located around Black Rock and Barrels Rock, about 5km south of the colony and 3km offshore. We would tentatively allocate this strategy to foraging over tide rips, but clearly surveys at sea are needed to ascertain whether or not the majority of Roseate Terns are using these shallow water reefs, or if this is simply the only part of a more extensive foraging area that is visible from land.

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5. OVERVIEW AND RECOMMENDATIONS

The focus of this INTERREG project was to enhance the conservation status of the Roseate Tern in the Irish Sea. Our aims were broadly threefold:

1) Improve colony management and protection and, if possible, restore former nesting sites

2) Boost research and monitoring of numbers, breeding productivity, feeding ecology, survival and movements of Roseate Terns

3) Extend observations of Roseate Terns into the wider marine environment to further our understanding of the distribution of Roseate Terns at sea and identify important foraging areas.

The preceding three chapters give full accounts of our work towards these aims. In an attempt to identify the shortcomings of the present study and potential topics for future study and collaboration between the INTERREG partners, an *"Irish Sea Tern Workshop" (ISTW)* was held in Holyhead (Anglesey) on 30 March 2000. The scope of the meeting was both to summarise conservation action and findings (seven presentations) and conduct thematic discussions (see workshop programme appended to the end of this chapter, together with the list of participants).

5.1 COLONY MANAGEMENT

An overview of the status of each of the seven tern colonies managed for Roseate Terns as part of the INTERREG Project is presented in Table 5.1. During the three year period, no site changed categories, despite the efforts described in Chapter 2. Clearly, Roseate Terns prefer the sites they presently utilise and are not easily persuaded or lured to relatively recently occupied colonies, nor to historical or alternative sites. Although Roseate Terns failed to respond to our conservation actions at historical/alternative sites, other tern species at each of the five key sites (excluding Dalkey Island and Inland Sea) thrived over the three years and demonstrated sustained population increases and improved productivity. Given Roseate Terns always nest in association with other tern species, then the health of the Irish Sea Sandwich, Common and Arctic Tern populations are vital to the future of the Roseate Terns.

Thriving	"Ticking over"	Intermittent	Restoration
Rockabill (CT)	Ynys Feurig (CT, AT)	Skerries (AT)	Dalkey Island
Lady's Island Lake (ST, CT, AT)		Cemlyn Bay (ST)	Inland Sea

Table 5.1 Status of Roseate Tern colonies managed in the INTERREG Project, with other species of national importance at each site. Key: ST = Sandwich Tern; CT = Common Tern; AT = Arctic Tern.

Increased conservation action at both Dalkey Island and the Inland Sea, including the use of tape lures and decoys at the former, did not yield a positive response from any species including the relatively small number of Common and Arctic Terns that nest there. Thus, future efforts could be scaled back to pre-1997 levels, though annual monitoring of numbers, predators and threats should be continued in case Roseate Terns show interest. Recent road improvements between Holy Island and Anglesey (across the Stanley Embankment) have impacted the Inland Sea. However, mitigation measures have included the creation of a new shingle island from a "peninsula". The usage of the new island by terns ought to be followed closely.

Construction of new islands was discussed at the ISTW, but the consensus was that there was little point in attempting to encourage recruitment to new sites unless extant colonies were at carrying capacity, seriously threatened by predators or competing species (e.g. gulls), or if colony managers are unable to provide the appropriate habitat due to vegetational succession. Sea level rise could also threaten the integrity of the shingle barriers at Lady's Island Lake and Cemlyn Bay and any breach could have serious repercussions for the tern colonies in the lagoon islands. Such threats reinforce the need to keep all colonies, that in the last decade or two have held reasonable numbers of Roseate Terns (Ynys Feurig and Skerries), appropriately managed and available, and to be prepared to resume intensive management at Dalkey Island and the Inland Sea if necessary.

5.2 RESEARCH AND MONITORING METHODOLOGIES

The only colony at which intensive research and monitoring on RoseateTerns proved feasible was Rockabill, a relatively remote site. Although reasonable numbers of Roseate Terns were present at Lady's Island Lake and lesser numbers were at Ynys Feurig, difficulties of access to the nesting islands (boating regulations, tides and weather) precluded all but baseline monitoring. Sites such as Cemlyn Bay, which are crossed by public rights of way, required wardens to spend considerable time in liaison with the public and thus reduced time available for work in the colony. However, at Skerries, similar to Rockabill, wardens were able to spend more time in carrying out research on the large colony of Arctic and Common Terns.

The ISTW agreed that, where possible, all data gathering on tern productivity and feeding ecology should be done using standardised common methodologies, which will enable more rigorous comparisons between colonies and across the Irish Sea. A fieldwork manual for Roseate Tern research has been available for some time (Ratcliffe and del Nevo 1995), but perhaps it is now time for an updated version, more geographically focused in the Irish Sea, and broadened in scope to include the other tern species, i.e. Sandwich, Common and Arctic Terns. However, at sites where changes are implemented, there should be a commitment to ensure they will be upheld for a sufficiently long time-period to justify the interrupion of a relatively long series of data already collected at that site.

Other differences in staffing between Ireland and Wales need to be overcome before equal effort can be put into future research and monitoring programmes. Wardening staff in Ireland are trained by project managers to ring and handle (weigh and measure) tern chicks at their colonies. Repeat captures of marked birds are needed in most methodologies for assessing breeding productivity. In Welsh colonies, ringing has traditionally been done by local amateur bird ringers working independently but co-ordinated by site managers. There would be a clear benefit in trying to recruit qualified, or at least trainee, ringers to the wardening positions on Anglesey and also encourage some of the managers to get involved in this component of the work programme.

5.3 TERNS AT SEA

The mapping of terns at sea (TAS) project around Rockabill proved highly successful and produced interesting results. Clearly, our relatively small budget only permitted the charter of a small seaworthy survey vessel and data could only be gathered on bird species and numbers, location and water depth. An increased survey budget would possibly enable more information to be collected, for example acoustic surveys of fish or plankton production. A great deal of analysis and interpretation still remains to be done on the 1998 and 1999 terns at sea data. The ISTW suggested that the distributional patterns of terns should be overlain with satellite images or other remotely sensed data of sea temperature and plankton productivity, which ought to show correlations with concentrations of small prey fish species (sandeel and sprat shoals) exploited by the terns.

Under the Birds Directive, EU States are obliged to identify important concentrations of birds, both on land and in territorial waters, and designate special protection areas (SPAs) for them. Under this Directive, all terns are high priority Annex 1 species. Thus our spatial information on Roseate and Common Terns around Rockabill could be an important initial building block on which to identify provisional boundaries of a marine SPA that emcompasses the principal foraging area for a large proportion (approximately 70%) of the NW European Roseate Tern population whilst they are nesting on Rockabill. Marine SPAs have already been designated in Denmark for seaducks, and in the UK one statutory authority, Scottish Natural Heritage, is tackling the question of marine SPAs encompassing feeding areas around large seabird colonies (N. Harding pers. comm.). Those in Wales (CCW) and Ireland (Dúchas - The Heritage Service) have yet to address this potential European Union obligation in detail. Extension of Rockabill type TAS surveys to sea areas surrounding Lady's Island Lake and North and West Anglesey colonies would provide the appropriate baseline information for these internationally and nationally important tern colonies.

5.4 OVERALL RECOMMENDATIONS

The joint Non-Governmental Organisation (NGO) / Statutory Authorities partnership that has steered the Irish Sea INTERREG Roseate Tern Project continues to function as the year 2000 tern breeding season approaches. Alternative sources of funding have been found to support basic wardening and Research and Monitoring at the five key colonies in the short- to medium-term. Following three years of intensive work, many more questions than answers still pervade our overall understanding of the dynamics of Irish Sea tern populations. Some of the major themes for further investigation are given below, together with brief justification.

a) **Establish an Integrated Population Monitoring Programme for all Irish Sea tern species.** This expands detailed work on Roseate Terns at Rockabill to other species (Sandwich Tern, Common Tern, Arctic Tern and perhaps Little Tern) and to all key colonies where detailed research and monitoring are feasible, e.g. Lady's Island Lake, Skerries and if possible Ynys Feurig and Cemlyn Bay. Both Sandwich and Little Tern populations in the UK and Ireland are threatened and in decline (Ratcliffe *et al.* in press). Very little recent data are available on survival rates and demography, breeding productivity, diet, feeding areas, energetics and the impact of kleptoparasitism for all species other than Roseate Terns.

The introduction of special ringing schemes, permitting individual identification without the need for recapture, for some of these species should be evaluated.

b) **Expand the breeding season terns at surveys (TAS) to cover Lady's Island Lake, Co. Wexford, North and West Anglesey** and extend the coverage around Rockabill (to include the Kish Bank in the courtship/early incubation period i.e. late May). Furthermore, extend coverage to include important post-breeding staging areas in August-September, notably the Greater Dublin Bay area (Kish, Bray and Burford Banks) and possibly Liverpool Bay. Establish a Geographical Information System to incorporate all the tern distributional data with other physical and biological marine datasets.

c) **Re-open studies of extent and intensity of tern trapping in West Africa, especially Ghana,** where Roseate Terns concentrate in autumn and winter, given it is the poor survival of immature birds that appears to be preventing the Irish Sea Roseate Tern population from recovering. The RSPB have recently agreed to initiate a two year pilot study of this problem in Ghana, commencing autumn 2000.

5.5 REFERENCES

Ratcliffe, N. and del Nevo, A. 1995. A fieldwork manual for research work on Roseate Terns in Europe. RSPB Report, Sandy, U.K.

Ratcliffe, N., Pickerell, G. and Brindley, E. (in press). Population trends of Little and Sandwich Terns in Britain and Ireland from 1969 to 1998. Atlantic Seabirds.

5.6 IRISH SEA TERN WORKSHOP

"Roseate Terns - The Natural Connection"

Ucheldre Centre, Holyhead: Thursday, 30 March 2000

Programme
Morning Session 10:00-13:00, Chairman Oscar Merne

10:00	Oscar Merne	Welcome
Site Reviews		
10:10	Stephen Newton	Rockabill, Lady's Island Lake & Dalkey Island
10:25	Chris Wynne & Alastair Moralee	Cemlyn Bay, Ynys Feurig, Skerries & Inland Sea
10:40	Julianne Evans	View from the North Sea - Coquet
10:50	Workshop session 1:	Colony-based conservation actions/ predator control
11:30	Coffee break	
11:50	Olivia Crowe	Introduction to workshop session 2 - experiences from Rockabill
12:10	Workshop session 2:	Methodologies for assessing Tern Productivity & Feeding Ecology [facilitators SN, NR]
12:40	Norman Ratcliffe	Benefits of ringing & ring-reading Roseate Terns
13:00	Lunch	

Afternoon Session 14:00-17:00, Chairman John Ratcliffe

14:00	Stephen Newton	Terns at Sea....When, Where & Why?
14:20	Workshop session 3:	Terns at Sea - Uses and application of data collected; terns and fisheries/oceanography [SN,PH,IR]
15:00	Norman Ratcliffe	The Ghana Connection
15:20	Coffee break	
15:30	Workshop session 4:	Life after INTERREG II - recommendations to the EU for continuing tern conservationaction and research in the Irish Sea. [SN]
17:00	John Ratcliffe	Summing up and close

Workshop Participants

IWC-BirdWatch Ireland:

Stephen Newton	Irish Sea Roseate Tern Research & Project Co-ordinator
Olivia Crowe	Senior Warden, Rockabill

North Wales Wildlife Trust (NWWT):

Chris Wynne	Reserves Manager
Eleri Stonehewer	Administrative Officer

Royal Society for the Protection of Birds (RSPB):

Alastair Moralee	Senior Warden, Anglesey
Ian Sims	Warden, Valley Wetlands
Norman Ratcliffe	Research Department
Julianne Evans	Reserves Ecology Department
Reg Thorpe	Habitats & Species Officer, Wales
Glynn Jones	former warden, Inland Sea & Ynys Feurig
Damon Bridge	former warden, Ynys Feurig
Dan Carrington	former warden, Ynys Feurig
Emyr Jones	Warden, Skerries; former warden Inland Sea

Countryside Council for Wales (CCW):

John Ratcliffe	District Officer, Anglesey

Dúchas – The Heritage Service:

Oscar Merne	Head, Bird Research, National Parks & Wildlife

Marine Institute:

Paul Hillis	Fisheries Biologist

University of Wales, Bangor:

Ivor Rees	Senior Lecturer, Oceanography

6. APPENDICES

APPENDIX 1. ACKNOWLEDGMENTS

This project would not have been possible without the help of many people. We would like to thank the following:

The EU Maritime Ireland/ Wales INTERREG Programme (1994 – 1999) whose generous funding support enabled this project to be undertaken.

The Roseate Tern INTERREG Steering Group: Oscar Merne, Alastair Moralee, Oran O'Sullivan, John Ratcliffe, Norman Ratcliffe and Chris Wynne for advice and support.

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And lastly, thanks to all the volunteers who assisted in a wide variety of ways towards the successful completion of this project, and apologies to anyone omitted from the above lists.

APPENDIX 2. OUTPUTS

A2.1 Talks and Presentations

14 June 1997	BirdWatch Ireland AGM, Dalkey "Roseate Terns" (S. Newton)
8 November 1997	3rd Ornithological Research Conference, UCC, Cork "Tern Research in Ireland" (S. Newton)
12 January 1998	Wicklow Branch, BWI, Greystones "Terns: their Ecology and Conservation" (S. Newton)
18 June 1998	INTERREG Workshop, Marine Institute, Dublin "Roseate Terns: the Natural Connection" (S. Newton)
22 October 1998	Colonial Waterbird Society Annual Meeting, Miami, Florida "Prey Fish and the Spatial Distribution of Foraging Areas of Roseate Terns Breeding at Irish Sea Colonies: a Preliminary Overview" (S. Newton)
22 October 1998	Colonial Waterbird Society Annual Meeting, Miami, Florida "Estimates of survival and natal fidelity of Roseate Terns Sterna dougallii from resighting data" (N. Ratcliffe)
15 April 1999	Seabird Monitoring Programme 10th Anniversary Symposium, Durham "Tern Population Trends in Britain and Ireland during a 30-year Study" (N. Ratcliffe, G. Pickerell & E. Brindley) "Seabird Monitoring in Ireland" (O.J. Merne)
23 December 1999	British Ecological Society Winter Meeting, Leeds "Population Ecology of Roseate Terns in Northwest Europe" (N. Ratcliffe)
1997 – 1999	8-10 talks given per year to local groups in North Wales on Bird Conservation Partnerships and the importance of EU/INTERREG funding (M. Parry & C. Wynne)
1997-1999	2-3 talks given per annum to local groups on Anglesey (A. Moralee & I. Sim)
17-19 March 2000	7th Seabird Group Conference, Wilhelmshaven, Germany "Irish Sea Roseate Tern Project 1996-1999: the role of food supply, foraging behaviour and weather on reproductive success" (S. Newton, O. Crowe & N. Ratcliffe). "Demography of the N.W. Atlantic Roseate tern Sterna dougallii metapopulation" (N. Ratcliffe, S. Newton & R. Green)
30 March 2000	Final Meeting, Ucheldre Centre, Holyhead, "Irish Sea Tern Workshop – Are terns (Sternidae) good indicators of the health of the health of the Irish Sea ecosystem?"

A2.2 Published and unpublished articles, reports and leaflets

BirdWatch Ireland Magazine

MacLoughlainn, C. 1996.	EU funds Irish Sea tern project. Wings 3: 5.
Anon. 1997.	INTERREG tern officer appointed. Wings 5: 5.
Newton, S. 1997.	Rare terns in the pink. Wings 6: 12.
Newton, S. 1997.	Ireland-Wales teamwork protects Irish Sea terns. Wings 7: 12.
Newton, S. 1998.	Tern protection plans for '98. Wings 9: 11.
Newton, S. 1998.	Dalkey terns try again. Wings 10: 12.
Newton, S. 1999.	Terning up trumps. Wings 14: 13.

Other Articles

Archer, E. 1998. Briefings – Roseate Tern. Subsea – Ireland's Diving Magazine No. 95: 5.

Coffey, C. & Newton, S. 1999. Case Study 11. In, EU Structural Funds 2000-2006: Conserving Nature, Creating Jobs. Institute for European Environmental Policy, London.

Wynne, C. 1998. INTERREG tern project at Cemlyn Bay. Natur (NWWT Newsletter) No.101 (January).

Project Reports (1997)

Archer, E. 1997. Dalkey Island Tern Report 1997. BirdWatch Ireland Conservation Report No. 97/5: 8pp.

Aspey, N., Wallace, E. & Newton, S.F. 1997. Lady's Island Tern Report 1997. BirdWatch Ireland Conservation Report No. 97/4: 52pp.

Aspey, N. 1998. Lady's Island Lake Tern Report 1997: Appendices. BirdWatch Ireland Conservation Report No. 98/9: 70pp.

Jones, W.G. 1997. Inland Sea Annual Report 1997. RSPB Report:14pp + maps & appendices.

Lewis, H. & Smithies, A. 1997. Cemlyn Nature Reserve Warden's Report 1997. North Wales Wildlife Trust Report: 47pp.

Mundy, R. & Millett, J. 1997. Rockabill Tern Report 1997. BirdWatch Ireland Conservation Report No. 97/3: 28pp.

Murray, T. & Bridge, D. 1997. Ynys Feurig Annual Report 1997. RSPB Report: 16pp + maps & appendices.

Rayment, P. & Pinder, S. 1997. Skerries Annual Report 1997. RSPB Report: 70pp.

Project Reports (1998)

Crowe, O., Aspey, N. & Newton, S.F. 1998. Rockabill Roseate Tern Report 1998. BirdWatch Ireland Conservation Report No. 98/2: 35pp.

Malsom, R. & Pinder, S. 1998. Skerries Annual Report 1998. RSPB Report: 53pp.

Munns, D. 1998. Inland Sea Annual Report 1998. RSPB Report: 18pp + maps & appendices.

Newton, S.F., Mullarney, K. & Crowe, O. 1998. Tern movements around Carnsore Point, Co. Wexford, May-July 1998. BirdWatch Ireland Conservation Report No. 98/3: 13pp.

Rankin, G.A. & Jones, H. P. 1998. Cemlyn Nature Reserve 1998 Season Report. North Wales Wildlife Trust Report: 97pp.

Rayment, P. & Jones, G. 1998. Ynys Feurig Annual Report 1998. RSPB Report: 22pp + maps & appendices.

Stammers, B. & Newton, S.F. 1998. Lady's Island Lake Tern Report 1998. BirdWatch Ireland Conservation Report No. 98/8: 44pp.

Project Reports (1999)

Bateson, D. & Carrington, D. 1999. Ynys Feurig Annual Report 1999. RSPB Report: 42pp.

Burton, P. & Malsom, R. 1999. Skerries Annual Report 1999. RSPB Report: 52pp.

Crowe, O., Jones, V. & Newton, S.F. 1999. Rockabill Roseate Tern Report 1999. BirdWatch Ireland Conservation Report No. 99/6: 45pp.

Davies, S. & Bulbert, M. 1999. Cemlyn Nature Reserve 1999 Season Report. North Wales Wildlife Trust Report: 87pp + appendices, maps & photographs.

Jones, G.E. 1999. Inland Sea Annual Report 1999. RSPB Report: 75pp.

Newton, S.F. & Crowe, O. 1999. Kish Bank: A Preliminary Assessment of its Ornithological Importance. BirdWatch Ireland Conservation Report No. 99/8: 8pp + 13 pages maps.

Newton, S.F., Daly, D. & Crowe, O. 1999. Ornithological Monitoring at Carnsore Point, Co. Wexford, April-July 1999. BirdWatch Ireland Conservation Report No. 99/7: 20pp.

Management Plans (2000)

Jones, W.G. 1997. Inland Sea Draft Management Plan. RSPB Report: 34pp + maps & appendices.

Moralee, A. (in prep.). Five year reviews for Ynys Feurig and Skerries. RSPB.

Newbery, P., Ratcliffe, N. & Peet, N. 1999. International (East Atlantic) Action Plan for the Roseate Tern Sterna dougallii. RSPB/BirdLife International, Sandy, U.K.

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Abstracts: Third (Irish) Ornithological Research Conference (1997)

[All published in Irish Birds Volume 6, Number 1 (1997); page numbers only given below.]

- Roseate Terns: The Natural Connection. (p.142)
- Rockabill Island Tern Colony, Co. Dublin 1995 - 1997. (p.142-143)
- Lady's Island Lake Tern Colony, Co. Wexford, 1993 - 1997. (p.143)
- Growth, Survival, Provisioning Rate and Diet of Roseate Tern Chicks at Rockabill, Co. Dublin. (p.141)
- The 1995 All-Ireland Tern Survey. (p.129-130)
- Little Tern Protection and Monitoring Schemes on the Irish East Coast 1993 - 1997. (p.119-120).

Published paper

Hannon, C., Berrow, S.D. & Newton, S.F. 1997. The status and distribution of breeding Sandwich Sterna sandvicensis, Roseate S. dougallii, Common S. hirundo, Arctic S. paradisaea and Little Terns S. albifrons in Ireland in 1995. Irish Birds 6: 1-22.

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Partridge, J. (1997). Species recovery planning: a case study of site and species management undertaken by the NWWT for the Roseate Tern at Cemlyn. M.Sc. Thesis, School of Biological Sciences, University of Wales, Bangor.

Leaflets/Brochures

- Cemlyn Nature Reserve: Tern Identification Guide (NWWT).
- Dalkey Tern Project (BirdWatch Ireland Information Leaflet No. 11).

APPENDIX 3. Maritime Ireland/Wales INTERREG Projects

The following co-operative projects and networks are supported under Measure 1.3 "Protection of the Marine and Coastal Environment and Marine Emergency Planning", of the Maritime (Ireland/Wales) INTERREG Programme (1994 – 1999):

Co-operative Projects

1. **Roseate Terns - The Natural Connection - A Conservation and Research Project linking Wales and Ireland**
   Irish Wildbird Conservancy / North Wales Wildlife Trust.
2. **Marine Mammal Strandings - A Collaborative Study for the Irish Sea.**
   National University of Ireland, Cork / Countryside Council for Wales.
3. **South West Irish Sea Survey (SWISS).**
   Trinity College Dublin / National Museum of Wales, Cardiff.
4. **The Fate of Nutrients in Estuarine Plumes.**
   National University of Ireland, Galway / University of Wales, Bangor.
5. **Water Quality and Circulation in the Southern Irish Sea**
   National University of Ireland, Galway / University of Wales, Bangor.
6. **Grey Seals: Status and Monitoring in the Irish and Celtic Seas.**
   National University of Ireland, Cork / Dyfed Wildlife Trust.
7. **Sensitivity and Mapping of inshore marine biotopes in the Southern Irish Sea SensMap).**
   Ecological Consultancy Services (Dublin), Dúchas / Countryside Council for Wales.
8. **Marine Information System: Scoping Study (Phase I). Marine Institute,**
   National Marine Data Centre/ Countryside Council for Wales.
9. **Achieving EU Standards in Recreational Waters.**
   National University of Ireland, Dublin / University of Wales, Aberystwyth.
10. **Irish Sea Southern Boundary Study**
    Marine Informatics Ltd (Dublin) / University of Wales, Bangor.
11. **Marine Information System: Demonstration (Phase II).**
    Marine Institute, National Marine Data Centre / Countryside Council for Wales.
12. **Emergency Response Information System (ERIS)**
    Enterprise Ireland, Compass Informatics, IMES / University of Wales, Bangor.
13. **Risk Assessment and Collaborative Emergency Response in the Irish Sea (RACER)**
    Nautical Enterprise Centre (Cork), National University of Ireland, Cork, University of Wales, Cardiff.
14. **Critical assessment of human activity for the sustainable management of the coastal zone.**
    National University of Ireland, Cork / University of Wales, Aberystwyth.
15. **SeaScapes – Developing a method of seascape evaluation**
    Brady Shipman Martin, National University of Ireland, Dublin / University of Wales, Aberystwyth.
16. **Ardfodir Glan – Clean Coasts/Clean Seas**
    CoastWatch Ireland / Keep Wales Tidy Campaign.

Co-operative Networks

17. **Irish Sea Hydrodynamic Modelling Network**
    Trinity College Dublin / University of Wales, Bangor.
18. **CoAST - Co-operative Action - Sustainability Network**
    Dublin Regional Authority / Isle of Anglesey County Council.
19. **ECONET - Erosion Control Network**
    Enterprise Ireland / Conwyn County Council.
20. **Navigate with Nature**
    Irish Sailing Association / Centre for Economic and Environmental Development (UK).
21. **"Land Dividing - Sea Uniting" Irish Seas Exhibition**
    Irish Seal Sanctuary, ENFO / National Assembly for Wales.

22. **From Seawaves to Airwaves**
West Dublin Community Radio / Radio Ceredigion CYF.

23. **BENSIS – Benthic Ecology Network**
Trinity College Dublin / National Museum of Wales, Cardiff.

24. **Remote Sensing of Suspended Sediment Load in the Coastal Zone**
National University of Ireland, Galway / University of Wales, Bangor.

25. **Paving the Information Highway**
Ecological Consultancy Services (Dublin) / Irish Sea Forum, University of Wales, Bangor.

26. **Inland, Coastal and Estuarine (ICE) Journal**
National University of Ireland, Dublin / Centre for Economic and Environmental Development (UK).

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