

Results from the first three years of monitoring post-breeding tern aggregations in Ireland

Brian Burke¹, Niamh Fitzgerald¹, Helen Boland¹, Tony Murray², Tom Gittings³ & T. David Tierney⁴

¹ BirdWatch Ireland, Unit 20 Block D, Bullford Business Campus, Kilcoole, Co. Wicklow

² National Parks & Wildlife Service, Wexford Wildfowl Reserve, Ardavan, North Slob, Co. Wexford

³ 3 Coastguard Cottages, Roches Point, Whitegate, Co. Cork

⁴ National Parks & Wildlife Service, Department of Culture, Heritage & the Gaeltacht, 90 North King Street, Smithfield, Dublin 7

Corresponding author: bburke@birdwatchireland.ie

Keywords: Terns, passage, staging, stopover, migration, *Sterna hirundo*, *Sterna dougallii*, *Sterna paradisaea*, *Thalasseus sandvicensis*

The Irish post-breeding tern survey was established to identify, and to determine the relative importance of roost sites used by terns after the breeding season and before migration. The survey focused on Common Tern *Sterna hirundo*, Arctic Tern *Sterna paradisaea*, Roseate Tern *Sterna dougallii* and Sandwich Tern *Thalasseus sandvicensis* aggregations. Each of these species is amber-listed as species of conservation concern in Ireland. The post-breeding period is an important stage of their life-cycle and pressures that might hinder their ability to build energy reserves before migration may have individual- or population-level impacts. Identifying important sites used by these species during the post-breeding period is therefore a conservation priority. Counters were asked to survey coastal sites for post-breeding terns between mid-August and mid-September, when numbers of congregating terns were expected to peak. Roosting tern flocks were recorded at 45 sites around the Irish coast in August and September between 2016 and 2018, inclusive. Peak counts of >1,000 terns were recorded at seven sites, four sites had 501-1,000 terns, 15 sites had 101-500 terns and 19 sites had peak counts of ≤100 terns. Sandwich Terns were the most widespread species across the surveyed roosts, followed by Common, Arctic and Roseate Terns, respectively. The first three years of this survey has provided an initial indication of the distribution of roosting tern flocks during the post-breeding season. Important sites have been identified and further survey effort is recommended to confirm their relative importance and to inform future site management and protection.



Introduction

Common Tern *Sterna hirundo*, Arctic Tern *Sterna paradisaea*, Roseate Tern *Sterna dougallii* and Sandwich Tern *Thalasseus sandvicensis* are all listed on Annex I of the E.U. Birds Directive (2009/147/EC) and are amber-listed species of conservation concern in Ireland due to their

localised breeding populations, declines in breeding range (Common, Arctic, Sandwich) and international importance of the Irish breeding population (Roseate) (Colhoun & Cummins 2013). Each is afforded high levels of protection at some of

Plate 11. Sandwich Terns (Shay Connolly).

their largest breeding colonies (e.g. Rockabill, Dublin Port, Lady's Island Lake) through site designation, regular monitoring and at some sites daily wardening. However, as migratory species they are vulnerable to threats at other parts of their annual cycle. According to Runge *et al.* (2015), 91% of migratory bird species have inadequate protection for at least one part of their annual cycle, representing a vulnerability to the protective regime at the flyway scale. Protection of migratory species needs to occur across habitat types and seasons at an international scale.

In the days and weeks immediately following the breeding season, young terns are learning to forage for themselves in the company of parents and to gradually transition to independence, in advance of an energetically-demanding migration of c.6,000 km or more to the wintering grounds (Burger 1980). In addition, pre-breeding birds (1-3 years old) visit colonies late in the breeding season and accompany breeding birds and their young during the post-breeding period (Nisbet & Spendelow 1999). Disturbance-free roosting sites in proximity to fish-rich feeding areas during the post-breeding season are crucial to the survival and future recruitment of these migratory seabirds. The loss or degradation of these sites can have population-level consequences (Warnock 2010). Given that Ireland hosts over 92% of the north-west European breeding population of Roseate Terns (66% of European total including the Azores; Macleod-Nolan 2019), it is particularly important that staging and stopover sites used by this species are identified and appropriately protected.

Non-breeding waterbirds in Ireland are monitored through the Irish Wetland Bird Survey (I-WeBS) (Lewis *et al.* 2019), which allows for the calculation of population estimates, trends and the identification of important sites for wintering wildfowl, wildfowl allies and waders in Ireland and contributes to flyway-level monitoring (Burke *et al.* 2019, Lewis *et al.* 2019). Recording of terns and gulls during I-WeBS counts is optional however, and given the timing and frequency of counts, and the focus on the mid-winter period, they do not represent sites used by terns after the breeding season and before migration. Targeted surveying in south Dublin Bay had identified the site as being of major importance to large numbers of Common, Arctic and Roseate Terns since the 1960's (Merne *et al.* 2008). This has been underscored by more recent work as part of the Dublin Bay Birds Project (Tierney *et al.* 2016), but little was known or formally recorded about sites elsewhere. A national post-breeding tern survey was established in 2016, under the auspices of I-WeBS, to fill this knowledge gap.

This study reports on the first three years of the Irish post-breeding tern survey. The survey aimed to identify important stopover and staging sites used by terns in Ireland in late summer and early autumn, and to gather preliminary

information on species distribution and relative abundance at these sites in order to improve the protection of Common, Arctic, Roseate and Sandwich Tern populations in Ireland.

Methods

The species considered by this survey are Common Tern, Arctic Tern, Roseate Tern and Sandwich Tern. In some cases, Common and Arctic Terns could not be differentiated, in which case the flock was categorised as 'Commic' Terns (i.e. a mix of Common and Arctic Terns in unknown proportions). I-WeBS counters were asked to survey sites that were known to be used for roosting by terns, or sites that seemed likely to be used (i.e. open sandy beaches, rocky outcrops). In addition, photos and reports of tern roosts on social media (i.e. Facebook, Twitter) and Irishbirding.com were followed up with requests for further information. The first year of the survey focused on the east and south coasts (Louth to Cork Harbour), after which the survey was extended around the entire coast of the Republic of Ireland.

Counters were asked to visit sites (ideally at least twice) between mid-August and mid-September. Many of the sites included here have terns roosting outside this period but August and September cover most of the post-breeding period and the window within which tern numbers at these sites reach their peaks. Where the importance of a site was unknown, counters were asked to undertake at least one count at dusk, when the tide was rising and approximately mid-way between low and high tide. This is typically when the terns are pushed into a smaller area and are closer to the observer and easier to count. During each site visit the total numbers of roosting terns of each species were counted or estimated where necessary. Counters were asked to delineate the specific point used by flocks via an ArcGIS.com mapping app.

Given that turnover of terns at roost sites can be very high, and the limited knowledge of sites used, opportunistic counts of roosting terns that deviated from this methodology were also welcomed and made a significant contribution to the data collected.

Results

Sites where post-breeding tern flocks of >50 individuals were recorded in August and September 2016, 2017 and 2018 are listed in Table 1, together with peak counts on any single visit, and peak counts of individual species recorded during the study period.

Coverage

Tern roosts were recorded at a total of 45 sites around the Irish coast in August and September from 2016 to 2018

Table 1. Sites where post-breeding tern flocks of >50 individuals were recorded during 2016-2018 inclusive, and the number of years from which records were received. Peak count is the largest number of terns present during any one count. Individual peak counts of Common (CN), Arctic (AE), 'Commic' (unidentified Common or Arctic; UI), Roseate (RS) and Sandwich (TE) Terns are also presented.

	Site	Years	Peak	CN	AE	UI	RS	TE
Louth	Dundalk Bay Outer	1	460	156	24	-	80	200
	Dundalk Bay	1	50	-	-	50	2	20
	Dunany Point - Clogher Head	3	4,000	350	40	4,000	-	120
	Boyne Estuary	2	123	7	-	20	1	110
Meath	Nanny Estuary & shore	3	1,300	650	50	1,300	30	250
Dublin	Skerries Coast	3	2,426	520	40	2,000	115	210
	Rogerstown Estuary	3	739	600	2	-	4	261
	Broadmeadow Estuary	2	160	8	10	150	-	100
	Dublin Bay	3	17,440	4,500	1,400	12,000	2,100	40
Wexford	Wexford Harbour & Slobs	1	1,500	825	-	1,500	275	15
	Crossfintan Point	3	2,500	1,000	250	2,290	750	30
	Lady's Island Lake	1	350	200	-	-	-	150
	Tacumshin Lake	1	650	-	-	650	Yes	-
	Bannow Bay	3	114	9	2	-	20	112
	Duncannon, River Barrow	3	170	1	2	-	-	170
Waterford	Tramore Back Strand	2	218	14	-	-	-	204
	Clonea Bay	2	800	750	1	-	50	80
	Dungarvan Harbour	1	287	26	1	-	-	260
	Ardmore Bay	2	130	60	-	-	1	80
Cork	Ballymacoda	2	58	-	-	-	-	58
	Ballycotton Shanagarry	3	137	6	-	3	17	137
	Cork Harbour	3	1,160	100	20	380	2	1,000
	Clonakilty Bay	1	51	-	-	-	-	51
	Rosscarbery	1	90	-	-	-	-	90
Kerry	Castlemaine Harbour & Rossbehy	1	70	-	-	-	-	70
	Brandon Bay - Inner Brandon Bay	1	900	-	900	-	-	-
	Tralee Bay, Lough Gill & Akeragh Lough	1	400	-	400	-	-	20
	Shannon & Fergus Estuary (Kerry)	1	320	60	10	-	-	250
Clare	Shannon & Fergus Estuary (Clare)	1	75	-	-	75	-	-
	Rinevilla Bay, Shannon Estuary	1	60	-	-	-	-	60
Galway	Inner Galway Bay	2	370	250	20	-	-	100
	Oilean na Lachan, Connemara	1	55	-	-	-	-	55
Mayo	South Mayo Coast	2	62	-	-	-	-	62
	Clew Bay	2	276	-	-	19	-	257
	Blacksod & Tullaghan Bays	1	127	-	-	-	-	127

Other sites where ≤ 50 roosting terns were recorded during the study period, with peak count in brackets: Carlingford Lough (ROI) (23), South Dublin Coastline (1), Lissagriffin Lake (27), Ventry Harbour (20), Smerwick Harbour (15), Carrigaholt Bay, Shannon Estuary (12), Inishkea Islands (45), Drumcliff Bay Estuary (46), Donegal Bay (35), Lough Swilly (32).

inclusive, totalling 329 records. Survey effort varied from year to year: 11 sites were surveyed in all three years, 11 surveyed in two years and 23 predominantly west-coast sites were surveyed in a single year. In general, there was a tendency for people to not submit records when no terns were seen on a visit. Over 50 counts were received for Cork Harbour, over 30 each for Dublin Bay and Rogerstown Estuary, 23 for Duncannon, and over ten counts each for Crossfintan Point, Skerries Coast, Bannow Bay, Ballycotton/Shanagarry and the Nanny Estuary and Shore.

The greatest number of post-breeding tern roost sites recorded were in counties Cork and Kerry (seven), with six sites in Wexford, five each in Dublin and Louth, four each in Mayo and Waterford and smaller numbers of sites in Clare, Galway, Donegal, Meath and Sligo. The number of sites at which post-breeding tern flocks were recorded is likely to be biased by surveyor availability and coverage.

Peak numbers

Counts of over 1,000 terns were recorded at seven sites, in counties Louth, Meath, Dublin, Wexford and Cork. Four sites had peak counts of 501-1,000 and 15 sites had 101-500 terns. Of the remaining 19 sites, 15 were surveyed in one year only. Nine of these had peaks of 51-100 terns and ten had less than 50 individuals.

Interannual variability

Figure 1 illustrates the peak tern numbers recorded in August and September in 2016, 2017 and 2018 at the four sites for which the greatest number of records were received. There was considerable variation in both the peak numbers recorded at sites in different years and the temporal usage of a given site during the post-breeding period. There was a tendency, though, for peak counts to be recorded in the middle or end of August at most sites and in most years.

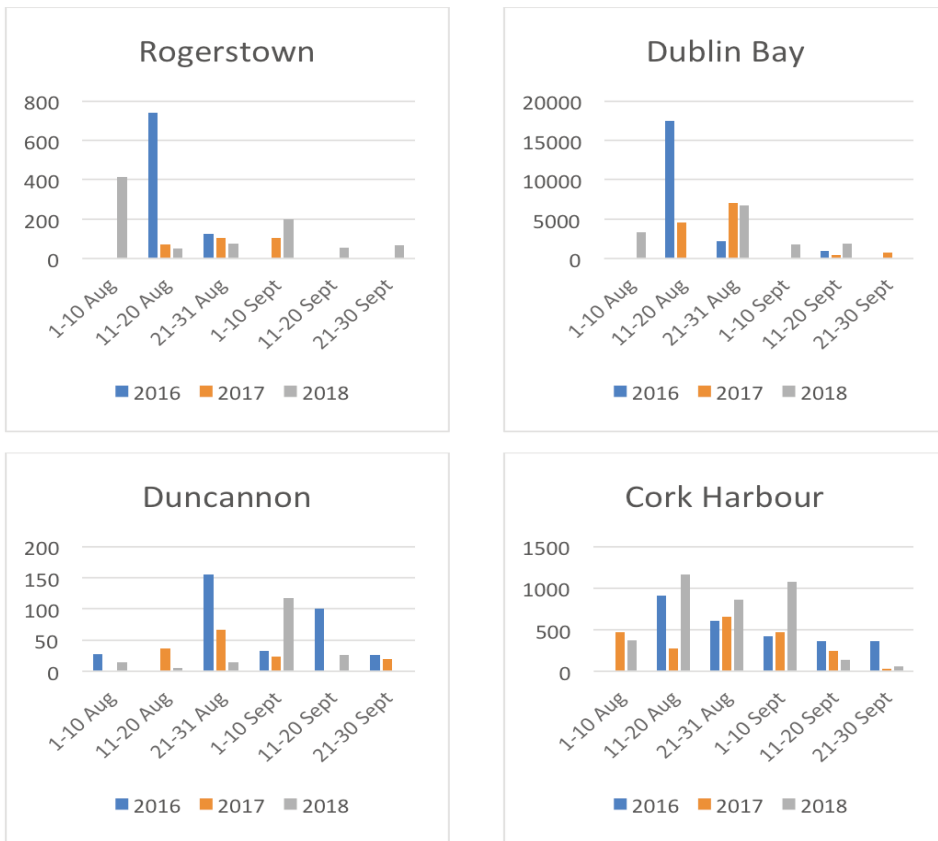


Figure 1. Numbers of post-breeding terns at the four sites for which the highest number of counts were received. Peak counts during circa 10-day windows in August and September, 2016, 2017 and 2018 are presented.

Distribution

The distribution of Common, Arctic, Roseate and Sandwich Tern roosts is illustrated in Figure 2. Sandwich Terns were the most widespread species, recorded at 41 of the 45 sites. The largest single count was in Cork Harbour (1,000) and peak counts of ≥ 200 were recorded at a further eight sites in six counties.

Common Terns were recorded at 29 sites in total, if 'Commic' records are included, with a predominantly east and south-east coast distribution. South Dublin Bay and Crossfintan Point in Wexford hosted peaks of 4,500 and 1,000 Commons respectively. The true figure is likely to be significantly higher though, given that peak 'Commic' flocks of 12,000 and 2,290 were recorded at those sites. Dunany Point

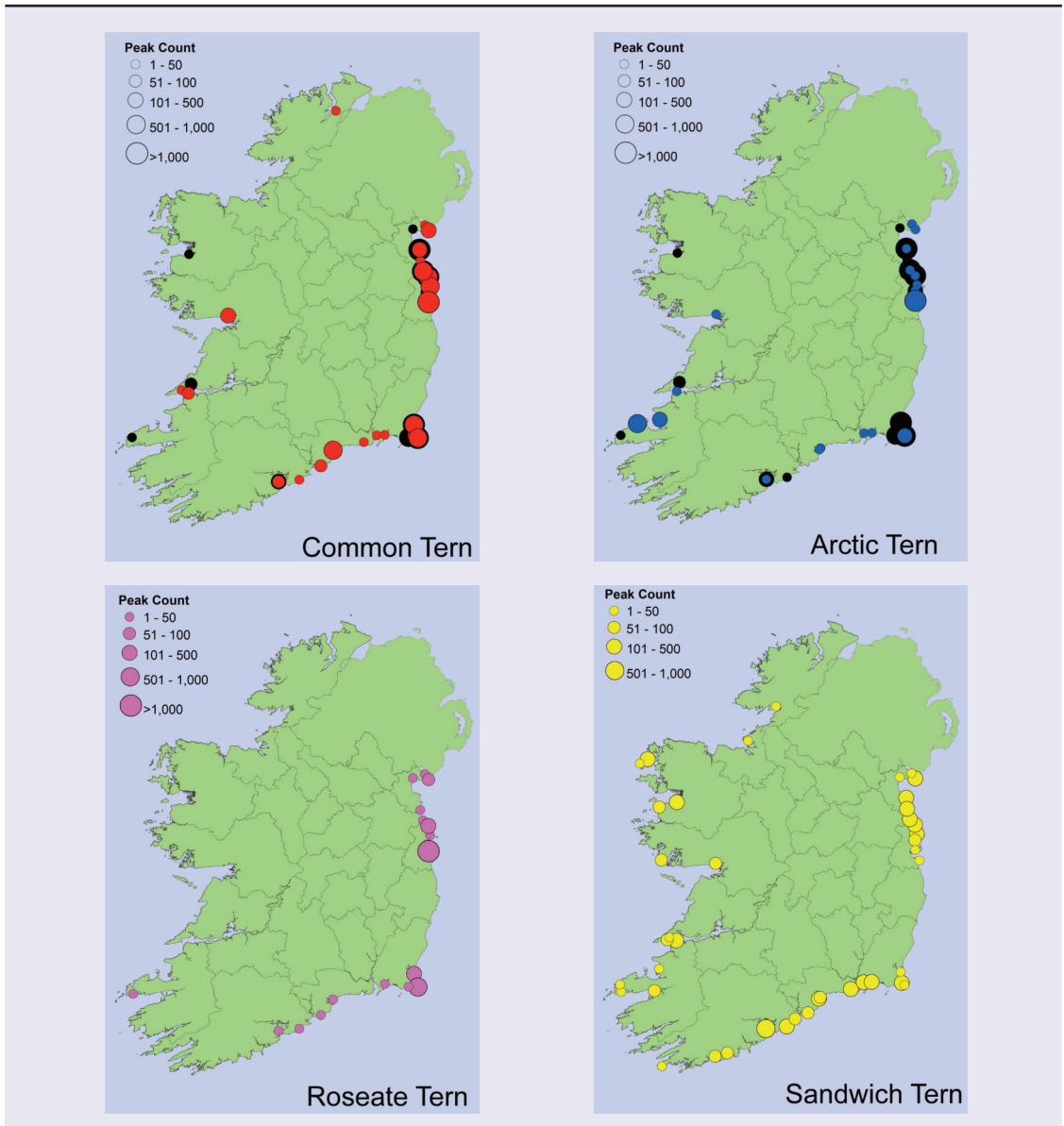


Figure 2. Post-breeding Tern roosts used in August and September, 2016, 2017 and 2018. Dots mark sites where the following species were recorded: Common Tern (red), Arctic Tern (blue), 'Commic' Tern (black), Roseate Tern (pink) and Sandwich Tern (yellow).

– Clogher Head (Louth) had a peak of 4,000 ‘Comemics’ and the Skerries Coast in Dublin had a peak of 2,000 ‘Comemics’. Other notable sites, on the basis that many ‘Commic’ flocks were generally thought to have had more Common than Arctic Terns, include Wexford Harbour and Nanny Estuary and shore.

Arctic Terns were recorded at 18 sites, with a further eight sites possible if ‘Comemics’ are considered. The largest confirmed Arctic Tern count was from Dublin Bay (1,400), though the peak ‘Commic’ count in Dublin Bay, estimated at 12,000 birds, is likely to have included a much higher number. The next highest counts of Arctic Terns were in Brandon Bay (900) and Tralee Bay (400) in Kerry, though numbers in the ‘Commic’ flocks at Dunany Point-Clogher Head, Crossfintan Point and the Skerries Coast may have been comparable.

Roseate Terns were recorded at 17 sites, with ten of those hosting more than five birds during any single count. Their distribution is very obviously biased towards the east coast, fitting with their breeding distribution, with some post-breeding dispersal along the south coast into Waterford. Highest numbers were in Dublin Bay (2,100) and Crossfintan point (750), while nearby Skerries Coast (115) and Wexford Harbour (275) also hosted notable numbers. It is possible that some Roseate Terns were included in counts of ‘Commic’ terns at the above-mentioned sites where Roseates are frequently recorded in good numbers, but less likely at sites where Roseate Terns are considered to be scarce or rare in occurrence (i.e. the west coast).

Discussion

Sites used by post-breeding terns around the Irish coast have received little attention to date apart from south Dublin Bay, despite their importance in the annual cycle of these long-distance migrants. This study presents the results from the first three years of the Irish post-breeding tern survey, identifying sites used by roosting Common, Arctic, Roseate and Sandwich Terns around the coast in August and September. Given the transient nature of individuals and flocks at sites post-breeding and pre-migration, and the inherent biases from varied survey effort, the results presented here should be considered merely a first step to determining the relative importance of sites for post-breeding terns.

Surveying difficulties

There are several difficulties in surveying post-breeding terns. At many sites, terns can be found roosting during the day, while others come and go and more still are feeding offshore out of sight of land. Surveys at sunset are more likely to record the highest number of terns, as birds finish feeding and come to shore to roost. Based on observations in Dublin Bay and

Cork Harbour, large numbers of birds arrive often after dark, when counting is no longer feasible, so final tallies may still represent an underestimate of numbers present. Separating species (particularly Common and Arctic, and occasionally Roseate Terns) at long range or in poor light can also be difficult, as can counting large flocks or separating species when the flock is subject to frequent disturbance. Tidal state also affects distance between the flock and the observer, as well as the availability of suitable roosting habitat and the potential for anthropogenic disturbance of birds, meaning some sites are best surveyed at low tide but others on a rising/high tide. With all of this in mind, counts presented here should be treated as minima for numbers using the site in a given season and the list of sites should not be considered comprehensive. It should also be stressed that, given the significant turnover possible even on subsequent days (1-83%; Tierney *et al.* 2016), peak counts reported here could well be only a fraction of the number of individuals using a given site within a season.

Disturbance

Many tern roosting sites are on coastal beaches that are also popular recreational sites and recreational disturbance is a well-known issue for non-breeding waterbirds in Ireland (Lewis *et al.* 2019). Walkers and dogs were the two main causes of disturbance during post-breeding tern counts, recorded at eight sites in seven counties. In most cases birds relocated within the site, though disturbance close to dusk at Lough Beg (Cork Harbour) has caused the terns to apparently abandon the roost (T. Gittings pers. obs.). Given the importance of these stopover sites, appropriate measures should be taken to minimise disturbance during this key period. These could potentially include zoning of areas to balance recreational and conservation needs (Stigner *et al.* 2016) and educating beach users of the adverse effects of disturbance on the local bird population (Le Corre *et al.* 2013). At present, the only sites designated for the protection of terns on migration (Common, Arctic, Roseate) are South Dublin Bay, River Tolka Estuary SPA (Special Protection Area) and Dalkey Island SPA. The results from the first three years of this survey should inform the appropriate conservation of other sites identified to be of relatively high importance for post-breeding tern populations.

Site importance

Sites supporting roosting flocks of post-breeding terns were recorded in all coastal counties except Leitrim and Wicklow, though small numbers of Sandwich Terns are known to stopover at Kilcoole (Wicklow) in late summer. Of the seven sites with >1,000 terns, six are on the east coast in the Irish

Sea and are a relatively short distance from large breeding colonies in Dublin (Rockabill, Dublin Port) and Wexford (Lady's Island Lake). Breeding birds are presumably drawn to the Irish Sea because of the abundant food resource and safe places to nest, with many post-breeding birds making use of the same food resource, and nearby expanses of coastline for roosting. Ringing studies in Dublin Bay (Tierney *et al.* 2016), and ring-reading efforts elsewhere, also confirm the presence of terns of all four species from British and European breeding colonies in Irish post-breeding tern roosts, suggesting a wider biogeographical importance of the major Irish roost sites. An updated collation of ringing and tracking datasets may shed further light on the countries from which post-breeding terns in Ireland originated and more accurately define the importance of Irish staging/stopover sites in an international context.

Dublin Bay

Dublin Bay, specifically Sandymount Strand, is clearly the largest post-breeding tern site in Ireland and is regularly used by significant concentrations from late July to late September each year (Merne *et al.* 2008, Tierney *et al.* 2016). As part of this study, enquiries were made as to the size of tern roosts in Northern Ireland, Isle of Man and Britain to investigate how they compare with those in the Republic of Ireland. Over a thousand roosting terns were recorded during peak counts at Gronant in Wales (1,200 Sandwich and seven Common in 2017; per G. Robinson), Seaforth at Merseyside (1,300 Common in 2016, 1,200 in 2015; per S. White), Ainsdale (>2,000 Sandwich in 2016; per P. Kinsella) and Fylde (1,993 Sandwich, two Common in 2017; per Fylde Bird Club and C. Batty) near the Ribble Estuary, all of which are on the west coast of Britain. The significant concentrations of post-breeding terns on both sides of the Irish Sea further underlines the importance of this area to terns during the pre/early migratory period.

Several hundred terns (mostly Sandwich Tern) were recorded at other sites including the River Tweed Estuary on the east coast of Britain, and the Teesmouth area is also known to be used (Ward 2000). Although this was only a limited snapshot of the major tern roosts in the UK, it does suggest that many of the east coast tern roosts in Ireland compare well in an international context and that Dublin Bay may be the most important tern staging site in north-west Europe.

Stopover and staging sites

Though the terms 'stopover' and 'staging' site are often used interchangeably in the context of migrating birds, Warnock (2010) argued that there is ecological and conservation value

in differentiating between the two. Stopover sites are used more opportunistically for resting and feeding and are generally of shorter-term importance and the loss or degradation of such sites would likely have individual-level effects. Staging sites are used by birds preparing for a significant energetic challenge (e.g. flying 1,000's of kms over an ocean) and are generally relied upon by larger numbers of birds as a predictable location to forage, rest and build fat reserves in advance of migration. Loss of staging sites would be expected to have population-level impacts (Warnock 2010). There are probably relatively few sites that meet the criteria of true staging sites for post-breeding terns in Europe and it is not currently clear how many of the sites surveyed to date in Ireland fulfil the criteria. South Dublin Bay likely meets the criteria to be considered a vital staging site in north-west Europe. Others that supported >1,000 terns with some regularity are also possible candidates, though more focused surveying within and between years should be carried out to confirm their status.

Sandwich Tern Despite having limited breeding range and numbers in Ireland, Sandwich Tern was the most widespread species in post-breeding roosts. Sandwich Terns remain in Ireland later in the year than the other terns and are still recorded during I-WeBS counts into October (Burke *et al.* 2018), with very small numbers overwintering. At some roost sites included here (e.g. Broadmeadows Estuary, Cork Harbour) Sandwich Terns are present for three months or more each year despite not breeding locally. The international 1% threshold for the west Europe/west Africa population of Sandwich Tern is 1,800 individuals with a 1% national importance threshold of 50 individuals. The national breeding population estimate is 2,519 pairs (Cummins *et al.* 2019.). Twenty-seven sites had peak counts of >50 Sandwich Terns during the post-breeding season, and if these sites are confirmed to be regularly used by similar numbers then they are likely to be of national importance, assuming that all Sandwich Terns from the Irish breeding population spend at least some time staging or stopping over around the Irish coast before migration. Ringing of Sandwich Tern nestlings is carried out annually at the Lady's Island (Wexford) colony and birds have subsequently been resighted along the coast in several counties in the north, north-west, south-west and along the east and south coasts during the post-breeding season, all in the opposite direction of migration. Ringing efforts at Lough Beg in Cork Harbour have yielded 25 Sandwich Tern recoveries as of 2019, 20 of which have come from Lady's Island, c.140 km to the east (B. O'Mahony pers. comm.), further highlighting the importance of these sites to the Irish breeding population.



Plate 12. Roseate Terns (John Fox).

Common and Arctic Tern The largest counts for both Common and Arctic Terns are from records of ‘Commics’, where the number or ratio of the two species could not be estimated with confidence. The 1% threshold for international importance for Common Terns is 1,800 individuals (Wetlands International 2019) and 100 individuals for national importance (Cummins *et al.* 2019), based on breeding numbers. It is possible that peak counts of ‘Commics’ at Dublin Bay, Dunany Point-Clogher Head, Crossfintan Point and Skerries Coast (all >2,000) contained internationally important numbers of Common Terns, given that most such flocks were thought to contain a higher proportion of Commons than Arctic Terns. The proximity of these sites to colonies where Commons predominate, adds circumstantial weight to the possibility that most flocks likely had more Common than other species. A total of 14 sites had nationally important numbers of Common Terns (including ‘Commic’ flocks), again based on the size of the breeding population and on the assumption that Irish-breeding Common Terns use post-breeding sites in Ireland.

The particularly high counts of Arctic Terns at two sites in Kerry were interesting, given that few Common or Roseate Terns were recorded on the west coast. Redfern & Bevan (2019) observed that some Arctic Terns breeding on the North Sea crossed over both England and Ireland to get to the North Atlantic, from where they presumably staged before heading south. Other studies over many years have indicated that some post-breeding Arctic Terns may move west and stage in

the North Atlantic (Austin 1928, Fijn *et al.* 2013, Redfern & Bevan 2019). The international and national population estimates for Arctic Tern are 2-5,000,000 individuals (Western Eurasian population; Wetlands International 2019) and 2,778 pairs (Cummins *et al.* 2019) respectively. Twelve sites supported numbers of national importance during this study, assuming ‘Commic’ flocks contained 55 or more Arctic Terns. Both Dalkey Island in Dublin and the Kish Bank lighthouse outside Dublin Bay are known to have hosted post-breeding Common, Arctic and Roseate Tern flocks in the past (Newton & Crowe 1999). Anecdotal evidence suggests Dalkey has not been used by significant numbers of terns outside the breeding season in recent years though this remains to be confirmed. Due to its location the Kish Bank lighthouse could not be surveyed during this study, though its previous use indicates the potential for other offshore lighthouses and outposts to host similar flocks.

Roseate Tern The European breeding population of Roseate Terns was 2,823 pairs in 2018 (Macleod-Nolan 2019); 58% and 8% were at Rockabill (Dublin) and Lady’s Island Lake (Wexford) respectively. Unsurprisingly, the largest aggregations of post-breeding Roseate Terns were at sites in Dublin (Dublin Bay, Skerries Coast) and Wexford (Crossfintan, Wexford Harbour) close to the two major breeding colonies. Dundalk Bay Outer also hosted numbers above the 1% international threshold and the 50 birds at Clonea Bay (Waterford) was above the 1% national threshold. The tens of

Roseate Terns in Louth, Meath and Waterford illustrate some of the initial dispersal from the colonies away from the direction of migration. Four thousand 'Commic' terns have been recorded elsewhere in Louth (Dunany Point – Clogher Head) and this may well have included a significant number of Roseate Terns. As is the case elsewhere in their range (Trull *et al.* 1999), having such a large fraction of the Irish and north-west European population of Roseate Terns concentrated into a small number of sites leaves them vulnerable to human disturbance during a sensitive and important time in their annual cycle. Given that they are a species of high conservation concern at national and European level (Colhoun & Cummins 2013, Macleod-Nolan 2019), protection of significant post-breeding roost sites in the Irish Sea could well minimise potential impacts on post-breeding adults and newly-fledged juveniles in advance of migration.

Turnover at sites

Evaluating the importance of a site requires a good knowledge of the number of individual birds of a species that use it. This is relatively easily done for breeding birds that are constrained to a given location throughout the summer (i.e. nest site), and wintering birds that are largely site-faithful for most of the winter, but much more difficult for birds moving through an area on passage over a period of weeks or months. Ideally, this could be reliably estimated through a combination of counts and resightings of marked individuals (Atkinson *et al.* 2007), but it is often very difficult to read colour-rings on Common, Arctic and Roseate Terns at the kind of distances involved for some of the roosts discussed here. Obtaining a sufficient number of resighting observations per count period (Atkinson *et al.* 2007, Verkuil *et al.* 2010) is likely to be impractical, although may be possible for Sandwich Terns at certain roost sites. This would likely necessitate ringing targeted at post-breeding sites, as well as incorporating birds marked elsewhere (i.e. colonies). Advancements and miniaturisation of tracking technology may allow for a technological solution to address this data gap in the future. In the meantime, it is recommended that regular counts, including counts on consecutive nights, at different tidal states, and in advance of dusk, be carried out to better understand the numbers of different tern species using post-breeding tern roosts around the Irish coast. Though timing likely depends on factors including start date of the breeding season, breeding success and failure, food availability, weather and phase of the moon (Vinicombe 2014) and species-specific differences, the period from the second week of August to the end of the first week of September seems to be when sites are most heavily used. This level of surveying should be carried out over a minimum of three consecutive years, with five or more counts over a four-week period from mid-August

to early/mid-September. At Cork Harbour, bimodal peaks in Sandwich Tern numbers were observed in two of the three years considered here, highlighting not only levels of turnover but also the importance of repeat within- and between-season surveying to accurately ascertain site usage.

Conclusion

The post-breeding period is an important part of the annual cycle of these species and represents an ecological bottleneck where birds must adequately prepare for the long-distance migration ahead. The first three years of the Irish post-breeding tern survey have provided initial data on locations of Common, Arctic, Sandwich and Roseate Tern roosts around the Irish coast, some of which are of significance for more than one species. The inclusion of these species onto the list of Species of Conservation Interest for relevant existing SPAs should be considered and their protection and conservation included in future conservation management at their respective sites.

Acknowledgements

The Irish post-breeding tern survey is part of the Irish Wetland Bird Survey (I-WeBS), funded by the National Parks and Wildlife Service of the Department of Culture, Heritage and the Gaeltacht and coordinated by BirdWatch Ireland. We wish to thank Olivia Crowe and Lesley Lewis for their assistance, support and advice over the course of the first three years of this project. We also thank the anonymous reviewer and editor for helping to improve the manuscript. Surveys of post-breeding terns in Dublin Bay were carried out under the Dublin Bay Birds Project of BirdWatch Ireland, funded by Dublin Port Company. Data for Cork Harbour includes counts carried out for Deputy Synthes Ireland.

We wish to extend a sincere thanks to all who have submitted records of roosting terns, many of whom have been counting and recording roosting tern flocks in their area since long before this project began. Thanks to K. Abariute, T. Adcock, C. Barton, D. Berridge, B. Black, A. Butler, E. Carty, M. Collins, R. Coombes, J. Copner, E. Cotton, D. Cotton, M. Cowming Snr., M. Cowming, C. Cronin, J. Crosher, G. Davies, M. Derwin, T. Doyle, J. Dunleavy, J. English, A. Farrell, N. Finn-Kelcey, D. Fitzpatrick, J. Fox, G. Franck, K. Griffin, N. Harmeey, K. Harrington, T. Hyde, C. Ingram, B. Johnston, C. Jones, T. Kavanagh, E. Keane, K. Kelly, N.T. Keogh, L. Lenehan, J. Lovatt, P. Lynch, J. Lynch, D. Lysaght, A. Malcolm, P. Manley, B. Martin, E. McGreal, E. McLachlan, R. McLoughlin, J. Milroy, MKO Ireland, P. Moore, S. Newton, B. O'Mahony, C. O'Sullivan, R.S. Pedersen, S. Pierce, H. Preston, G. Prole, J. Proudfoot, P. Ryan, D. Sinnott, P. Smiddy, D. Suddaby, M. Taylor, N. Tierney, P. Veale, P. Walsh, R. Whelan.

Thanks too to those in Northern Ireland, Isle of Man and Britain who responded to requests for counts from their localities in 2017: J. Armstrong, G. Gibbs, G. Gordon, A. Grubb, M. Hughes, P. Kinsella, N. Morris, M. Murphy, G. Robinson, L. Samson, R. Sandham, M. Tickner, N. Waterman, S. White, S. Williams, D. Wright, C. Wynne.

References

- Atkinson, P., Choquet, R., Frederiksen, M., Gillings, S., Pradel, R. & Rehfisch, M.M. 2007. Towards Developing Thresholds for Waterbirds That Take Into Account Turnover. *BTO Research Report No. 463*. British Trust for Ornithology, Thetford.
- Austin, O.L. 1928. Migration-routes of the Arctic Tern (*Sterna paradisaea* Brunnich). *Bulletin of the Northeastern Bird-Banding Association* 4: 121-125.
- Burger, J. 1980. The transition to independence and post fledging parental care in seabirds. *Behavior of Marine Animals* 5: 367-447.
- Burke, B., Fitzgerald, N. & Lewis, L. 2018. Irish Wetland Bird Survey: results of waterbird monitoring in Ireland in 2015/16. BirdWatch Ireland, Wicklow.
- Burke, B., Lewis, L.J., Fitzgerald, N., Frost, T., Austin, G. & Tierney, T.D. 2019. Estimates of waterbird numbers wintering in Ireland, 2011/12 – 2015/16. *Irish Birds* 41: 1-12.
- Colhoun, K. & Cummins, S. 2013. Birds of Conservation Concern in Ireland 2014-2019. *Irish Birds* 9: 523-544.
- Cummins, S., Lauder, C., Lauder, A. & Tierney, T. D. 2019. The Status of Ireland's Breeding Seabirds: Birds Directive Article 12 Reporting 2013 – 2018. *Irish Wildlife Manuals, No. 114*. National Parks and Wildlife Service, Department of Culture, Heritage and the Gaeltacht, Ireland.
- Fijn, R.C., Heimstra, D., Phillips, R.A. & van der Winden, J. 2013. Arctic Terns *Sterna paradisaea* from The Netherlands migrate record distances across three oceans to Wilkes Land, East Antarctica. *Ardea* 101: 3-12.
- Le Corre, N., Peuziat, I., Brigand, L., Gélinaud, G. & Meur-Férec, C. 2013. Wintering waterbirds and recreationists in natural areas: a sociological approach to the awareness of bird disturbance. *Environmental Management* 52: 780-791.
- Lewis, L.J., Burke, B., Fitzgerald, N., Tierney, T.D. & Kelly, S. 2019. Irish Wetland Bird Survey 2009/10 – 2015/16. *Irish Wildlife Manuals* 106. National Parks and Wildlife Service, Dublin.
- Macleod-Nolan, C. 2019. *Annual Roseate Tern Newsletter 2018*. Roseate Tern Life Project. Royal Society for the Protection of Birds, Sandy.
- Merne, O.J., Madden, B., Archer, E. & Porter, B. 2008. Autumn roosting by terns in south Dublin Bay. *Irish Birds* 8: 335-340.
- Newton, S.F. & Crowe, O. 1999. *Kish Bank – a preliminary assessment of its ornithological importance*. BirdWatch Ireland, Monkstown.
- Nisbet, I.C. & Spendelow, J.A. 1999. Contribution of research to management and recovery of the Roseate Tern: review of a twelve-year project. *Waterbirds* 22: 239-252.
- Redfern, C.P.F. & Bevan, R.M. 2019. Overland movement and migration phenology in relation to breeding of Arctic Terns *Sterna paradisaea*. *Ibis* DOI:10.1111/ibi.12723.
- Runge, C.A., Watson, J.E., Butchart, S.H., Hanson, J.O., Possingham, H.P. & Fuller, R.A. 2015. Protected areas and global conservation of migratory birds. *Science* 350: 1255-1258.
- Stigner, M.G., Beyer, H.L., Klein, C.J. & Fuller, R.A. 2016. Reconciling recreational use and conservation values in a coastal protected area. *Journal of Applied Ecology* 53: 1206-1214.
- Tierney, N., Whelan, R. & Valentín, A. 2016. Post-breeding aggregations of roosting terns in south Dublin Bay in late summer. *Irish Birds* 10: 339-344.
- Trull, P., Hecker, S., Watson, M.J. & Nisbet, I.C. 1999. Staging of Roseate Terns *Sterna dougallii* in the post-breeding period around Cape Cod, Massachusetts, USA. *Atlantic Seabirds* 1: 145-158.
- Verkuil, Y.I., Wijmenga, J.J., Hooijmeijer, J.C.E.W. & Piersma, T. 2010. Spring migration of Ruffs *Philomachus pugnax* in Fryslân: estimates of staging duration using resighting data. *Ardea* 98: 21-32.
- Vinicombe, K. 2014. The migration of Common and Arctic Terns in southern England. *British Birds* 107: 195-206.
- Ward, R.M. 2000. Migration patterns and moult of Common Terns *Sterna hirundo* and Sandwich Terns *Sterna sandvicensis* using Teesmouth in late summer. *Ringling & Migration* 20: 19-28.
- Warnock, N. 2010. Stopping vs. staging: the difference between a hop and a jump. *Journal of Avian Biology* 41: 621-626.
- Wetlands International. 2019. Waterbird Population Estimates. Retrieved from: wpe.wetlands.org Accessed on: 31 Jul 2019.